Innovations in the Food System: Exploring the Future of Food: Proceedings of a Workshop (2020)

DETAILS

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INNOVATIONS
in the
FOOD SYSTEM
EXPLORING THE FUTURE OF FOOD

PROCEEDINGS OF A WORKSHOP

Melissa Maitin-Shepard, *Rapporteur*

Food Forum

Food and Nutrition Board

Health and Medicine Division

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This Proceedings of a Workshop was reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise. The purpose of this independent review is to provide candid and critical comments that will assist the National Academies of Sciences, Engineering, and Medicine in making each published proceedings as sound as possible and to ensure that it meets the institutional standards for quality, objectivity, evidence, and responsiveness to the charge. The review comments and draft manuscript remain confidential to protect the integrity of the process.

We thank the following individuals for their review of this proceedings:

CHRISTINA KHOO, Ocean Spray Cranberries, Inc.
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Although the reviewers listed above provided many constructive comments and suggestions, they were not asked to endorse the content of the proceedings, nor did they see the final draft before its release. The review of this proceedings was overseen by **HUGH H. TILSON,** University of North Carolina. He was responsible for making certain that an independent examination of this proceedings was carried out in accordance with standards of the National Academies and that all review comments were carefully considered. Responsibility for the final content rests entirely with the rapporteur and the National Academies.

Contents

1

Introduction

On August 7–8, 2019, the Food Forum of the National Academies of Sciences, Engineering, and Medicine hosted a public workshop in Washington, DC, to review the status of current and emerging knowledge about innovations for modern food systems and strategies for meeting future needs. As described by Food Forum chair Sylvia Rowe, SR Strategy, LLC, in her opening remarks, the Food Forum comprises diverse members from academia, government, the private sector, and civil society, and has the goal of achieving concordance around timely, relevance, and often controversial issues. She explained that the workshop would address different perspectives on the topic of food systems and would build on a workshop on the topic of sustainable diets hosted by the Food Forum in August 2018.

The workshop explored new consumer demands related to high-quality, nutritious, and sustainable foods, along with policy and marketplace strategies in response to such demands. The 1.5-day workshop included an opening session that provided a broad look at food systems (Chapter 2), case studies in food system evolution from the federal government and the private sector (Chapter 7), and a closing discussion (Chapter 10). The remainder of the workshop was organized into six sessions focused on innovations and their implications for food systems in the areas of (1) food production, processing, and packaging (Chapter 3); (2) alternative food production (Chapter 4); (3) food distribution (Chapter 5); (4) food marketing and food value chains (Chapter 6); (5) food data and analytics

BOX 1-1
Workshop Statement of Task

An ad hoc planning committee will plan and convene a 1.5-day public workshop that will review the status of current and emerging knowledge about innovations for modern food systems, and strategies to meet future needs. Broadly, the workshop agenda will explore new consumer demands related to high-quality, nutritious, and sustainable foods, along with policy and marketplace strategies that are occurring in the system in response to such demands.

Workshop presenters may discuss topics on the supply side such as urban agriculture, food waste reduction and sustainability, and food access and affordability. On the demand side, consumer behavior and perceptions of health and wellness may be explored. Changing population dynamics, and economic growth and urbanization may be explored for their impact on sustainable food systems. Additionally, topics related to conveying information in the marketplace, such as traceability, transparency and communications may also be considered.

The planning committee will define the specific topics to be addressed, develop the workshop agenda, and select and invite speakers and discussants. After the workshop, proceedings of a workshop—in brief and full proceedings of the presentations and discussions at the workshop will be prepared by a designated rapporteur.

(Chapter 8); and (6) food access and affordability (Chapter 9). The Statement of Task for the workshop is provided in Box 1-1.[1]

[1]The workshop planning committee's role was limited to planning the workshop, and this Proceedings of a Workshop was prepared by an independent rapporteur as a factual summary of what occurred at the workshop. Statements, recommendations, and opinions expressed are those of independent presenters and participants, and are not necessarily endorsed of verified by the National Academies of Sciences, Engineering, and Medicine, nor should they be construed as reflecting any group consensus.

2

Taking a Broad Look at the Food System

The workshop began with an opening session moderated by Jennifer Otten, University of Washington, focused on taking a broad look at the food system. This session was intended to answer two key questions: (1) What are innovations within a food systems frame? and (2) What does it mean to use systems thinking in addressing food systems innovations?

THE USEFULNESS OF SYSTEMS APPROACHES IN ADDRESSING FOOD SYSTEMS INNOVATIONS

Food Systems as Complex Systems

Kate Clancy, an independent food systems consultant and visiting scholar at Johns Hopkins University, began by describing the value of systems approaches in addressing innovations in food systems. She noted that, given the complexity of food systems, the 2015 Institute of Medicine (IOM) and National Research Council (NRC) report *A Framework for Assessing Effects of the Food System* included the recommendation to apply analytic methods and an understanding of complex systems in exploring food systems issues (IOM and NRC, 2015). The framework from this report is presented in Figure 2-1. Clancy observed that the report has been widely utilized around the world for teaching, planning, and research purposes on topics including climate change, food procurement, and food security.

According to Clancy, the 2015 report built on a report titled *Toward Sustainable Agricultural Systems in the 21st Century*, which states: "The

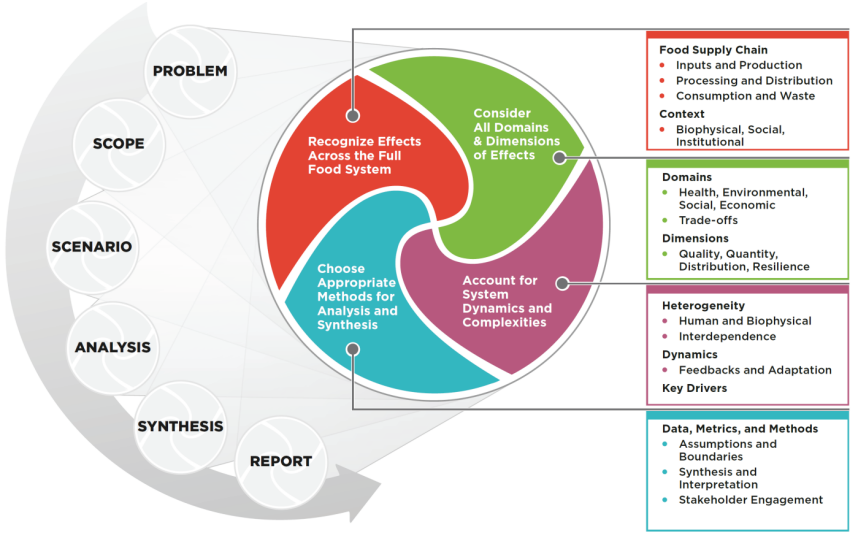

FIGURE 2-1 Conceptual illustration of an analytic framework for addressing the complexity of food systems.
SOURCES: Presented by Kate Clancy on August 7, 2019, from IOM and NRC, 2015.

transformative approach to improving agricultural sustainability … would facilitate the adoption of production approaches that capitalize on synergies, efficiencies, and resilience characteristics associated with complex natural systems and their linked social, economic, and biophysical systems" (NRC, 2010, p. viii). The report explains further that in order to effectively instill systemic changes in current farming systems, research must address the various dimensions of sustainability and require the application of a systems approach. Clancy added that while the report focuses on agricultural production, its emphasis on examining economic and social dimensions also applies to other food system elements.

Clancy shared a graphic of a food system (see Figure 2-2) that captures many of the components of such a system, including supply chains, social organizations, science and technology, the biophysical environment, and policies and markets. She explained that as food and food service flow through a supply chain, money and demand information move through it in the opposite direction. She emphasized that it is inaccurate and confusing to define a supply chain as a food system; rather, as Figure 2-2 illustrates, the supply chain is but one of the system's components. Furthermore, she pointed out that hundreds of thousands of food systems exist across the

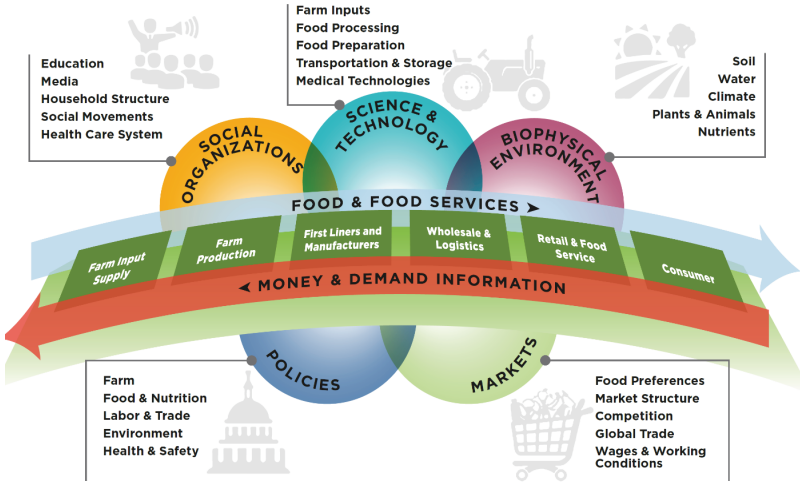

FIGURE 2-2 The components of a food system.
SOURCES: Presented by Kate Clancy on August 7, 2019, from IOM and NRC, 2015.

country and the globe, and context is needed to understand which food system is under discussion.

Clancy defined systems thinking as "a set of synergistic analytic skills used to improve the capability of identifying and understanding systems" (Arnold and Wade, 2015, p. 675). The value of a systems approach, she elaborated, is that it makes one consider a wide range of variables, such as people's values and internal and external barriers, involved in a problem. It is also useful, she continued, for acknowledging trade-offs and multiple potential solutions, anticipating unintended consequences, making predictions, and targeting intervention points. In particular, she observed that innovation is likely to result in trade-offs, and acknowledging them allows greater circumspection about the roots of problems and leverage points for solutions.

Clancy mentioned that the 2016 United Nations Environment Programme (UNEP) report *Food Systems and Natural Resources* uses the term "food systems approach" in its conceptual framework to describe the connections among variables and how they lead to outcomes related to multiple goals and possible synergies (UNEP, 2016). According to the report, this approach can be used to manage complexity, including dynamics, feedback loops, unpredictability, and other system qualities. However, Clancy added, the authors do not clearly apply elements of systems thinking in much of the report, nor do they discuss systems modeling or modeling tools, such

as causal loop diagramming, which she finds useful for visualizing systems issues.

Clancy then described in more detail the IOM and NRC framework that lays out four steps in carrying out a food system assessment. The first is to recognize the effects across the entire food system one is assessing. The second is to consider the health, environmental, social, and economic domains and the dimensions of quality, quantity, distribution, and resilience. The third is to account for system dynamics and complexity, including heterogeneity, interdependence, and adaptability. And the fourth is to choose appropriate methods for conducting the assessment. According to Clancy, systems thinking may be particularly useful for complex problems involving multiple actors for which solutions are not obvious. It can also be used to anticipate unintended consequences, make predictions, better target intervention points, and identify workable policies.

Examples of the Use of Systems Thinking

Clancy provided several recent examples of groups using systems approaches to explore complex food system issues with consideration of the economic, social, health, and environmental domains. In the first example, the World Economic Forum identified four core aspirations for the world's food systems: (1) adequate quantities of food, (2) economic and social inclusion for all, (3) minimal environmental damage, and (4) access to nutritious and healthy food. The group also outlined four potential future scenarios, noting that they could occur as soon as 2030: (1) unchecked consumption, (2) survival of the richest, (3) local is the new global, and (4) open-source sustainability (WEF, 2017). Clancy elaborated that these scenarios were framed with consideration of the uncertainties of shifts in food demand across the globe and connectivity among markets.

The second example cited by Clancy, from a paper titled "Feeding Prometheus," describes work by a multidisciplinary group at the University of Michigan, which referenced the Greek myth to make an argument about freeing the world from an unsustainable global food system (Vandermeer et al., 2018). As Clancy explained, these researchers argue that it is necessary to ask new questions and have a better analytic framework that includes agricultural ecology; equity; cultural dimensions; and the linkage between global public health and the type, quality, and availability of food.

In Clancy's third example, scholars, researchers, and practitioners from U.S. and Canadian universities and the U.S. Department of Agriculture's (USDA's) Agricultural Research Service applied resilience thinking to agriculture to identify strategies for reducing food system vulnerabilities. The strategies they agreed on were gender equity, agroecological approaches,

regional food systems, and the embedding of access to healthy and culturally relevant foods in production policies.

The final example of systems thinking Clancy referenced involved the Lancet Commission report *The Global Syndemic of Obesity, Undernutrition and Climate Change* (Swinburn et al., 2019). She noted that while the Commission was originally tasked with addressing obesity, it reframed the problem because many recommendations had already been proposed with what she termed "patchy progress" and little meaningful change. As Clancy explained, the Commission applied a systems perspective to its work and defined the major systems driving the syndemic of obesity, undernutrition, and climate change as food and agriculture, transportation, urban design, and land use. The report distinctly describes how complex, man-made adaptive systems interact with each other and the natural ecosystem at the micro, meso, and macro levels. It also delineates five crucial feedback loops to be addressed: business, health, supply and demand, ecology, and governance.

Clancy then provided examples of on-the-ground research using a systems approach, including W.K. Kellogg's Food and Fitness Initiative. This 9-year initiative involved experts in six areas of the country working to increase equitable access to locally grown food and safe places for physical activity for children through a focus on creating and changing local systems and policies that determine health. In addition to utilizing a systems thinking framework, the project entailed years of training for community partners in systems approaches and systems thinking, including their application in low-income communities.

The second on-the-ground research example Clancy highlighted was the Enhancing Food Security in the Northeast (EFSNE) project, for which she served as deputy director. This 7-year project analyzed the economic, social, and biophysical constraints on the expansion of regional food systems in the 12 Northeast states and the District of Columbia. It involved 11 institutions and nearly that many low-income urban and rural study sites. According to Clancy, the overall goal of the project was to begin to answer the question of whether the growth and strengthening of regional food systems can contribute to better food security across the region and in low-income areas while benefiting supply chain actors and other food system components. She explained that researchers from 17 disciplines worked on interdisciplinary teams and integrated systems elements into the work, including consideration of the environmental, social, cultural, economic, and health domains. She added that the research also took account of boundaries, scale, heterogeneity, adaptability, and resilience. Clancy reported that the team was able to develop baseline findings on supply chain capacity, as well as many other variables related to food access.

As a shorter-term example, Clancy described a 4-day summer institute for public health professionals on applying systems approaches to obesity

prevention, which she co-led. The result, she said, was the immediate successful application of systems principles by several of the students in their public health work.

Final Remarks

Clancy concluded by highlighting the complementarity between systems thinking and interdisciplinary research. She outlined the benefits of the latter as learning across fields, developing more creative ideas, building trust, improving communication, and setting boundaries. She also enumerated challenges to inter- and transdisciplinary research, which can include transaction costs, different paradigms, delays in publication time, and the need for specific skills and competencies.

In closing, Clancy emphasized that systems thinking can be very effective when applied to complex problems that involve helping multiple actors see the bigger picture; recurring problems; problems without obvious solutions; and assessments, interventions, policy, planning, and development. She asserted further that it also works in most types of institutions and with both cross-sectoral and cross-disciplinary issues. However, she lamented that systems thinking is still largely underrepresented in undergraduate and graduate curricula in food and agriculture across the country.

THE FUTURE OF THE FUTURE OF FOOD SYSTEMS

The next speaker, Roni Neff, Johns Hopkins University, continued the conversation and stage setting on systems thinking and food systems, focusing on "the future of the future of food systems."

Food Systems

Neff described the food system as encompassing food production, processing, and packaging; alternative forms of food production; food distribution; marketing and value chains; data and analytics; addressing waste; and food access and affordability. She noted that some of these issues would be addressed by other workshop speakers. She then outlined the breadth of the U.S. food system, stating that it encompasses 52 percent of U.S. land, 80 percent of consumptive water use, 16 percent of energy use, and nearly 20 percent of jobs (Bigelow and Borchers, 2017; Canning et al., 2017; BLS, 2019; Hellerstein et al., 2019; USDA/ERS, 2019). She added that, while the 13 percent of U.S. household expenditures currently spent on food is higher than the percentage in recent history, it is low in the broader historical context and less than in most other countries in the world. She observed further that, as the food system is globally interconnected, effects on the system in

one part of the world will have ramifications in the United States and vice versa, as well as effects outside of the food system.

According to Neff, the food system is at a "critical juncture," affected by climate change, food waste, food insecurity, chronic disease, and innovation. With respect to climate change, she stated, food production is a key contributor of greenhouse gas (GHG) emissions, noting that an intergovernmental panel has recommended that global GHG emissions decline beginning in 2020 (IPCC, 2018). Moreover, she observed, food production and distribution, the nutritional value of food, biodiversity, and the availability of water and other resources are also at risk from climate change. With respect to food waste, she continued, about 30 percent of the global food supply and 40 percent of the U.S. food supply is discarded. Regarding food insecurity, she reported that 821 million people globally are chronically hungry, including almost 12 percent of U.S. households, which experience food insecurity (FAO, 2011; FAO et al., 2019; USDA/ERS, 2019). Finally, regarding health and chronic disease, she pointed to poor diet as the number one risk factor for mortality in the United States (U.S. Burden of Disease Collaborators, 2018), largely because of its impact on chronic diseases.

Neff noted that innovations to be discussed during the workshop would address the issues she had just described, as well as others. Referencing the food systems framework Clancy had presented, she argued that innovations should attempt to solve problems in the domains of health, society, economy, and environment.

Neff next referenced the book *Meals to Come: A History of the Future of Food* and its discussion of the history of predictions about how food will change in the future (Belasco, 2006). She described Belasco's insight that while the most dire or innovative predictions get attention, most progress is incremental. Another key insight she cited is that future predictions say a great deal about the current state of anxieties, hopes, and assumptions. She then illustrated how the same predictions tend to recur. In the context of food security, for example, possible scenarios include (1) running out of food, (2) technology as the solution, or (3) sustaining ourselves by increasing equity. More broadly, in terms of how food will change in the future, Neff elaborated, three characterizations recur: (1) classical, with the future evolving from the past, getting bigger and better; (2) modernist, with unprecedented breakthroughs that value simplification, streamlining, and technology; and (3) recombinant, a combination of the two. According to Neff, the dominant view is recombinant, suggesting a future food system that offers choice, convenience, and small improvements on the current state that make it more modern. She also pointed out that framing matters: presenting an innovation as classical, evolving from tradition, can make it palatable, while framing it in modernist terms, perhaps as a "frankenfood," raises anxieties.

Neff then provided a few examples from Belasco (2006) and elsewhere of past predictions that turned out to be inaccurate and may even seem absurd today. In 1919, for example, an American geographer stated, "It is true that the farm tractor is on the way, but it has less prospect of displacing the work animal in food production than the automobile has of driving the workhorse off the road." As another example, in 1930 it was predicted that, in 2030, agriculture would cease to exist, as people would prefer tastier, synthetic foods. Another prediction, from later in the 20th century, was that food of the future would look like astronaut food. Neff also shared items from the cutting edge of futuristic/fantastical food development today, such as a robotic chef to cook and clean, pears grown in the shape of babies, edible paint, and 3-D printed burgers.

Innovation

To set the stage for the upcoming sessions on innovations, Neff cited the *Oxford English Dictionary*'s definition of innovation as "a new method, idea, or product" (Innovation, 2019). She differentiated this term from an invention, defined as something that did not previously exist, whereas innovation can be more gradual and sequential. She also defined the term "game-changer" as denoting purposeful innovations that could significantly change the food system and society. She clarified that most of the innovations being discussed at the workshop are purposeful but that natural events, such as climate change, will also have an impact on the food system.

Neff suggested that, while much attention and positive interest focus on innovation, "innovation isn't everything." She referred to a group of social scientists called "The Maintainers" who focus on maintenance, including infrastructure, its repair, and related labor and expertise, that sustains the world (Russell and Vinsel, 2017; The Maintainers, n.d.). She added that individuals in maintenance roles are often lower-income and female, and while those engaged in such day-to-day operations are often ignored, they may have the most important insights needed to build a well-functioning future food system.

Neff also emphasized that "technology isn't everything." She posited that changes to human behavior are among the most important shifts needed, and that such changes can be much more difficult to effect than changes in technology. According to Neff, people are complex and diverse and may be irrational with respect to where they place trust. She suggested that throughout the workshop, audience members consider potential implications for future food systems, including potential interactions among multiple innovations, and emphasized the importance of considering effects across the full food system and ways to address them in research, policy, and practice.

To encourage the audience to think in terms of systems impacts, Neff concluded with an example of a food system innovation from her work: "direct-from-frozen" seafood. She is focused on increasing consumption of seafood, which would both provide health benefits and require less energy, water, and feed to produce relative to consumption of terrestrial food animals. According to her team's prior research, 41–47 percent of the U.S. seafood supply is wasted, largely at the consumer level. Neff argued that preparing seafood directly from frozen without defrosting it first could lead to less waste on the part of retailers and consumers, and she described this research as being focused on assessing the feasibility and potential impacts of this innovative approach. As part of the project, she explained, the Drexel Food Lab in Philadelphia prepared and consumer-tested a set of recipes, in partnership with the World Wildlife Fund. Neff reported that while her team initially encountered resistance from consumers, consumers become more supportive of the concept when they learned that most "fresh" seafood was originally frozen. She asked audience members to suggest ideas for this direct-from-frozen innovation that could have implications for future food systems and beyond. In response, audience members pointed out that the innovation could make seafood more affordable, safer, and less perishable, although unintended consequences could include a need for more freezer space or electricity.

In her concluding remarks, Neff asserted that the innovations examined in the workshop would change the future food system, along with social systems and the economy. Therefore, she suggested that each innovation be examined with a broad food systems lens, considering the urgency of issues facing society and the innovation's potential impact, including its impact on issues of equity.

AUDIENCE DISCUSSION

Otten opened the audience discussion by asking Clancy and Neff for their suggestions for accelerating food systems thinking. While Clancy observed that interdisciplinary research can take many years, Neff pointed to the urgency of addressing issues affecting food systems. Clancy responded that more education in systems thinking is needed, including curricula at every level. She suggested that any academics working on food systems require their students to use systems methods and begin to do interdisciplinary work. Neff added that funding agencies could provide an incentive for work on food systems by making it a higher priority.

Christina Khoo, Ocean Spray Cranberries, Inc., asked Clancy what tools and methods were most important for her interdisciplinary work and what sectors are most underrepresented in food systems research. Clancy responded that several senior researchers were helpful in guiding the

process, and the team placed a great deal of emphasis on communication and trust building. They also created a glossary of terms to ensure that all individuals involved would use the same terminology and understand its meaning. Clancy added that she believes the economics profession is most underrepresented in food systems research.

Another audience member asked the speakers for their thoughts on the idea that it may be difficult to quantify outcomes when working with complex systems from different domains. Clancy agreed and expressed her hope that as people learn more about systems thinking, the use of qualitative analyses will see greater acceptance. Neff added that a great deal of work is being done in the food systems space to create indicators of progress.

Amy Brown, Natural Resources Defense Council, asked the panelists whether they agree that factors that are positive for one domain, such as health, environment, social, or economic, typically benefit other domains as well. Neff responded that this is not always the case, and trade-offs may be involved. As an example, she pointed out that if all food were highly processed, less would be wasted, but nutrition might suffer. She argued that identifying these trade-offs provides opportunities to work toward a more beneficial outcome in multiple domains.

3

Innovations in Food Production and Processing and Implications for Food Systems

Session 2 of the workshop, moderated by Helen Jensen, Iowa State University, was the first of several sessions focused on innovations and their implications for food systems. In this session, speakers described innovations in food production and processing. Jensen opened the session by highlighting a recent National Academies Consensus Study Report titled *Science Breakthroughs to Advance Food and Agricultural Research by 2030* (NASEM, 2019). The report identifies the types of science breakthroughs and innovations needed, where barriers to achieving those breakthroughs exist, where there are opportunities, and the trade-offs to be considered. Jensen pointed out that food systems are dynamic and suggested that they should reflect changes both in the market environment and in science and innovation.

FOOD SYSTEMS LINKAGES TO RURAL ECONOMIC DEVELOPMENT

Becca Jablonski, Colorado State University, spoke about the food system's linkages to rural economic development. She began by pointing out that there have been recent changes in consumer demand for products, including where they shop, how they buy food, and interest by urban stakeholders in value-based procurement for institutional buyers.

Leveraging Municipal Procurement

Citing data from Johns Hopkins University, Jablonski stated that as of 2016, there were more than 300 food policy councils in the United States

(Sussman and Bassarab, 2017; Johns Hopkins Center for a Livable Future, 2019). According to Jablonski, given that 80 percent of the U.S. population lives in urban areas, it should not be surprising that most municipal food plans are urban-focused and do not explicitly address linkages to rural areas.

Jablonski explained that many of these plans deal with food procurement issues, with the aim of leveraging the buying power of institutions. As an example, her home state of Colorado is working to leverage the buying power of the National School Lunch Program, a $13 billion program operating in more than 100,000 schools across the United States. Highlighting data from the National Farm to School Network (NFSN), she pointed out that most bills related to farm to school in 2017 or 2018 addressed local procurement (NFSN and CAFS, 2019).

Jablonski further used the Denver area as an example for considering the extent to which opportunities to leverage procurement can support linkages with an entire region, including advancing rural economic development and the profitability of farms and ranches. She noted that in 2017, Denver's mayor signed the Denver Food Vision, which included a "vibrant" pillar focused on economic development that contained "2030 Winnable Goals." One goal was that 25 percent of all food purchased by public institutions would come from Colorado. That goal prompted an examination of what Denver public institutions were purchasing and how much of it was Colorado grown or raised. Jablonski shared some initial data, but she noted that a more comprehensive analysis is currently under way.

Jablonski explained why strategies for food systems development need to include rural–urban linkages, pointing out that the farms and ranches that feed urban areas are usually located outside of metro areas. She used data from the 2017 Census of Agriculture showing that Denver County has only 12 farms, none grossing more than $100,000, to illustrate that Denver is unable to feed itself. She added that while she had used Colorado as an example, a similar situation exists in many other metro areas. She observed, for instance, that the majority of the farms and ranches that sell in the New York City farmers' markets are from rural areas outside of the metro area.

Implications for Farmers

Jablonski questioned the American Farmland Trust's statement that leveraging local procurement opportunities always means farmers and the community both win. Although farmers may "win" from selling foods through local markets as consumers are willing to pay a premium for their products (Low et al., 2015), she elaborated, producers selling through these markets have a different cost structure from that of farmers and ranchers

selling through traditional commodity markets. She again used Colorado as a case study illustrating the expenses and profitability of different local food market channels in that state, as well as the role of risk and farmers' preferences. Her takeaway was that profit margins vary significantly for farmers selling through local food channels. For example, she highlighted tremendous variation in profit margin between the top and bottom performers in farmers' markets and farm stands, whereas less variation is found for community-supported agriculture (CSA).

Using national data, Jablonski then reported that for farms and ranches selling through local food markets, labor expenses increase significantly as a percentage of total expenditures as gross income increases (Bauman et al., 2018). She suggested that a reason consumers are willing to pay more for local food is the opportunity to build relationships with farmers and ranchers and understand the story behind their food. Greater labor expenses result from the additional time required to build these relationships, combined with the need for producers to do their own marketing, processing, and distribution may make it hard to cut these labor costs.

Considering trade-offs, Jablonski observed that while using more labor could potentially reduce the profitability of farms and ranches, it might also support more jobs in rural places. Considering variation in profitability by sales class, she presented data showing that top performers with a strong return on assets exist even among small-scale producers (Bauman et al., 2018). With respect to variability by market channel, she pointed out that for farms using intermediated channels only, the return on assets for top performers is greater than that of those using direct-to-consumer channels only (Bauman et al., 2018).

According to Jablonski, the greatest benefits of urban agriculture may be to educate consumers about how food is grown and to provide a connection to the food, thereby encouraging its consumption, as urban farms are not always profitable. She cited data from a 2012 national survey of urban farms indicating that only 28 percent had a primary farmer earning a living from the farm, and only about the same number included economic motives in their mission (Dimitri et al., 2016).

Implications for the Community

Turning to the question of whether the community "wins," Jablonski referenced several studies examining the short-term economic effects of local food markets (Hughes et al., 2008; Swenson, 2010; Gunter and Thilmany, 2012; Deller, 2014; Hughes and Isengildina-Massa, 2015; Jablonski et al., 2016; Schmit et al., 2016), which show a small but positive effect. She cautioned, however, that given finite resources, every decision involves a trade-off on the supply or demand side. Regarding trade-offs on the supply

side, she observed that most arable land is already in use, and producing more of one commodity means reducing production of another.

Thoughts About Moving Forward

Going forward, Jablonski recommended that legislators consider the implications for farmers of bills focused on increasing local procurement. She cited those implications as including whether these new markets would increase price points, enable producers to scale up production, or create a market for seconds, and whether intended producers have in place the food safety processes and other infrastructure needed to respond to this market opportunity. She also suggested considering the long-term impacts of local procurement, including how farmers' markets may serve as business incubators, allowing farmers to generate new knowledge and business experience.

Jablonski also emphasized the importance of the interactions that take place between the farmers selling at farmers' markets and their customers, other farmers, and market managers. She cited a study finding that 75 percent of farms had made or intended to make changes to their business operations based on ideas they gleaned from these interactions, and 82 percent had shared these ideas in rural areas (Schmit et al., 2017).

Looking to the future, Jablonski recommended that urban food policy councils include the farmers and ranchers that produce, raise, and process the food. She concluded by highlighting some of the work she and her colleagues are doing in Colorado in an effort to facilitate meaningful engagement between stakeholders in Denver's food system and farmers and ranchers. As she explained, the Denver Sustainable Food Policy Council is considering a recommendation to the mayor that the city adopt the standards of the Good Food Purchasing Program, which include metrics associated with local economy, environmental sustainability, valued workforce, nutrition, and animal welfare. According to Jablonski, some are concerned that racial and gender equity is not pronounced enough in the framework, and that it does not fully consider differential impacts based on regional context.

Jablonski has been working in Colorado to bring producers of different scales and from diverse commodities together with urban stakeholders to consider how to ensure that the leveraging of procurement will meet the goals of both urban and rural stakeholders. She explained that she is collaborating with a broad range of partners on this initiative, including health advocacy organizations, commodity groups, and urban-focused organizations. Key questions, she said, include whether the new market opportunities will work for producers of different scales and communities, how various models may provide a competitive advantage for different producers, and whether the right infrastructure is in place. She closed by expressing her hopes that urban food policies can be leveraged to create

viable market opportunities that not just meet urban food goals but also support farmers, ranchers, and rural communities and economies.

URBAN FOOD SYSTEM INNOVATIONS: MULTISCALE MODELING AND ACTION ANALYSIS

In her presentation, Anu Ramaswami, Princeton University, took an interdisciplinary approach to food systems. Speaking about urban food systems modeling, she focused on four key topics: (1) an interdisciplinary framework, (2) the new urban agriculture lever, (3) innovations and trade-offs within urban systems, and (4) partnering with cities and policy makers.

Background and Interdisciplinary Framework

Ramaswami described her participation in the Sustainable Healthy Cities Network, a multidisciplinary group of researchers focused on food systems, among a broad range of issues, across multiple sectors within a city, such as buildings, energy, food, green infrastructure, transportation, water, and waste, and their interactions. She explained that the group uses the social–ecological–infrastructural urban systems framework, which incorporates demands within a city and transboundary flows whereby issues produce effects outside the city borders (Ramaswami et al., 2012). While such issues as health, well-being, and equity have local effects, she stressed, they also have higher-level, transboundary impacts. The framework she presented (see Figure 3-1) depicts how changes in local infrastructure at the city level can have transboundary impacts on the environment, well-being, and climate change all the way up to the global level.

The New Urban Agriculture Lever

Picking up on Jablonski's earlier presentation, Ramaswami noted that, given the interest in local production, a new urban agricultural lever has emerged. Globally, she stated, more than 500 cities have signed on to the Milan Urban Food Policy Pact, whose objections include increasing urban agriculture. She also echoed Jablonski's observation that many cities have food action plans with objectives addressing health, equity, economy, and other priorities. However, she continued, quantifying the benefits of local agriculture may be difficult because of such questions as what constitutes local, whether industries within a city's limits are also considered, and whether the demand is only for fresh products (e.g., a whole tomato) or also for products embodied in other products (e.g., tomato sauce).

Ramaswami explained that she and her colleagues assessed the current local production capacity of U.S. metropolitan areas and compared it with

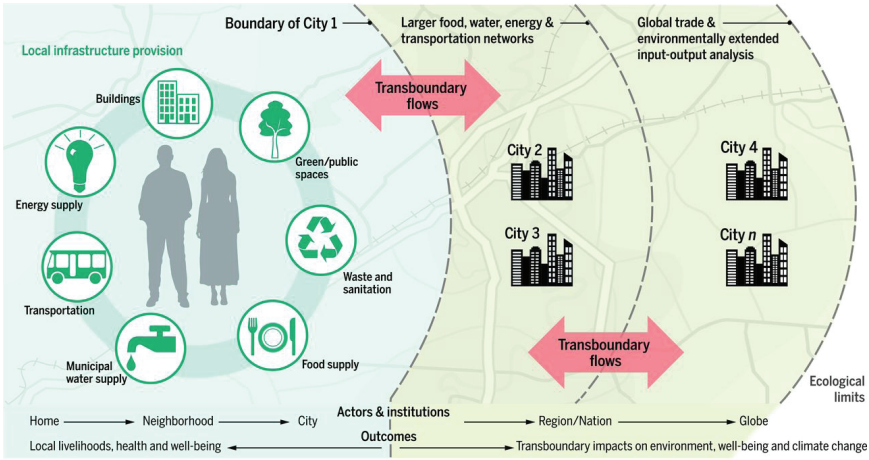

FIGURE 3-1 An interdisciplinary social–ecological–infrastructural urban systems framework depicting how changes in infrastructure at the city level can have transboundary impacts at higher levels.
SOURCES: Presented by Anu Ramaswami on August 7, 2019, from Ramaswami et al., 2016. Reprinted with permission from the American Association for the Advancement of Science.

expenditure data by food category to assess the extent to which local areas could be self-sufficient in their demand for various food products, even with today's spatial distribution of agricultural production. She noted that even in areas where there is currently significant local production, those products may not necessarily be used in local supply chains.

Ramaswami described how her research considered variations based on whether the analysis included only an immediate metro area or a broader geographic area of 100 miles. The researchers also considered variations based on whether the demand was only for fresh products or for both fresh and embodied foods. Using milk as an example, Ramaswami pointed out that the difference between demand for a fresh product (e.g., milk) and for its embodied form (e.g., cheese and yogurt) varies significantly—by nearly four times in the case of milk. She reported that according to her research, 21 percent of U.S. cities or urban areas could be self-sufficient today in their demand for embodied milk and eggs, with a slightly lower percentage for vegetables (16 percent) and fruits (12 percent) (Nixon and Ramaswami, 2018). With respect to fresh products, she continued, more than 60 percent of urban areas could be locally self-sufficient in their demand for fruits, vegetables, dairy, and eggs if supply chains enabled local supply–demand connections. She characterized this as

quite a remarkable finding, one that indicates much agriculture currently existing in and around urban areas.

Innovations and Trade-offs Within Urban Food Systems

Ramaswami next described innovations in modeling and sustainability analytics by presenting a transboundary environmental footprinting framework (see Figure 3-2) showing how food, water, and energy systems are interconnected both within the boundaries of a city and in transboundary supply chains. While there may be some production within a city, she explained cities typically cannot produce all the food, water, and energy needed for the homes, businesses, and industries within their borders. She emphasized the importance of the food system's interactions with the energy and water systems, as well as their impacts on the environment both within and outside the city.

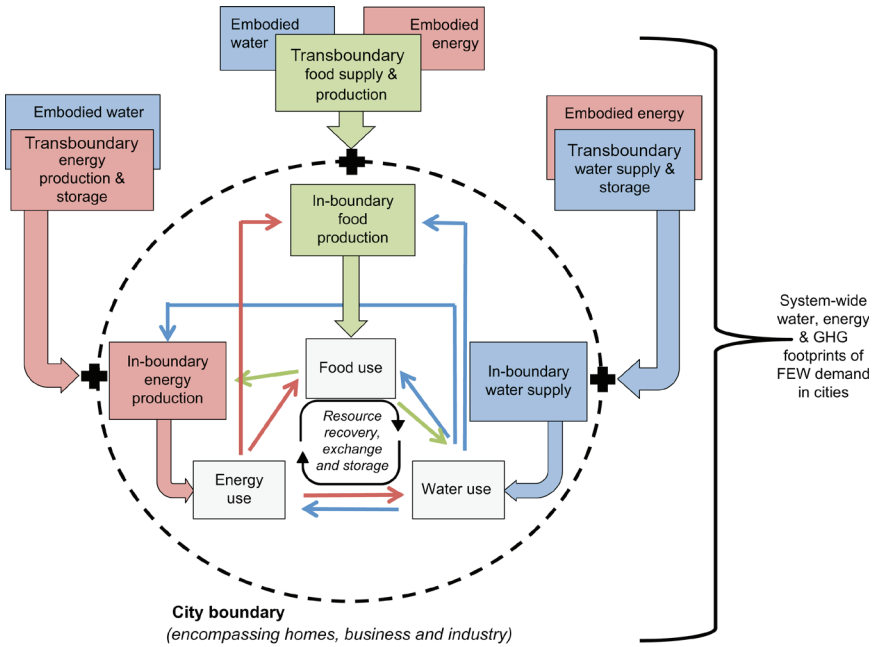

FIGURE 3-2 A transboundary footprinting framework depicting the interaction among community-wide water, energy, and greenhouse gas footprints of food–energy–water supply to cities.
NOTE: GHG = greenhouse gas.
SOURCES: Presented by Anu Ramaswami on August 7, 2019, modified from Ramaswami et al., 2017. Modified with permission from IOP Publishing.

Ramaswami next provided an example of how this framework was used to explore the interplay among food, water, and energy systems in Delhi, India, a large city of 16 million people with high rates of malnutrition and a shortage of clean water and energy. This example, she said, clearly illustrates that systems are multisector and transboundary, and that they depend largely on activities outside their borders. She added that the framework also allowed modeling of the impact of policy changes in addressing such issues as nutrition, urban agriculture, and greenhouse gas emissions, as well as identifying and prioritizing trade-offs (Boyer and Ramaswami, 2017).

Innovations in Food Actions

Ramaswami closed by describing some innovative food actions within the United States. One example she cited was Minneapolis's launching of a Food Action Plan being developed through an 18-month community engagement process, with the goal of creating a roadmap for a more equitable, climate-resilient, and sustainable local food system. She stressed that within a city, the spatial design of urban farms is very important with respect to such issues as flood and heat island mitigation. She also highlighted opportunities to consider different types of gardening and their business case. Ramaswami and colleagues are developing a systems framework to help cities like Minneapolis prioritize their goals related to the spatial design of urban farms, whether those goals be local farming, diet and behavioral interventions, food-based management, or farm to school, for example.

BLOCKCHAIN AND IMPLICATIONS FOR THE FOOD SYSTEM

Dawn Jutla, Peer Ledger Inc., spoke about blockchain and its implications for the food system.

Definition and Overview

Jutla defined blockchain as "a set of computer science technologies, particularly from distributed data management, peer-to-peer networking, and cryptography, which enables us to, when put together, provide a digital encrypted set of transactions within a distributed shared ledger environment." As she explained, previously clearinghouses for such information retained transaction information, and multiple versions could exist at different party sites. Jutla described how blockchain uses both a single distributed ledger with identical copies for multiple parties that automatically update and cryptographic methods, providing consistent data and transparency and helping to guard against fraud and promote traceability through

the supply chain. However, she added, a shortcoming is that blockchain may be unable to distinguish between who has ownership of an item from who has custody.

Food Industry Benefits

Jutla believes that blockchain can bring important benefits to the food industry. For example, she explained that blockchain may be able to create new business models using "smart contracts" that embed the rules of buying and selling within the industry and trigger the rules based on events, potentially removing the need for an intermediary. She added that blockchain also allows for shared, consistent data, driving an increase in transparency. For example, Jutla's company worked with the Canadian food inspection agency to use blockchain to share license information with customers and supplies, protecting against the use of fake licenses.

Jutla then described cryptocurrency aspects of blockchain, such as Bitcoin, that could provide a new medium for financial transactions. Blockchain could allow one to record, clear, and settle in a single transaction, she elaborated, removing inefficiencies in the payment system. She predicted that this capability could be part of the "future of the future of food" if the appropriate financial market and regulatory environment were in place.

Jutla turned next to the Hyperledger project, launched in 2017, describing it as modular and as providing the infrastructure, framework, and tools for many private commission blockchains. She reported that the project has hundreds of millions of dollars in funding for research and development from large corporations. According to Jutla, there is a great difference between the consensus mechanisms used in public untrusted blockchains and the contract mechanisms and known players of private-commission blockchains. She pointed further to trade-offs in speed, stability, and finality between public blockchains such as Bitcoin and private blockchains used by companies. For example, she elaborated, public blockchains have poor speed and finality but high stability, whereas companies need private blockchains that have high speed and high security. According to Jutla, Hyperledger fabric uses the permission voting-based algorithm for reaching consensus, has moderate scalability, good speed, and good finality, meaning a transaction can be completed quickly, meeting the needs of industry.

With respect to food safety, Jutla explained that blockchain allows for tracing a contaminant and identifying all parties that have touched a product all within minutes, a process that could otherwise take days or weeks. This capability, she observed, allows companies to respond rapidly in the event of a health-related outbreak, including directly messaging all relevant parties. She added that rapid response could also help reduce food waste by quickly identifying the source of contamination, thus avoiding the need to

dispose of those items not implicated. Jutla acknowledged that at the same time, rapid tracing could potentially increase food waste by quickly identifying a large number of products containing the contaminated ingredient, but she noted that this is a trade-off that could potentially save lives and promote public health.

As an additional benefit, Jutla observed that blockchain can also support corporate social responsibility and risk management by allowing for permanent recording of a company's policies and practices related to the environment, treatment of livestock, or labor, for example, at each step in the supply chain. Additional documentation, including auditors' reports or certifications, can be permanently recorded as well.

Jutla stated further that blockchain can be used to provide information to consumers about where their food originated and how it was processed. To quickly obtain information about where a product came from, for example, a consumer could scan a "Quick Response" code. Jutla suggested that this functionality could be integrated into retailers' consumer apps. She added that the traceability and transparency aspects of blockchain could also benefit producers, who might be able to obtain a price premium by documenting their favorable policies and practices related to antibiotic use or sustainable production, for example.

Jutla noted further that because blockchain is immutable, it can provide quality assurance and increase trust in what a product contains and the manner in which it was produced, while also allowing for sharing of standardized data. She provided an example from the gold industry of the use of blockchain to authenticate the material, including where it came from and how it was processed. Similarly, she asserted, blockchain could be used to authenticate a food product through mechanisms such as DNA testing.

AUDIENCE DISCUSSION

Jablonski opened the discussion session by questioning the statement made by Jutla that producers would receive a price premium for providing additional traceability. In her work with field to market, for example, she found that verification at the farm level becomes part of the cost of doing business, and that producers do not necessarily receive a price premium for this additional effort. Jutla responded that she thinks it may take time for the marketplace to catch up, pointing to the many studies showing that consumers are willing to pay more for a better-quality product, as well as to experience with other products demonstrating price premiums for increased traceability. She suggested that more marketing may be needed to empower consumers with increased knowledge about the availability of such information.

Vivica Kraak, Virginia Tech, asked how the circular economy in urban areas may be involved in scaling up production. Ramaswami responded that she does not believe it is feasible to cycle all material and energy at an urban scale, emphasizing the importance of cross-scale. She noted that her team is conducting a comparison of food waste and value, and pointed as well to existing technologies that allow the creation of new plastics, for example, from sewage. Ramaswami also provided an example of "industrial symbiosis," which involves industry groups, such as those involved in food packaging, paper production, and food processing, working together to produce and cycle heat and other valuable resources. For example, she observed, the European Union is extracting heat from large refrigeration systems in grocery stores and from computer systems being cooled. She suggested that using "waste heat" in municipal energy systems is equivalent to using free resources.

4

Innovations in Alternative Food Production and Implications for Food Systems

The next session, moderated by Naomi Fukagawa, U.S. Department of Agriculture (USDA), explored innovations in alternative meat production and their implications for food systems.

HOW GAME CHANGING IS ALTERNATIVE FOOD PRODUCTION FOR THE ENTIRE FOOD SYSTEM?

Jan Dutkiewicz, Johns Hopkins University, focused on how production of meat alternatives may impact the food system. He began by highlighting interest in meat alternatives. For example, Burger King is rolling out the Impossible™ Burger nationwide, while Beyond Meat®, another company producing meat alternatives, had the single most successful initial public offering in 2019. At the same time, Dutkiewicz observed, organizations such as the Intergovernmental Panel on Climate Change (IPCC), the EAT-Lancet Commission, the World Wildlife Fund, and Greenpeace are increasingly recommending a more plant-based diet.

Conventional Meat Production in America

Dutkiewicz explained that the United States is generally a meat-eating nation in part because of the historical success of the American meat industry in providing cheap protein and embracing such technologies as refrigeration and long-range transport that allow centralized production to reach distant consumer markets. For example, he noted, the first industrial-scale slaughterhouses in Cincinnati and Chicago pioneered the disassembly

line model of animal production, which enabled low-skilled workers to efficiently convert animal bodies into salable cuts of meat. Overall, he said, the meat industry is like many other large industries in that it uses an economies-of-scale model aimed at selling cheap, standardized products to consumers.

Dutkiewicz told the audience that the U.S. meat industry processes nearly 10 billion animals per year, about 9 billion of which are chickens (NAMI, 2017). Chicken represents the largest share of total meat processed by weight, he elaborated, but beef and pork also make up a significant portion of the total (NAMI, 2017). He added that the average American consumer eats about 200–220 pounds of meat per year while paying less for that meat than is paid in any other country as a percentage of income. Overall, he reported, Americans spend just 6.4 percent of their income on food as the result of a system of "cheap food" production (Patel and Moore, 2017) with respect to both the end result and the inputs, such as labor.

Dutkiewicz explained that cheap food production creates a number of externalities, including those related to the environment, labor, and animal rights. Environmental concerns relate to land use, greenhouse gas (GHG) emissions associated with food animal production, and water use and contamination. With respect to labor, Dutkiewicz cited concerns regarding the conditions at poultry plants and the business practices of major meat processors that give them a monopsonic relationship with suppliers, meaning they can unduly influence prices for animals and disadvantage contracted farmers. In addition, he noted concerns regarding animal welfare, which have increasingly entered mainstream discussion.

The Emergence of Meat Alternatives

Dutkiewicz pointed out that historically, attempts to address the negative externalities of conventional meat production have targeted the values of individual consumers, including by calling on individual consumers to buy local or become vegetarian or vegan. However, he observed, the impact of such efforts has been limited, as 97–99 percent of American meat continues to come from conventional agriculture, and the percentage of the population that is vegetarian or vegan has remained at about 2–5 percent for the past decade or two.

In contrast with that approach, Dutkiewicz continued, a new wave of food entrepreneurs, innovators, and disrupters are working to address the externalities of conventional meat production by creating a product as analogous to meat as possible. The aim, he said, is to change the methods of production of what consumers are eating while changing the actual product ("meat") as little as possible. This approach, he explained, is based on the

theory that consumers make decisions based primarily on price, taste, and habit, with ethics serving as a less important factor.

Plant-Based Meat Alternatives

Dutkiewicz distinguished the new generation of plant-based (cellular) alternatives, such as the Impossible Burger and the Beyond Burger®, from traditional plant-based products by pointing out that producers of the latter products did not aim for taste parity with meat by targeting an audience that was already vegetarian or vegan or concerned about health. In contrast, the new products target consumers who like meat and are intended to compete with conventional meat on price, taste, and habit but with less of an ecological impact. According to Dutkiewicz, "Compared to a conventional beef burger, a [plant-based] Beyond Burger uses 99 percent less water, 93 percent less land, emits 90 percent fewer GHG emissions, and uses 46 percent less energy," statistics based on a University of Michigan life-cycle assessment (Heller and Keoleian, 2018). He characterized the alternative meat market as the fastest-growing segment of the U.S. food sector and noted that 70 percent of purchasers are not vegetarian or vegan.

Dutkiewicz pointed out that the products are mass-produced and narrowly target concerns regarding animal welfare and the ecological footprint of conventional meat production. The success of these highly processed products means that they do not need to also benefit food justice or public health for consumers to purchase them.

Dutkiewicz posited that the technology used in producing these meat alternatives could offer broader opportunities to shift away from monocrop agriculture if the nutritional and protein profiles of plants could be incorporated into alternatives. He sees opportunities for collaboration among small farmers that grow nonmonocrop products, food science, and public health in developing a broader range of nonmonocrop products that would move the United States away from a corporate food regime to a "food tech justice regime." He suggested this would involve, for example, cutting animal farms, slaughterhouses, large-scale processors, and fast food chains out of the food supply chain.

Cellular Agriculture

Dutkiewicz next provided a brief history and description of cellular agriculture. As he explained, the first hamburger grown from cow stem cells in a lab was created in 2013 at a cost of $332,000. Production costs have declined significantly to about $50 today, he reported, and products such as meatballs and chicken nuggets have been created that are indistinguishable in taste and even at the cellular level from the traditional products.

Dutkiewicz explained that the cellular agriculture process begins with a biopsy from an animal or animal model in a lab that is placed in a bioreactor and fed a growth medium. Inside the bioreactor, muscle or fat tissue grows, just as it would inside the body of an animal, and becomes edible.

Dutkiewicz characterized such lab-grown meat products as "disruptive," with taste and DNA indistinguishable from those of conventional meat products and a dramatically reduced ecological impact, including reduced energy use, GHG emissions, land use, water use, and a more efficient and shorter value chain. He noted that many of the major meat and pharmaceutical companies are already investing in the technology and that it offers the potential for increased jobs in the biotech field. He acknowledged, however, that issues related to production at scale; technology, including the cost and use of growth mediums; and the timeline for mass-market release and return on investment still need to be addressed. He added that most funding for cellular agriculture research has come from venture capital, meaning the intellectual property is being developed within private companies, and little information is available publicly.

Dutkiewicz concluded by pointing out that cellular agriculture technology is disruptive because it has the potential to create meat as a food product that is distinct from agriculture and offers major ecological benefits, but he noted that the impacts on labor and land use are unknown.

ALTERNATIVE FOOD PRODUCTION SYSTEMS: THE SCIENCE AND IMPLICATIONS

James Reecy, Iowa State University, spoke about the science and implications of in vitro meat, comparing and contrasting it with the conventional meat industry and the incremental innovation that has occurred within the meat industry. He also described the implications for climate, natural resources, cultural considerations, and nutrition and health.

In Vitro Cell Culture

As Reecy explained, animals comprise many single nucleated cells with the ability to replicate. The muscle that provides the taste and mouthfeel of meat is formed when the myoblasts fuse together. Reecy reiterated Dutkiewicz's explanation that lab-grown meat is created when muscle fiber cells are placed in a bioreactor external to the animal and used to produce meat; animals still have to be used as the source of these cells, but many fewer animals are harmed than with conventional animal agriculture. Based on several assumptions, he estimated that as few as 14 head of cattle per year could produce the same amount of meat as 39 million head through conventional agriculture.

He added that one cell can replicate only a finite number of times before it is necessary to start again with new cells, and that while the cells could be genetically modified to be capable of replicating an infinite number of times, this may not be socially acceptable.

While lab-grown meat currently costs about $50 per serving, Reecy believes it will eventually become cost-competitive with other protein sources. He suggested that finding the solution is a matter of simple engineering, although this engineering will need to involve a great deal of innovation. However, he acknowledged that challenges come with mass-producing lab-grown meat, including how to keep the meat sterile as it grows and ensure that bacteria do not grow along with it without using large amounts of antibiotics. He also echoed Dutkiewicz's concern that because most of the technology that has been developed in this area is proprietary, limited information about it is publicly available.

Comparison with the Meat Industry

Comparing lab-grown meat with traditional meat, Reecy observed that both industries have inputs and outputs. In the case of lab-grown meat, the bioreactor takes the place of the animal itself in growing the muscle cells. With traditional animal agriculture, inputs include grass, roughages or concentrates, minerals, and vitamins, and outputs include meat, manure, and numerous other products. Reecy noted that manure provides value as organic matter that can go back into the soil. With lab-grown meat, inputs include purified amino acids and glucose, and outputs include a waste product in liquid form, that is, spent cell culture media, in addition to the meat. Reecy added that livestock production is a trillion-dollar industry in the United States, accounting for 5.6 percent of the nation's gross domestic product.

Improvements in Protein Production Over Time

According to Reecy, U.S. milk production has steadily increased since the 1950s, with the amount of milk produced nearly doubling and fewer than half as many cows being used (Capper et al., 2009). This is possible, he observed, because milk production per cow is nearly four times greater than was previously possible. The situation is similar for beef and poultry, he added. The amount of time needed to raise a poultry bird to be ready for sale is now less than one-third of the time required in the 1960s, and the animal is now twice as large.

With these increased efficiencies in production, Reecy acknowledged that carbon dioxide (CO_2) emissions per animal have increased as well; however, emissions per unit are only about one-third of what they were in

the 1960s (Capper et al., 2009). He explained that most of the increased efficiency can be attributed to changes in the genetics of the animals. In 2005, he elaborated, a process called "genomic selection" was initiated to leverage the genetic potential of the animal based on its genotype, resulting in more than a doubling of production efficiency over the prior process. In 2010, after the process had been revised again, production efficiency again doubled, and it continues to increase. Reecy suggested that to be competitive, the in vitro meat industry will have to increase its production efficiency on an ongoing basis.

Environmental, Cultural, and Nutritional Concerns

While in vitro meat would have less of an environmental impact than that of traditional agriculture, Reecy pointed out that the growth hormones used to get the cells to grow may raise concerns. He noted similar concerns arise with the growth hormones used to stimulate milk production in cows.

Reecy also explained that the nutritional profile of in vitro meat could be superior or inferior to traditional meat based on multiple factors, such as whether or not heme iron is present and the fat content of the meat.

In closing, Reecy highlighted that the livestock industry provides much more than meat, including leather and wool, and that moving to lab-grown meat would have implications for these other commercial products. He pointed out that these other industries would also have to undergo innovations if the animals were removed from production.

ALTERNATIVE FOOD PRODUCTION: CONSUMER CONCERNS

The final speaker of the session, Michael Hansen, Consumer Reports, addressed consumer concerns regarding alternative meat products. He defined several basic categories of such products: (1) traditional plant-based products; (2) "high-tech" versions of traditional plant-based products, such as the Beyond Burger; (3) plant-based products with genetically engineered inputs, such as the Impossible Burger, which is made with genetically engineered soy leghemoglobin containing heme iron; and (4) animal cell–cultured products. Hansen compared the ingredients, nutritional qualities, and climate impact of the Beyond Burger, the Impossible Burger, the Amy's Organic California Burger, and a ground beef burger. He also identified safety concerns with the Impossible Burger and provided information about cell-cultured meat, including the findings of a consumer study.

Comparison of Ingredients, Nutritional Characteristics, and Climate Impacts

Comparing the ingredients of the various burgers, Hansen noted that the Beyond Burger and the Impossible Burger have many highly processed ingredients, including protein isolates, and are not organic. He pointed out that research has linked consumption of highly processed foods to overeating and weight gain (Hall et al., 2019). He added that the ground beef burger has a small number of ingredients (primarily beef) and can be non–genetically modified or organic, while the Amy's Organic burger contains primarily organic vegetables and is less processed than the other plant-based burgers. More detail on the ingredients in each of the burgers is presented in Table 4-1.

With respect to nutritional quality, Hansen reported that the plant-based burgers have more sodium than the beef burger, and the Beyond Burger and Impossible Burger have similar levels of calories, fat, and saturated fat. The Amy's Organic burger is slightly healthier, he observed. A comparison of the nutritional characteristics of these burgers is presented in Table 4-2.

With respect to climate impacts, Hansen observed that the Beyond Burger and Impossible Burger are associated with about 90 percent fewer GHG emissions relative to conventional industrially produced meat. However, he pointed out that grass-fed, ecologically sustainable meat produced through regenerative agriculture can produce net negative GHG emissions, as shown by the case of ground beef produced by White Oak Pastures. With regenerative agriculture, he elaborated, soil is built up instead of being degraded, and carbon is deposited back into the system instead of being removed.

Potential Concerns with Impossible Burger Components

Hansen stated that the Impossible Burger contains genetically engineered soy leghemoglobin and 46 proteins from *Pichia pastoris* yeast, a combination termed "soy LegH Prep." He explained that, following several years of back and forth between Impossible Foods and the U.S. Food and Drug Administration (FDA), Impossible Foods received a "No Questions" letter from FDA in 2018 regarding the company's Generally Recognized As Safe (GRAS) Notice on soy LegH Prep for use as a flavoring and iron source in meat. In 2019, FDA approved soy LegH Prep as a color additive. However, Hansen questioned the safety of soy leghemoglobin and the yeast proteins, as they are new to the food supply. He pointed out that for the GRAS Notice, Impossible Foods conducted short-term 14- and 28-day feeding studies in rats to assess the systematic toxicology of soy leghemoglobin, and used the same data for its proposal to use soy leghemoglobin as a color additive.

TABLE 4-1 Comparison of the Ingredients in Various Plant-Based Burgers and a Beef Burger

Characteristic	Ground Beef 80% Lean (USDA 23573) 1 Patty (113 g)	Beyond Burger 1 Patty (113 g)	Impossible Burger 1 Patty (113 g)	Amy's Organic California Burger, Light in Sodium 1 Patty (71 g)
Ingredients	Beef	Water, pea protein isolate, expeller pressed canola oil, refined coconut oil, rice protein, natural flavors, cocoa butter, mung bean protein, methylcellulose, potato starch, apple extract, salt, potassium chloride, vinegar, lemon juice concentrate, sunflower lecithin, pomegranate fruit powder, beet juice extract (for color)	Water, soy protein concentrate,* coconut oil, sunflower oil, natural flavors,* 2% or less of: potato protein, methylcellulose, yeast extract,* cultured dextrose,* food starch modified, soy leghemoglobin,* salt, soy protein isolate,* vitamin E,* zinc gluconate, vitamin B1,* vitamin C,* niacin, vitamin B6,* vitamin B2,* vitamin B12*	Organic mushrooms, organic bulgur wheat, organic onions, organic celery, organic carrots, organic walnuts, organic wheat gluten, organic potatoes, organic high oleic safflower and/or sunflower oil, sea salt, organic garlic
No GMOs	Can be	Yes—non-GMO Project Verified	No	Yes—prohibited in USDA organic
USDA Organic	Can be	No	No	Yes

NOTE: GMO = genetically modified organism; USDA = U.S. Department of Agriculture.
*Potentially genetically engineered.
SOURCES: Presented by Michael Hansen on August 7, 2019, modified from Peachman, 2019.

Hansen explained that the 28-day feeding study, which was based on a small sample size of 10, found several statistically significant adverse effects. These effects included a decrease in body weight gain; changes in blood chemistry, such as a decreased reticulocyte count, which can be a sign of anemia or damage to bone marrow; decreased clotting ability; decreased

TABLE 4-2 Comparison of the Nutritional Characteristics of Various Plant-Based Burgers and a Beef Burger

Nutritional Characteristic	Ground Beef 80% Lean (USDA 23573) 1 Patty (113 g)	Beyond Burger 1 Patty (113 g)	Impossible Burger 1 Patty (113 g)	Amy's Organic California Burger, Light in Sodium 1 Patty (71 g)
Calories	306	250	240	150
Total Fat (g)	20	18	14	5
Sat Fat (g)	7.5	6	8	0.5
Cholesterol (mg)	100	0	0	0
Sodium (mg)	85	390	370	270
Potassium (mg)	345	300	610	240
Carbohydrates (g)	0	3	9	21
Fiber (g)	0	2	3	4
Protein (g)	29	20	19	6
Calcium (%DV)	2	8	15	2
Iron (%DV)	15	25	25	8

NOTE: USDA = U.S. Department of Agriculture.
SOURCES: Presented by Michael Hansen on August 7, 2019, modified from Peachman, 2019.

blood levels of alkaline phosphatase, which has been linked to malnutrition and celiac disease; increased blood albumin, which can result from acute infection or damage to tissues; an increase in potassium values and decreased blood glucose and chloride, which could indicate kidney problems; and increased globulin values (Fraser et al., 2018). These findings were explained as "minimal" change, "non-dose-dependent," "non-adverse," of "no toxicological relevance," and "within expected biological variation," findings with which Hansen disagrees. Given that there were statistically significant findings for a short-term study with a small sample size, he suggested that more longer-term studies are warranted.

Hansen also expressed concern that the heme B iron in the Impossible Burger could increase the risk of colorectal and other cancers linked to red meat consumption and heme B (Bastide et al., 2011; Ward et al., 2012). While heme B iron is found primarily in meat products, he added, it has not previously been extracted from its natural source, and the effects could be different. He suggested that safety standards should be higher when a substance is added to a food product instead of being naturally occurring in that product, as is the case with caffeine in coffee beans, for example.

Hansen also pointed out that 33 percent of the ingredients in the soy leghemoglobin product are the *Pichia pastoris* yeast proteins, which have been used to make food additives and drugs but have not previously been used in the human food supply. He also expressed concern about the dismissal of the feeding study results related to the yeast proteins.

In addition to further studies to explore changes in blood chemistry, gene expression (transcriptomics), and metabolic changes (metabolomics) associated with these products, Hansen suggested that research is needed to identify any long-term effects of their consumption, such as increased cancer risk and reproductive or developmental effects.

Animal Cell–Cultured Foods

Hansen also commented on animal cell–cultured foods, agreeing with Dutkiewicz and Reecy regarding potential concerns about safety, such as contamination, appropriate growth media, use of hormones, engineering, and the lack of transparency because much of the research to date has been proprietary. He provided an overview of the regulatory framework for cell-cultured foods, which was announced in 2018 in a joint statement from USDA and FDA. As he explained, FDA will oversee the cell collection, cell banks, cell growth, and differentiation; USDA and FDA will jointly oversee cell harvest; and USDA will have authority over the production and labeling of food products derived from cells of livestock and poultry. Hansen noted that regulations have not yet been issued, and unanswered questions remain, such as whether chemical inputs will be considered GRAS or will need to undergo the additive approval process.

Hansen concluded by sharing the results of a June 2018 survey of more than 1,000 consumers conducted by Consumer Reports on the best terminology to use for lab-grown meat. The top consumer choices were "lab-grown meat" and "artificial/synthetic meat." "Clean meat," "in vitro meat," and "cultured meat" were all less popular (Consumer Reports, 2018). According to Hansen, "clean meat" and "cell-cultured meat" were the industry's preferred terms.

AUDIENCE DISCUSSION

An audience member from USDA's Food Safety and Inspection Service commented that USDA and FDA held a series of public meetings in 2018 on meat alternatives. One key takeaway from these meetings was that stakeholders disagree regarding what cell-cultured meat products should be called, with traditional meat producers being opposed to use of the term "meat." This audience member also said that development of a regulatory scheme has been suspended until scientific and technological issues

associated with the production of these products have been resolved. She stated that she sees the alternative meat products as complements to rather than replacements for traditional meat, and suggested that with the world's population growing, innovation is welcome.

Another audience member expressed surprise that all of the presentations during a session on the topic of alternative food production were focused on meat alternatives, noting that there are also other types of alternative food production. She commented that she thinks the primary motive of meat innovators is profit rather than solving a health, social, or environmental problem. She also highlighted the need for social innovations in the food system. She cited a recent report on agroecology[1] and food system innovations from a panel of experts of the Committee on World Food Security, which found agroecology, which includes the regenerative agriculture Hansen had addressed, to be the most significant alternative to the U.S. industrial food system. She argued that regenerative agriculture has benefits for the economy, health, the environment, and culture, and that this type of innovation in the food system should be a higher priority.

Dutkiewicz responded, noting that producers of alternative meat products are not attempting to mitigate the animal welfare, environmental, and labor impacts of traditional meat production. He asserted that the production of meat alternatives has the potential to make obsolete aspects of the food system that are particularly exploitative of the environment, animals, and labor. In the U.S. free market system, he added, one of the best ways to effect systemic change is through the private sector.

A third audience member asked about the extent to which there should be increased emphasis on improving global livestock practices compared with the emphasis on innovative alternatives to meat or behavioral change. Reecy responded that improvements in livestock production have great future potential, but that cultural changes are needed to implement them globally. As an example, he observed that, in some developing countries, livestock is seen as a ready source of income that could be used to improve one's standard of living.

[1]Agroecology is defined by the U.S. Department of Agriculture (USDA) as follows: "Loosely defined, agroecology often incorporates ideas about a more environmentally and socially sensitive approach to agriculture, one that focuses not only on production, but also on the ecological sustainability of the productive system" (USDA/NAL, 2007).

5

Innovations in Food Distribution and Implications for Food Systems

Session 4, moderated by Helen Jensen, Iowa State University, focused on innovations in food distribution and their implications for food systems.

INNOVATIONS IN LOGISTICS

Michelle Miller, University of Wisconsin, led off the session by exploring current innovations in food transportation and logistics.

A Brief History of Food Distribution

Miller began with a quick overview of food distribution in the past 50 years. She stated that in the 1960s many small companies were involved in food distribution, but by the 1970s volatility in fuel prices had led distributors to seek efficiencies. Vertical integration of entire supply chains accelerated in the 1980s in what she described as an adaptive response to the increasing risk in the system as gas prices became more volatile. In the 1990s, she continued, big box stores further improved the efficiency of distribution and took market share from corner grocery stores; in the 2000s, consolidation in the food industry accelerated. According to Miller, consolidation trends reduced competition while disadvantaging regional food systems and creating unintended environmental disruptions. To illustrate this point, she referenced research documenting increased concentration of distribution that has crowded out mid-sized companies and suppressed

innovation (Howard, 2016). In the past decade, she observed, climate volatility has further disrupted the food production and distribution system.

System Characteristics and Food Flow

Miller referenced a 2015 Institute of Medicine and National Research Council report identifying the food system as a complex, adaptive, self-organizing system (IOM and NRC, 2015). In such a system, she explained, as certainty decreases, as with fuel and labor prices or climate change, agreement within the system must increase to keep it self-organizing (Parsons, 2007). She went on to say that complex systems may also be understood according to the system properties of diversity, flow, nonlinearity, and aggregation (Monostori and Ueda, 2006). Regional and local food systems are relatively unorganized, she added, while the predominant vertically integrated food system is organized. She suggested that as climate change leads to more uncertainty in the system, more agreement becomes necessary. In self-organizing systems, she explained, agreement results from democratic processes and governance, as well as through ownership of the system.

Miller continued by observing that farmers and markets moved away from regional crop diversity because of seasonal volatility, with most fruit and vegetable production migrating to the "fruitful rim" states of California, Florida, Georgia, Oregon, Texas, and Washington (Aguilar et al., 2015). The result, she explained, was a highly efficient production and distribution system with unintended environmental and social consequences. Miller pointed to ecological research identifying a need to optimize diversity and efficiency (Goerner et al., 2009). She pointed out that optimizing diversity in products and in supply chain ownership supports food system resiliency, but stressed the importance of balancing diversity with efficiency in distribution and logistics.

Regarding food flow, Miller referred to a 2016 study that found 123 nodes of distribution in the United States, 9 of which are critical to system function; of those 9, 3 are in the Midwest (Lin et al., 2014). She added that food warehousing is concentrated in the Chicago region, which can be considered the "epicenter for private food warehousing" in the United States.

According to Miller, smaller food distribution systems face unique challenges. She explained that last-mile distribution through public terminals is particularly important for regional supply chains and that small wholesale supply chains lack analytics, a capacity that is commonplace for large companies, such as Walmart. She observed that collaborating through public terminals can give small supply chains access to analytics.

Miller went on to point out that food supply chains are nonlinear, because systems must adjust for seasonal production, geographically based

routes (e.g., accounting for congestion and landscape features), and different segments of the supply chain where ownership and product custody change (Guerrero Campanur et al., 2018). In supply chains, she noted, agreement is reached through trust, communication, reduced risk, and vertical integration.

Logistics for Supply Chain Segments

As described by Miller, the logistics and opportunities to improve market access and food access are different for each segment of the supply chain. She outlined the key logistical segments as first mile (farm to processor or warehouse), over-the-road or regional (dependent on the distance to wholesale market), and last mile (within the destination city) (Pullman and Wu, 2012). Logistics involve monitoring and control of product movement through a system. Miller has documented concerns for food transportation in her research (Miller et al., 2016), which has shown that key factors shaping supply chains include who owns the product and pays for the distribution at each step along the supply chain, the amount and diversity of supply to be transported, and the distance of each segment.

For first mile, Miller continued, the distance from the farm to the aggregation point should be as short as possible. At that point, she noted, the product may be sold to a distributor, processor, or packer. If the farmer continues to own the product, she observed the farmer will continue to incur costs for moving the product along the supply chain.

With respect to the over-the-road and regional trip segments, Miller explained, the distance to wholesale market is the most important factor. While companies of all sizes are still involved, she pointed to a reduction in medium-sized businesses in transportation, farming, and retailing due to the concentration at all points in the system. Depending on whether the segment is over-the-road or regional, she added, efficiencies can be realized with tractor trailers. For instance, regional trip segments do not require use of a sleeper car and may use alternative fuels since the route is short enough to allow for refueling at home base.

Miller identified supply of the product as another key factor in supply chain efficiency. Efficiency, she explained, requires enough of a single product to fill at least a single pallet and enough pallets to fill a truck. At the same time, she observed, diversity of products is important to meet consumer demand and serve wholesale buyers.

Turning to last-mile distribution, Miller stated that the focus is on distribution within a market area, such as a city. She pointed out that small farmers who choose to drive their own product into the city for direct or wholesale distribution need to consider the distance traveled to be fuel efficient. Also important, she said, are access to short-term cold storage

warehousing and appropriate truck size to navigate congestion and city streets. She noted that which party pays for the last-mile distribution varies and may be the consumer, wholesaler, retailer, or farmer.

Miller stressed that challenges with last-mile distribution have made it difficult for small businesses to compete, although there has been a movement toward solutions that allow them to remain in business. For example, she said, e-commerce with a single point of pickup, such as a buying club or grocery store, is increasing in popularity. She noted that public food terminals that sell to business wholesale were much more common until many closed in the 1990s and 2000s. She pointed out that public food terminals can be key components of last-mile distribution, especially for small businesses that serve unique populations with specific food preferences, such as natural foods and foods commonly consumed by people of particular ethnicities.

Sustainability as an Emergent Property

Miller referenced the book *The Great Mindshift*, which offers a conceptual framework whereby ecological, organizational, and technological responses are all important to consider (Göpel, 2016). She emphasized that "all wealth lies with the land," and that environmentally sound and socially acceptable agriculture builds on that idea, creating economic viability. She suggested redefining sustainability as an emergent property whereby operating within environmental limits makes it possible to create community and support health and well-being with a robust economy.

Miller identified several barriers to innovation in the food system, which may include scale disconnect, ownership issues, a lack of equitably shared risk and reward through a supply chain, and asymmetrical access to information and technology. Looking to the future, she envisions system redesign to improve access to regional markets and foods while reducing waste, energy consumption, and greenhouse gas (GHG) emissions. Returning to regional supply chains, she argued, has the potential to create resilience. She pointed to the increased interest in public food terminals that meet public and private goals as one organizational solution when combined with improved rural broadband, potentially opening the door for small businesses to use open-source technology with compatible platforms and other technological innovations to reduce uncertainty in the supply chain and improve information flow. Such technological innovations, she explained, might include machine learning, distributed ledgers (discussed in an earlier session), multitenant applications (applications on a single server that are used by different customers), digital twins (which allow virtual observation and forward planning), and engine and vehicle innovations such as the use of telematics and hybrid electric or renewable energy.

Miller then described how CR England, the largest cold chain distributor in the United States, developed, first with the assistance of public terminals and then with its own distribution centers. She explained that the company has won numerous awards and recognition of its efforts to improve efficiencies by separating the over-the-road and last-mile segments. She added that the company has been able to adopt technology to reduce fuel costs and improve labor conditions. Moreover, drivers are paid differently for the two segments: over-the-road drivers are paid as most drivers are (by the mile), while those navigating the last mile and its variable congestion challenges and dock conditions are paid an hourly rate. As another example, Miller cited the Ontario Food Terminal, which supports small- to medium-sized farmers, truckers, and wholesale buyers so they can make a profit in a regional market.

Final Remarks

Miller concluded with suggestions for systemic changes to improve food access. These suggestions included recognizing that food should be a right and not a privilege, increasing both physical and economic access to food, increasing the flow of food through the supply chain before establishing grocery sites, establishing food terminals as a public utility, and promoting logistics in the public interest through increased funding for federal data collection and analysis.

INNOVATIONS IN FOOD PACKAGING

The second speaker of the session, Claire Sand, Packaging Technology and Research, LLC, spoke about innovations in food packaging. She began by acknowledging that packaging will always have an impact on the environment, but asserted that it can be made more sustainable. She identified as one such opportunity improving the collection and sorting of recyclable packaging, such as polyethylene terephthalate (PET) plastic water bottles, noting that only 15–35 percent of recyclable PET water bottles in the United States are actually recycled.

Sand cited two main types of innovation in food packaging: design innovation and science innovation. She noted that food waste has been at approximately 30 percent for the past several decades, and suggested that there are opportunities to improve sustainability and reduce waste throughout the supply chain. A focus on the circular economy also fuels a desire for more sustainable food packaging, she added.

Sand explained how food packaging has multiple purposes, including making food affordable, convenient, and more sustainable; preserving the moisture content; and ensuring food safety. She then outlined several food

packaging innovations. One such innovation is responsive packaging, which can identify and respond to a change in pH in the product. Other types of innovative packaging improve water barriers, incorporate edible microbials such as cinnamon (see below), and use in-store modified atmosphere packaging that can reduce food waste and the resulting economic impact.

Design Innovation

Sand identified three opportunities for design innovation: (1) recycle-ready packaging, made of chemically recyclable polymers; (2) single-component materials; (3) and redefined packaging.

According to Sand, recycle-ready packaging, which denotes packaging that can be recycled using existing systems, can be created using a variety of different methods and products, including polyethylenes. She used chemical recycling—whereby a product can be broken down to the monomer level in PET, for example—to illustrate the potential of this type of packaging innovation, suggesting that further innovation could help make this sort of recycling more economical.

As an example of a single-component material, Sand cited a high-density polyethylene milk jug that provides a barrier using nanoparticles of high-density polyethylene. She argued that more research and innovation are needed in this area as well.

Finally, Sand gave an example of redefined packaging: interior packaging that is recyclable but provides for a shorter shelf life, contained within a large outer paper package to be opened at a restaurant or food store. She noted that this form of packaging is already being used in the meat industry and could easily be used for other products as well, such as chips. She suggested that the concept could be expanded by making the packaging more sustainable and returnable into the system.

Science Innovation

Sand described two types of science innovation: active packaging and intelligent packaging. Active packaging, Sand explained, fulfills a function, such as moisture and odor containment or reduction of bacterial growth. One type of active packaging absorbs oxygen, which negatively affects food, and emits CO_2. Another example is use of edible antimicrobials, such as cinnamon, in packaging to reduce microbial growth and increase product shelf life.

Turning to intelligent packaging, Sand explained that it may have time, temperature, microbial, or oxidation indicators that provide information to consumers about how fresh a product is or by when they need to consume it for it to be safe. The indicator may be activated when the package is opened,

providing information on when it will go bad. To illustrate, Sand cited the time–temperature indicator, which uses information about both time and temperature to determine how much longer a product will be safe to eat. The amount of time remaining adjusts according to the temperature at which the product is stored (e.g., in the refrigerator or outside on a hot day). According to Sand, one use of the time–temperature indicator could be to determine whether a product was properly chilled throughout the supply chain, offering customers more confidence in the safety of their food. A microbial indicator, Sand continued, measures the change in CO_2 in a product, which is a sign of a reaction within meat products or the amount of volatile gases, which impacts the product's pH level. And another type of indicator measures the presence of bacteria. Sand noted that all of these types of indicators are already on the market, and that many have existed for several decades.

Sustainable Packaging

Sand explained that her company recently completed a large study on sustainability, food waste, and food packaging. The study found that, with the exception of water, the impact on the environment of food waste is much greater than that of food packaging, and noted that this is the case whether one is considering GHG emissions, water use, or other metrics. She suggested that increased focus is needed on how food packaging can be better used to reduce food waste.

Collection and Sorting

Sand next emphasized the importance of investment in the collection and sorting of recyclable products including the collection of products in such places as oceans, landfills, and city trash cans and removal of nonrecyclable items from recycling bins if the circular economy is to be effective. She added that such organizations as the Sustainable Packaging Coalition have undertaken consumer-directed communication initiatives designed to educate consumers on how to recycle properly. She also acknowledged that much of the plastic and packaging in the world's oceans originates outside the United States, particularly in developing countries. She concluded by asserting that while much more work remains to be done, innovation in food packaging is moving in the right direction.

CONSIDERATIONS FOR THE USE OF AUTONOMOUS VEHICLES AND DRONES IN SUSTAINABLE FOOD DISTRIBUTION

The final speaker of the session, Brent Heard, University of Michigan, spoke about the sustainability implications of the use of connected autonomous

(self-driving) vehicles and unmanned aerial vehicles (drones) in food distribution. He began by stating that self-driving vehicles and drones have the potential to either improve or impede the sustainability of the food system, depending on how they are used and the conditions surrounding their adoption. He cited two motivations for addressing the use of self-driving vehicles and drones within the food system: that the current food system is unsustainable, contributing 19–29 percent of anthropogenic GHG emissions, and that nearly 12 percent of U.S. households are food insecure.

Heard defined sustainability as encompassing environmental, economic, and social impact. He expects that the food distribution industry will be an early adopter of self-driving vehicles and drones because of their ability to deliver perishable food quickly; help reduce food losses by decreasing food distribution and storage times; increase capacity through the potential for 24/7 service; and lower marginal costs through fuel savings, improved logistic efficiencies, and reduced driver wages. Heard argued for use of a system sustainability approach to consider the impact of the technologies, an approach that involves assessing how they may affect or be affected by consumer behavior and public policies in addition to their direct environmental, economic, and social implications.

Preretail Food Distribution

Heard presented a visual depiction of the food supply chain, which shows food moving from agricultural production to the regional distribution center, to preretail distribution, to grocery store retailing, and finally to last-mile transportation, which often involves a consumer traveling to and from the store. He expects that autonomous trucks could replace long-haul trucking in preretail food distribution and that both drones and self-driving vehicles could be used in the last mile of the supply chain to deliver food to the customer. He suggested that connected and autonomous vehicles, which both communicate with other similar vehicles and with cooperative communication technologies and drive themselves without the need for a driver being present, could provide efficiency and environmental improvements by optimizing routing, speed changes, transport time, and other technical aspects of food transport and reducing road fatalities. He gave the example of platooning, in which a series of vehicles closely follow each other to reduce aerodynamic drag, which could reduce the energy use of heavy trucks by 10–25 percent (Wadud et al., 2016). He also cited cooperative communications within a vehicle fleet, which could reduce CO_2 emissions by about 12 percent (Barth et al., 2014). He added that 71 percent of the total transportation emissions associated with the U.S. food supply come from preretail food distribution, typically involving trucks (Weber and Matthews, 2008).

Heard pointed out, however, that the environmental benefits of autonomous vehicles might not be realized in certain circumstances. For example, if autonomous vehicles traveled faster than conventional vehicles, or increased energy were needed to facilitate their communication and self-driving capabilities, fuel consumption could increase. Heard noted, though, that experts consider these situations unlikely. He also emphasized that while optimized logistics in the preretail supply chain could reduce the time food is in refrigerated storage, thereby reducing emissions and food loss, the energy and water needed for the data communication centers required for these vehicles should also be considered. In addition, he observed that if autonomous vehicles replaced rail or inland water transportation with lower carbon or energy intensity than that of traditional trucking, emissions could increase. An emissions rebound effect could also occur, he added, whereby the reduction in emissions due to behavior change would result in an increase in trip lengths or numbers of trips, reducing the lowering of emissions that could otherwise be expected. Heard cited one study that estimated a rebound effect of about 30 percent after fuel efficiencies were realized for U.S. tractor trailers (Leard et al., 2015), meaning that 30 percent of the fuel efficiencies were offset by an increase in distance traveled. He noted further that, according to a UK study, the rebound effect may vary widely, from 21 percent to more than 137 percent (Sorrell and Stapleton, 2018), adding that rebound values of more than 100 percent reflect an increase in emissions due to increased vehicle miles, eclipsing any efficiency gains.

Heard also described the potential economic and social sustainability implications of the use of autonomous vehicles. One potential benefit he cited is a reduction in road fatalities due to human error while driving. He highlighted the importance of this benefit by reporting that there were nearly 5,000 deaths from crashes involving large trucks in the United States in 2017, and overall, fatalities from such crashes increased 12 percent over a recent 10-year period (NCSA, 2019). Heard also expects that distribution companies adopting autonomous vehicle technology are likely to see increased profits due to efficiency savings, the potential for increased sales volume, and reduced costs of driver wages, noting that, for example, 36 percent of truck operating costs currently are attributable to driver wages (Grenzeback et al., 2013), costs that could be displaced by self-driving vehicles. At the same time, Heard acknowledged that an adverse effect of the reduction in drivers could be an increase in unemployment, not only for truck drivers, but also for related businesses, such as food and lodging stops along the highway. He pointed out that the U.S. tractor trailer driving industry for food distribution employs more than 63,000 people (BLS, 2018), and that while new jobs would likely be created in their place, such as in food distribution or warehousing, they would potentially require different skills, necessitating retraining for displaced workers.

Last-Mile Food Distribution

For last-mile food distribution, bringing food to the ultimate consumer, Heard observed that drones have become advanced enough to be able to find and scan a barcode on a package and know where to deliver it. He then described the environmental impact of delivery using drones—battery-powered unmanned aerial vehicles that may be either remotely or self-piloted—in comparison with truck delivery. Research has found, he observed, that the impact varies based on the size of the package being delivered and the size of the drone.

Heard referenced a study that tested delivery of a half-kilogram package using a small drone and delivery of an 8-kilogram package using a large drone, modeling the impact of warehouse placement and operation to support drone delivery (Stolaroff et al., 2018). The study found lower GHG emissions for the small drone than for truck delivery with the small package. For the large drone, there was a 9 percent reduction in emissions when the drone was charged with low-carbon electricity, but a 24 percent increase when it was charged using the average U.S. electricity grid (Stolaroff et al., 2018). Heard noted, however, that use of either type of drone resulted in lower emissions relative to use of a personal vehicle to make a round trip to the store. He pointed out that a large drone similar to the one examined in this study is the type that would likely be used for food delivery, given its typical size and weight.

Heard believes that drone delivery will likely raise profit, employment, and crash considerations similar to those raised by autonomous vehicles. He added that flights in neighborhoods may also entail additional zoning and urban planning considerations, as more warehouses will be needed to support drones' relatively shorter delivery range. For example, he reported that the delivery range of tested drones in the above study was about 4 kilometers, requiring 112 warehouses to support an area the size of metropolitan San Francisco (Stolaroff et al., 2018). Heard observed further that, as package delivery by drones is likely to occur in urban areas, locations for new warehouses will be particularly challenging to obtain. He explained, moreover, that the regulatory scheme for drone flight is still being established; package delivery by drones is currently approved by the U.S. Federal Aviation Administration (FAA) on a pilot basis. He pointed out further that drones also have social acceptability issues, including the noise they produce and their military associations.

Heard went on to say that use of self-driving vehicles for the last mile of the supply chain is likely to have efficiency, crash, and employment impacts similar to those of the drones, including the possibility of an emissions rebound effect resulting from increased consumer purchasing. At the same time, however, they also have the potential to facilitate e-commerce

and stimulate increased home delivery of groceries, which Heard stated would reduce such burdens on grocery retailing as food loss resulting from overstocking and the need for refrigeration, while increasing options for healthy foods in places with limited access to such foods. He cited a study indicating that use of home delivery in place of round trips to a store could result in a reduction in emissions of 18 to 87 percent (Siikavirta et al., 2003), depending on the delivery mode. He pointed out, however, that if changes in delivery mode led to increased consumption of foods produced using high GHG emissions, adverse environmental and health effects could result. In response to a question from an audience member, he added that the extent of any gains would also depend on whether the drone or autonomous vehicle were delivering food to a single customer on demand or to a centralized location at a predetermined time.

Final Remarks

Heard concluded by highlighting that transportation is responsible for only approximately 11 percent of an average U.S. household's diet-related GHG footprint, including all the emissions associated with food production, distribution, storage, consumption, and end of life (Weber and Matthews, 2008). In contrast, food production is responsible for about 83 percent of emissions. Therefore, Heard argued, changes in the type of food produced have greater environmental impacts than those due to mode of transportation.

In summary, Heard stated that while self-driving vehicles and drones could improve sustainability if used under the right conditions, these benefits may not necessarily be achieved without decarbonizing the electricity grid and limiting rebound effects. Additionally, he observed that potential emissions reductions resulting from e-commerce and home delivery are available without the use of new technology. Finally, he stressed that economic and social sustainability implications of self-driving vehicles and drones, including employment and zoning considerations and warehousing needs, must also be addressed.

AUDIENCE DISCUSSION

Jensen opened the audience discussion by asking Miller and Sand about barriers in food systems logistics and food packaging. Miller responded that one of the key barriers for organizational and technological innovations is scale, in that large, vertically integrated supply chains suppress innovation. She added that reaching agreement, making decisions, and sharing the risks and reward of innovations across complex supply chains are further challenges.

In response to a question from Lindsay Smith, Metropolitan Washington Council of Governments, Miller also highlighted the importance of the data analytics of large supply chains. She pointed out that smaller supply chains do not have the same information, and suggested that the government could play a role in providing access to data useful for both managing logistics and responding to emergency food situations. She gave the example of a disruptive weather event in which it would be helpful to know where food supplies are located, information that currently is proprietary and would require the purchase of expensive datasets.

An audience member asked Heard about the potential implications for social isolation in a society filled with self-driving vehicles and drones that would reduce the need for social interaction. Heard responded that existing research demonstrates the adverse health effects of social isolation and that technology may play a role in separating people from each other. Sand added that it may be possible to have increased remote interaction.

6

Innovations in Food Marketing and Food Value Chains and Implications for Food Systems

Session 5 moderator Christina Khoo, Ocean Spray Cranberries, Inc., opened the session by explaining that it would explore additional topics in food flow, including water and land use, contracting in the supply chain, and food labeling and marketing.

WATER AND LAND USE: CONSIDERATIONS FOR THE FEASIBILITY OF VALUE CHAINS AND THE FOOD SYSTEM

Christian Peters, Tufts University, spoke about land and water as fundamental natural resources for supporting food systems, why they are important for food system sustainability, and how transdisciplinary science can impact assessment of the feasibility and sustainability of supply chains. He pointed out that in the United States, most land is privately owned, and water is used for private benefit, yet land and water are essential public goods.

Historical Context

Peters began his presentation by providing context on changes in land use, the development of irrigation, and increased agricultural efficiency. He showed a series of maps displaying the geographic shift in total U.S. cropland from the 1860s to the late 1990s, with farms being located continually farther west as the country developed until they became concentrated in the central United States by the mid-20th century. He added that the United States transitioned many decades ago from being a country of expanding

farmland to one that works within its existing footprint, and given that the most suitable land is already used for agriculture, innovations have focused on ways to grow more food by increasing the productivity of that land. Referencing the index for total factor productivity, which calculates the return on all agricultural inputs, including land, labor, and other inputs such as fertilizer, Peters stated that worldwide, increased food production is due primarily to increased productivity of land and more efficient use of water, as has been the case in the United States since 1948.

Peters explained further that irrigation has been a key contributing factor to the increase in output per unit of land. He pointed out that irrigation increased significantly from 1890 through most of the 20th century until it leveled off about 20 years ago. He suggested that water is another resource for which innovation needs to focus on more efficient use.

Peters then provided the example of the increase in the total factor productivity for corn. As he explained, crop yields for corn increased from about 20 bushels per acre in 1900 to about 140 bushels per acre in the late 1990s. Innovations that drove this increase in productivity included the development of a light tractor, corn hybrids, use of fertilizers and herbicides, and biotechnology (Fernandez-Cornejo, 2004).

Peters went on to say that there is now an expanded range of concerns related to land and water use that include (1) production efficiency, (2) ecological impact and sustainability, and (3) health impacts. Referencing Welch and Graham (2000), he noted that the production paradigm of increasing output and the efficiency of its production was predominant during most of the 20th century (Welch and Graham, 2000). He added that the sustainability paradigm focuses on mitigating ecological impacts, while the food systems paradigm emphasizes human health, as well as other social and community impacts. These concerns, he stressed, are all additive.

Innovation of the Transdisciplinary Study of Food Systems

Peters next spoke about the innovation of the transdisciplinary study of food systems as a way to understand the sustainability of natural resources such as food and water. He distinguished transdisciplinary research from multidisciplinary or interdisciplinary research by explaining that transdisciplinary research involves partners from multiple disciplines (including academia and elsewhere) working together to address a common question, problem, or solution (Kajikawa, 2008) that provides the impetus for collaboration and the organizing of the work. In contrast, multidisciplinary research involves multiple fields that work in parallel but are not integrated. And interdisciplinary research involves interaction at the interfaces between disciplines, but this interaction may not be focused on a central problem, question, or solution.

Case Study: The Eastern Broccoli Project

As an example of transdisciplinary research, Peters described the Eastern Broccoli Project, an initiative funded by the U.S. Department of Agriculture (USDA) and led by Cornell University, in which academia and industry partners are working to create a regional food network for broccoli as a model for other specialty crops. While 89–98 percent of fresh broccoli production in the United States currently takes place in the western United States, relying on irrigation, broccoli-growing areas that are part of the Eastern Broccoli Project range from Maine to Florida and many locations between, depending on the weather and the time of year. Peters added that moving fresh broccoli sourcing from the southern portion of the eastern United States to the northern states reduces the seasonality of broccoli production and creates a year-round supply in the eastern states.

Peters referenced a study that examined the potential cost savings from moving a portion of broccoli production to the eastern states, considering various increases in broccoli acreage, production costs, and transport costs. Overall, he reported, the study found that the savings in transport costs resulting from no longer needing to distribute broccoli from the West Coast to the East Coast more than compensated for a small increase in production costs (Atallah et al., 2014). Therefore, relocation of production to the East Coast could take place without an increase in costs to the consumer.

To implement this system, Peters explained, development and testing would be needed for broccoli varieties that grow well on the East Coast, as most of the existing varieties were developed for the climates of the Western United States. A sufficient supply of seeds for commercial production would also need to be created and commercial vegetable growers identified; needed as well would be a new or enhanced distribution system for the crop, retailer acceptance, and market pickup. According to Peters, plant breeders, agronomists, horticultural scientists, extension researchers, agricultural economists, and the broccoli industry are all working together in a transdisciplinary manner to effect these changes.

Challenges with Transdisciplinary Research

Peters concluded his presentation by pointing out that transdisciplinary research is often difficult. He highlighted five key challenges: (1) framing of a research question or problem that will motivate all players; (2) integration of methods across disciplines; (3) the time required for the research process and knowledge production; (4) the need to engage practitioners, who often have different needs and timelines from those of researchers; and (5) the fact that generating impact often requires multiple projects over a long period of time (Brandt et al., 2013).

With respect to funding, Peters pointed out that total investment in agricultural research and development has risen and fallen in the past 45 years, with a slight overall rising trend. In the past 10–20 years, he added, public funding has leveled off or decreased, while private-sector funding has increased. He asserted, however, that as public and private funds are used for different types of research, both types of funding are needed.

INNOVATIONS IN SUPPORT FOR CONTRACTING IN SUPPLY CHAINS

Jill McCluskey, Washington State University, spoke about innovations in support for contracting with universities and plant breeders in the initial stages of supply chains.

Development of New Plant Varieties

As McCluskey explained, universities can patent the intellectual property rights from the research they conduct, providing them with needed revenue for research and development in the face of declines in funding from other sources. She emphasized the importance of public research in the development and marketing of new crop varieties to support the long-term profitability of farmers. As consumer expectations for quality and variety increase, she added, there is a continual need to develop and market new and improve existing crop varieties. She pointed out that as new crop varieties need to be commercialized, her team is focused on how universities could commercialize them. She noted that different licensing schemes can have different impacts on producers in plant-breeding programs, and that the goal of universities is to maximize their own profits as well as the profits of their licensees.

McCluskey explained that Washington State University began an apple-breeding program in 1994, with the aim of providing new varieties that could command higher prices. In Washington State, she elaborated, apple growers pay assessments to the Washington Tree Fruit Research Commission, and the funds are used to support research.

Example: The Cosmic Crisp® Apple

McCluskey used the example of the Cosmic Crisp apple variety to explain the process of the development and commercialization of new plant varieties. As she explained, while this variety was developed in 1997, the product only became available in 2019, 22 years later. She observed that it often takes even longer than that for trees to mature and produce fruit.

Only Washington State growers will be allowed to grow the Cosmic Crisp variety, she added, and it is being commercialized by a private firm. She noted that when the Cosmic Crisp saplings first became available, growers' demand for 4 million trees outpaced the 300,000 available, so a lottery was held to distribute the first available trees, and that 13 million trees were planted within 3 years. While the first crop of 200,000 apples was expected to be available in 2019, supply is expected to grow exponentially over the next few years, up to 10.5 million in 2022. McCluskey expressed concern that the large volume of apples being produced has the potential to erode prices. She explained that whereas most agricultural research is focused on reducing costs, the Cosmic Crisp innovation is intended to increase demand, and therefore price.

Contracting and Licensing Schemes

McCluskey shared an economic model developed by her team that could be used to maximize profits for both innovators and licensees, consistent with a land-grant university's goals (Akhundjanov et al., 2020). Under this model, she said, each grower decides whether to pay for the license that allows use of a demand-enhancing innovation and what quantity of the product to produce, using both the old and new technology. Based on these data, the university then chooses the scheme that maximizes the weighted sum of its own and the licensees' profits, considering different pricing schemes, assumptions of consumer demand, and various weighting of the division of profits between the university and the growers. According to McCluskey, the licensing mechanism that maximizes the joint profits of the university and the growers depends on the number of growers and the innovation level. Her team found that a two-part tariff (a combination of a one-time, per-tree fee and a per-box royalty) maximizes joint profits when the level of innovation is high, as is the case with Cosmic Crisp, and a per-unit royalty does so when the innovation level is low.

To test their model, McCluskey and her team conducted a study with apple growers with an average of 23 years of experience in apple production and collectively 16 percent of all apple acreage in Washington. Participating growers were provided with information on various licensing options and asked to submit bids under each option. McCluskey explained that growers whose bids were at least as high as the randomly selected market price would be required to purchase the right to grow the variety. Participants were also asked to complete a survey in which they were presented with assumptions related to the production cost, price, and yield of a new apple variety, allowing them to calculate hypothetical profits. Depending on their bid, they could either gain or lose money (up to $10.00 out of a $20.00 participation stipend). McCluskey and colleagues calculated the willingness

to pay under different licensing schemes and found that growers' willingness to pay depended on the apple variety they currently grew. However, consistent with the researchers' theoretical modeling, overall, growers were willing to pay most under a two-part tariff.

Final Remarks

In conclusion, McCluskey emphasized that there are political and institutional limitations on licensing contracts involving a public university whose plant-breeding programs are focused on creating new varieties available to all growers statewide. She reported that, consistent with her team's research, the Cosmic Crisp has a two-part tariff, which includes a fee for trees and a per-box royalty.

MARKETING CHANNELS AND PRODUCTION CLAIMS/ CONSUMER BEHAVIOR RELATED TO FOOD LABELS

Brenna Ellison, University of Illinois at Urbana-Champaign, spoke about marketing channels and production claims and consumer behavior related to food labels.

Marketing Channels

Ellison began her presentation by describing the multiple channels through which food reaches consumers, ranging from direct (producer to consumer) to mediated (potentially involving agents, wholesalers, distributors, and retailers in between). She explained that direct marketing strategies, such as on-farm stores, community-supported agriculture (CSA) farms, and online sales, are commonly used by smaller producers for local distribution, allowing farmers to share their story and their values directly with consumers. She cited data showing that as farm size grows, the use of mediated channels does as well (Low et al., 2015).

In contrast to that trend, however, Ellison pointed out that large retailers are also increasingly eliminating intermediaries. To illustrate, she noted that Walmart is establishing its own beef supply chain, while Costco is adopting a similar strategy for rotisserie chicken. She added that, because mediated marketing channels can make it difficult for producers to communicate their story and values, many use labels to provide such information and signal their values to consumers.

Research on Food Labels

As Ellison explained, labels provide information about attributes of a product that cannot otherwise be easily seen or verified. For example, she elaborated, an animal welfare label may be used because it is not possible for the consumer in the grocery store to see how animals were treated on the farm. She added that the information on labels is particularly strong when it is verified by a trustworthy party and that nutrition labels may be viewed as a public surveillance system and an indication that the food supply is being monitored. Labels can also signal public values and allow consumers to vote with their dollars, she observed, and may be used by producers to differentiate their products from others in the marketplace.

At the same time, Ellison pointed out that there are many challenges associated with labels: most have multiple claims competing for attention; consumers may not understand the meaning of the claims or know which to trust; and many are conflicting or duplicative. As an example, she cited four chocolate bars with four different fair trade labels reflecting different fair trade components. She also shared the example of the front of a package of cheese with four different labels, with two of the labels stated more than once. She added that the back also repeats some of the same claims as those on the front and contains conflicting information related to the product's origin. Ellison noted as well that non–genetically modified organism (GMO) is a subset of organic, yet producers often pay to put both labels on the same product.

Ellison explained that research shows consumers are willing to pay more for a product with a specific attribute, such as being local or organic. Yet, she observed that while research often attempts to isolate the effect of a single label, this scenario does not reflect the consumer environment.

Ellison then presented findings from her research showing that consumers perceive the same product differently depending on where it is sold. For example, she pointed out that consumers have different perceptions of similar products sold in Walmart and Target, even though to use the organic label, they must meet the same standards, and in some cases, they may be the same product. Ellison's research also found that healthy products, such as produce carrying the organic label, are typically purchased based on perception of taste; however, less healthy products labeled as organic, such as cookies or ice cream, are perceived as more healthful than their nonorganic counterparts (Ellison et al., 2016). As a takeaway for producers from these findings, Ellison highlighted that the organic label will not be interpreted uniformly across products or retail settings, so it is important for them to consider trade-offs between differences in brand reputation and sales volume when deciding where to sell a product and the labels to put on it.

Ellison stated further that consumers have a different perception of the percent organic content of various products with an organic label. For example, respondents in her study estimated organic strawberries to be 85 percent organic, while organic cookies were estimated to be 62 percent organic, yet both products must meet the same 95 percent organic requirement to use the organic label (Ellison et al., 2016).

Ellison next presented the results of her research examining which livestock production claims matter most to consumers. This study involved a nationwide survey of more than 1,000 consumers to assess which of seven livestock production claims across four product types (beef, chicken, milk, and eggs) resonate most with consumers. The label claims focused on specific on-farm practices. Respondents were asked to indicate which of the claims were most important and least to them across a range of products. Ellison reported that across product types, the top three labels were those that stated no growth hormones, non-GMO, and humanely raised (Ellison et al., 2017). She added that humanely raised was particularly important for milk and eggs, products for which the animals live through production. Ellison also pointed out that although the addition of growth hormones is prohibited for all poultry and pork products, most of these products have this label because consumers care about the information and do not know this fact. In addition, she suggested, producers likely feel compelled to include this information on their labels when it is on the labels of competing products. Ellison expressed her surprise that organic was considered the least important claim, given the popularity of organic products.

Ellison closed by presenting the key takeaway from her research: that many factors play into consumers' food purchase decisions, and taste and price are the ultimate drivers of their decision making. She stressed that while labels can be useful in differentiating between products, consumers must be able to understand and use them relatively quickly if they are to make a difference, and that may be difficult given the large amount of information they currently contain.

AUDIENCE DISCUSSION

Khoo opened the audience discussion by asking Ellison and McCluskey to what extent consumer preferences influence production changes at the farm level. Ellison replied that consumer preferences have driven a number of production changes. She cited as examples changes promised by companies such as Panera, Chick-fil-A, and McDonald's, including switching to eggs from cage-free chickens. McCluskey agreed that consumer preferences are becoming more important to producers because they realize that satisfying those preferences will help increase their profits. Indeed, she said,

innovations are increasingly focused on meeting consumer preferences, such as development of an apple that does not brown.

Peters was asked for his thoughts on how to reconcile the need to address some of the water or land resource issues related to climate change quickly when it can take 22 years to grow a new orchard or plant variety. Peters responded that, given such long lead times, it is important to be able to anticipate potential problems and solutions and plan ahead accordingly. He also suggested that moving slowly and deliberately in the right direction is not necessarily problematic.

In addressing a question from Barbara Schneeman, University of California, Davis, about how consumers might respond to seeing a front-of-package label with both positive and negative nutrition information, Ellison responded that she expects consumers would continue to make decisions based on habit, as the front-of-package information would compete with other label claims. She added that some production label claims address food production issues rather than nutrition or health, but that some consumers may still think they are making a healthy choice when selecting a product based on such claims. She pointed out this is the case, for example, with fair trade chocolate.

An audience member from the U.S. Environmental Protection Agency asked Ellison how she expects consumers to respond to label claims or indications that certain products support local social programs, especially when this messaging may compete with other label claims Ellison had referenced. Ellison responded that research has shown consumers are willing to pay more for products with these types of labels; however, she acknowledged that research results to date are insufficient for understanding how consumers prioritize when viewing products with multiple labels.

7

Exploring Cases of Food System Evolution: Federal Programs and the Private Sector

The final session of day 1 of the workshop, moderated by Jennifer Otten, explored two case studies of food system evolution—one from government and one from business.

HOW FOOD SYSTEMS ARE EVOLVING WITHIN FEDERAL PROGRAMS

Tricia Kovacs, U.S. Department of Agriculture (USDA), explored how food systems are evolving within federal programs. She began by suggesting that to learn faster, funders should encourage and fund research that applies food systems and transdisciplinary approaches. She pointed out that focus of this session on evolution rather than innovation was appropriate because federal programs have been addressing local food system issues for a long time, and have not seen the sudden changes characteristic of innovations discussed in previous sessions. Rather, she said, programs have been added and adjusted as food systems research and practice have identified new complexities and needs for investment.

Kovacs elaborated by pointing out that seemingly simple initiatives, such as farm-to-school and direct marketing, involve multiple complexities with incremental changes. To illustrate this point, she described how she started a farm-to-school program in Washington State in 2009 and how supporting this relatively direct market required addressing such issues as procurement standards, food safety requirements, and distribution challenges.

Federal Local Foods Programs

Kovacs outlined the evolution and purpose of federal programs designed to facilitate local and regional food systems. The Farmers Market Promotion Program was established in the 2008 Farm Bill to support the sale of locally and regionally produced agricultural products in direct-to-consumer markets. The next Farm Bill added the Local Food Promotion Program (LFPP), which recognizes the role and supports the development of intermediaries in getting local agricultural products to consumers. The LFPP provides both planning and implementation grants. Kovacs pointed out that intermediary markets can help address challenges faced with direct marketing channels noted during prior sessions, such as high labor costs.

Kovacs explained that USDA Rural Development has the Value Added Producer Grant program, which was established in 2000 and has been adapted through several farm bills since then. In the 2018 Farm Bill, this program, which supports local marketing and other value-added activities for producers, was combined with the Farmers Market and Local Food Promotion Programs of the Agricultural Marketing Service to establish a cross-agency Local Agriculture Markets Program (LAMP). The LAMP has mandatory funding and requires collaboration across federal agencies that use different systems. Kovacs noted that the Farmers Market Promotion Program and LFPP grants are in progress for fiscal year 2019, and given changes in the 2018 Farm Bill, can now be used to fund investments in addressing such issues as food safety that the programs were previously unable to fund. She added that release of value-added producer grants has been delayed because of the need for rulemaking. As Kovacs explained, USDA hopes to streamline the grant awards for all of these programs in the future.

The LAMP also will provide Regional Food Systems Partnership Agreement grants, Kovacs continued, which will fund partnerships to plan and develop regional food systems through more comprehensive approaches, leveraging funding from outside partners. She explained that this program, currently in development, reflects the ongoing evolution of program tools as it recognizes the need for multiple sectors and partners to come together to coordinate on food systems development, reduce duplication, and improve outcomes. She noted that funded partnerships will include an entity that may be the recipient of funding and technical assistance, along with partners that bring such resources as expertise, assistance, or match funding. She added that across the LAMP programs and the Specialty Crop Block Grant Program, USDA is also developing a framework to measure and assess program impacts using a systems approach.

Kovacs also mentioned that another federal program, Local Foods, Local Places, managed by the U.S. Environmental Protection Agency (EPA),

provides for placemaking[1] through health and food considerations. She reported that at least 92 communities across the United States have received strategic planning support and facilitation through this initiative.

Coordination of Federal Programs Addressing Local Foods

According to Kovacs, overall there are at least 30 USDA programs relating to the local food supply chain. She manages an interagency workgroup charged with coordinating USDA staff involved in these initiatives and enabling them to stay informed about relevant activities at other agencies. She added that the interagency workgroup also meets regularly with researchers working on food systems and field agency staff. Kovacs also manages an interagency grant workgroup focused on grantmaking and assessment of impact.

Kovacs went on to explain that, to further learn and disseminate information, USDA's Agriculture Marketing Service (AMS) also has cooperative agreements with outside researchers to develop resources and tools for stakeholders outside of the federal government. Selected data sources she described include the Local Food Marketing Practices Survey, the Census of Agriculture, and the Agricultural Transportation Open Data Platform. Together, Kovacs stated, these programs, along with cross-agency collaboration and research, aim to support local and regional food systems in a way that accords with current understanding of needs and opportunities.

FOOD ASSET POTENTIAL

Thomas McQuillan, Baldor Specialty Foods, provided a private-sector example of food system evolution and described how his company was successful in achieving zero organic waste for landfill disposal companywide.

Baldor's Journey to Reducing Food Waste

McQuillan explained that Baldor is a distributor of produce and specialty foods and also owns a fresh-cut produce operation. In 2015, Baldor executives became concerned about food being wasted through food production, and decided to use their company's excess to address the high rates of food insecurity in the surrounding Bronx neighborhood. While initial discussion of solutions referenced 2030 or 2050 deadlines, McQuillan wanted to make changes happen faster.

[1]According to the Project for Public Spaces (PPS), placemaking is an approach to the planning, design, and management of public spaces to promote health, happiness, and well-being (PPS, 2009).

In response, McQuillan said, the company launched the Imperfect Produce program, which resulted in the capture of 4,000 cases of tomatoes, which were sold to chefs or donated to people in need during the program's first year. In 2018, 190,000 pounds of food that would otherwise have been wasted was recaptured, and the company has a goal of moving 1 million pounds of produce in 2019. McQuillan drew an analogy with wasting gas to illustrate the point that Americans waste large amounts of food without considering the impact on the environment.

McQuillan went on to describe Baldor as a food distribution company whose business consists of 75 percent produce and 25 percent specialty foods, such as chocolate, olive oil, and caviar. He explained that the company converts 1.2 million pounds of produce per week into 588 different types of fresh cuts (e.g., carrot sticks). As part of that process, he said, parts of the produce (e.g., carrot peel, carrot tops, celery tops) remain. Aware that wasted food in the United States is worth $218 billion, impacting companies' bottom lines, Baldor embarked on an effort to use 100 percent of its food product, and as McQuillan reported, the company delivered on its commitment of zero organics to landfill on November 10, 2016.

Food Recovery Hierarchy

McQuillan explained that Baldor was successful in meeting its commitment of saving 150,000 pounds of organics from landfill by using EPA's Food Recovery Hierarchy, shown in Figure 7-1. This hierarchy lists the most to least preferred methods of reducing food waste. McQuillan argued that landfill and incineration, at the bottom of the pyramid, should be completely removed.

McQuillan next described how Baldor uses its leftover food, stressing that food is an asset to be consumed by humans or animals or used for compost—it is never waste. Some leftovers, he elaborated, such as vegetable peels, may be sold to chefs for use in recipes; other leftovers, such as produce that is not fit for sale to chefs, is donated to nonprofit organizations; and inedible scraps are given to farmers for use as animal feed or compost. He noted that all of these deliveries are made to locations within the company's existing supplier network or delivery range.

In closing, McQuillan asserted that overall, Baldor has saved 22 million pounds of food from landfills, perpetuating the circle economy. He suggested that a culture change and regulations may be needed to restrict comingling food with waste. In addition, he observed, solutions for reducing food waste may also help reduce the toxicity of brownfields or improve soil systems, for example.

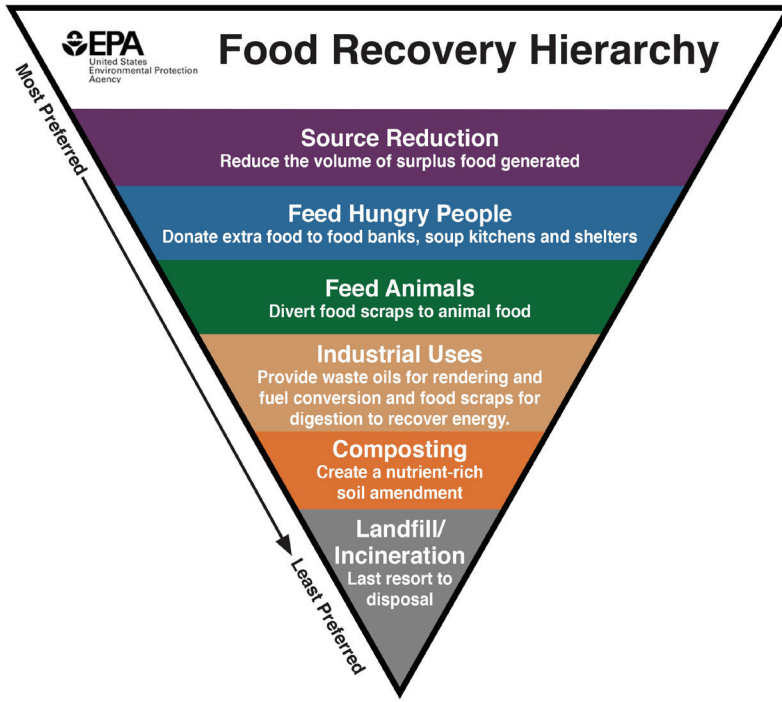

FIGURE 7-1 A hierarchy of methods for reducing food waste.
SOURCES: Presented by Thomas McQuillan on August 7, 2019, from EPA, 2017.

AUDIENCE DISCUSSION

McQuillan opened the audience discussion by responding to an audience member's question about reducing food waste, pointing out that Baldor had donated 2 million pounds of food to local people who are food insecure. In response to another audience member's question about food safety concerns with donated food, he stated that Good Samaritan laws protect entities that donate food as long as it is stored properly and donated to a nonprofit organization that will treat the food responsibly.

Jablonski suggested that there may be trade-offs involved in reducing food waste. She gave the example of waste treatment facilities, which are a major economic driver in some communities in upstate New York. In reducing food waste, she argued, it may be important to consider how to replace the associated economic development opportunity. Jablonski also pointed out that having some biodigestible waste in overall food waste may help break the waste down faster. McQuillan said he supports the idea of

anaerobic digestion once goals of reducing waste and feeding other people have been met.

In response to a question from Jensen about scaling strategies for reducing food waste, McQuillan observed that what works for Baldor may not be the best solution for all companies. He highlighted the example of an app called "Food for All" that allows food-insecure consumers to search for and order leftover food from restaurants that is available at half price. He noted that this food is provided in the same manner as other food available from the restaurants, avoiding the stigma associated with receiving food from a food pantry or soup kitchen.

Another audience member suggested that the conversation shift away from feeding hungry people with leftover food to recognizing food and nutrition as human rights. McQuillan acknowledged that Baldor could be more purposeful with its donations and use its capacity to help distribute food to people in need in addition to donating whatever leftover food it may have. He agreed that this approach would better allow food banks to address nutrition among the population it serves.

The same audience member also commented that overproduction of food leads to low prices and increased food waste. Kovacs suggested that USDA's programs could be helpful in supporting farmers in switching to crops that are not overproduced or are low priced. McQuillan argued that overproduction can be important in protecting against the harms of natural disasters that could destroy crops, and he added that it is difficult to determine how good a harvest will be when the crops are planted.

Jean Halloran, Consumer Reports, asked McQuillan what other food distributors think of Baldor's food waste strategy. McQuillan responded that he thinks Baldor is ahead of the competition, but is willing to share its approach. He suggested that overall, a culture shift is needed to value more highly food that people choose not to eat. He even went as far as to suggest that there may be a role for government regulation in disallowing the comingling of food with waste. Kovacs pointed out that a model for that idea exists in Seattle, where all restaurants, homes, and businesses have a compost pickup.

Peters asked Kovacs to share an example of how a group of stakeholders in a single geographic area could leverage multiple USDA grants and resources to work together in solving a problem. Kovacs responded that the grants she had described can be used for farmers' markets, direct-to-consumer markets, food hubs, and other distribution solutions, and businesses may be eligible grantees. There are also farmer–rancher grants, other grants for underserved groups to receive training about farming, and specialty crop block grants, for example. Kovacs suggested that a partnership could engage in regional thinking and consider the types of grants to leverage to achieve the partners' overall goals. However, she cautioned

against "grant chasing" and instead suggested seeking funding sources that can help implement portions of the partnership's strategic plan.

RECAP OF DAY 1 OF THE WORKSHOP

Halloran opened day 2 of the workshop by highlighting three points from the previous day. Box 7-1 summarizes her takeaways.

BOX 7-1
Halloran's Takeaways from Day 1

- Food systems and changes therein should be viewed holistically. Food systems have components focused on health, the environment and sustainability, social impact, and the economy, and there are often trade-offs among these four dimensions.
- The most hyped innovations should be viewed critically and may not meet expectations.
- Some of the best innovations, such as terminal markets, local production, farmers' markets, and methods for reducing food waste may be reminiscent of the past.

8

Innovations in Food Data and Analytics and Implications for Food Systems

Christina Khoo opened the second day of the workshop as moderator of a panel on innovations in food data and analytics, including tools to help mitigate food waste across sectors and the nutritional implications of food waste.

SCALING FOOD WASTE PREVENTION GLOBALLY THROUGH MEASUREMENT AND ANALYTICS

Steven Finn, Leanpath, focused on scaling food waste prevention through measurement, data, and analytics. He began by pointing out that one issue on which there should be broad consensus is the need to reduce waste across the food supply chain. He emphasized that the best way to reduce food waste is to prevent it from occurring in the first place, and stated that prevention can best be achieved through measurement. He also suggested that with respect to food waste reduction, "behavior change is everything." And he asserted that scaling of food waste prevention programs is possible.

Global Burden of Food Waste

According to Finn, it is unsustainable from both social and environmental perspectives for the world to waste between 30 and 50 percent of the global food supply annually. Accordingly, he said, there is increasing momentum behind Target 12.3 of the United Nations' Sustainable Development Goals (SDGs), which calls for cutting global food waste in half

by 2030 and reducing food loss along supply chains. According to Finn, wasting food exacerbates problems of hunger and environmental harm due to water consumption and greenhouse gas (GHG) emissions. He believes that the global problems of hunger and climate change will not be resolved without efforts to address food waste.

A Focus on Food Waste Prevention

Finn described Leanpath as a pioneer in food waste prevention, having invented food waste prevention technology for the food service sector in 2004. He informed the audience that the company has four offices around the globe and operates in more than 30 countries and all 50 states, and its customers include major companies, such as Aramark, Google, Ikea, and Sodexo. Focusing on food waste prevention, Finn explained, allows the company to achieve maximum social and environmental impact across the food supply chain by preventing unnecessary resource consumption and avoiding the emissions impact of food that would otherwise go to waste.

Finn suggested that to achieve the 50 percent global reduction in food waste outlined in SDG Target 12.3, it is important to shift attention to preventing the occurrence of food waste (i.e., source reduction) as opposed to the traditional focus on downstream recovery efforts. The key to preventing food waste in the food service sector at scale, according to Finn, is the use of automated tools for tracking and measurement to drive operational and behavior change in kitchens. He described the "elephant in the kitchen" as the high levels of food waste that have long been present in kitchens, effectively hiding in plain sight because of cultural norms around abundant food. Finn outlined two key areas of food waste to be addressed in the food service sector: (1) preconsumer kitchen waste due to overproduction, spoilage, and trimming (which is controlled by kitchen staff); and (2) postconsumer "plate" waste (which is controlled largely by guests, but also influenced by portion sizes). He stated that consumers can reduce plate waste through behavior change.

Finn explained further that food is often wasted in food service as a way to manage risks. In particular, food service professionals never want to run out of food, which often leads to excess production. According to Finn, front-line food service workers have the greatest role to play in reducing food waste because they see exactly how much food is needed and how much is being wasted each day and are capable of adjusting production levels and maximizing food utilization. Leanpath connects these workers at client companies to the global food waste challenge and energizes them to make a difference.

Food Waste Measurement as a Prevention Strategy

Leanpath's vision, Finn continued, is to ensure a sustainable future by eliminating global food waste, and the company's mission is to make food waste prevention an everyday practice in the world's kitchens. The company believes that organizations can and should take control of their food waste using a comprehensive food waste prevention strategy.

Finn reported that Leanpath has enabled clients to prevent more than 40 million pounds of food waste since 2014, an environmental impact equivalent to removing the annual emissions of 27,000 cars and saving more than 16 billion gallons of water. He highlighted a measurement gap related to food waste, as many organizations do not understand how much food they are wasting, nor do they have measurement programs in place. In accordance with the idea that "what gets measured gets managed," Finn said, organizations can track each occurrence of excess food in their kitchens with Leanpath and thereby establish a baseline level with which to track progress and measure changes over time, obtain data on the root causes of food waste, facilitate solutions in the kitchen, and engage people in the initiative.

Finn emphasized three key points related to closing the food measurement gap: first, the path to meaningful food waste reduction requires a focus on prevention; second, measurement is the optimal route to prevention; and third, automation is the optimal approach to measurement. He pointed out that automation is three times as effective as manual tracking, saving organizations time and money. Finn explained that the process of tracking with Leanpath's integrated hardware and software tools creates a cloud-based database that allows organizations to analyze the causes of food waste and take action to reduce it in the short term while preventing its recurrence in the future. At the same time, the process allows organizations to drive behavior change among staff, connecting front-line food service workers to the food waste challenge and creating a culture focused on food waste prevention.

Business Case for Food Waste Prevention

According to Finn, food waste reduction has become a basic expectation for food service organizations, and regulatory, environmental, and social trends highlight the need for prevention to be a key component of a reduction strategy. He outlined five ways in which wasted food "costs" organizations: (1) the cost of the food itself, (2) the utility and water costs involved in production, (3) the labor costs of production, (4) lost sales and profit from the waste, and (5) the disposal costs. Thus, he stated, reducing food waste yields significant financial benefit. He also identified additional

benefits, including reduced environmental externalities in the form of decreased GHG emissions and reduced water consumption, creation of a more engaged workforce, and positive societal recognition for leadership in sustainability.

Delivering on Food Waste Prevention

Finn stressed that delivering on food waste prevention requires behavior change at scale and that metrics influence behavior. Measurement, he explained, includes identifying what is being wasted and why, establishing goals for improvement, and tracking progress. He described the process as follows. Leanpath provides a suite of customized tracking devices designed to meet the needs of each client site, such as bench scales with photography, mobile tablet solutions, and floor scales. Gamification is built into the tracking tools to further energize employees. The data that are tracked flow to the analytics program Leanpath Online, which allows food service organizations to view and organize the data in myriad ways to drive that food waste reduction. For example, data can be viewed for a single site, multiple sites, or across the entire organization. The process is augmented by additional features, such as goal setting to target specific items and real-time alerts that allow for immediate intervention on specific food waste transactions. According to Finn, data motivate action and inspire measurable improvement.

Finn also described Leanpath Spark, a postconsumer product that allows food service organizations to engage consumers in the food waste reduction process. The product displays impactful waste data and messaging to spark behavior change at the consumer level.

Final Remarks

In conclusion, Finn emphasized the importance of food waste prevention, reiterating that it will not be possible to meet the global goal of 50 percent reduction in food waste through recovery efforts alone. He therefore recommends shifting the focus on reducing food waste downstream to upstream prevention efforts that engage businesses in responsible production to avoid creating excess food in the first place. He reported that Leanpath's prevention efforts typically result in a 50 percent reduction in food waste and approximately 2–8 percent reductions in food costs, depending on the site. He added that a prevention-focused approach would benefit the environment and free up resources for redirecting food waste recovery to address the root causes of hunger and poverty. And he again stressed that the best way to achieve the goal of food waste prevention is through continued measurement that makes waste visible within organizations.

INNOVATIONS TO MITIGATE FOOD LOSS: FROM THE FARM TO THE CONSUMER

Norbert Wilson, Tufts University, spoke about mitigating food loss, primarily for produce, and about how food labels influence food waste. Loss occurs at several points along the supply chain, he observed, including at the consumer level, during transport, and on the farm.

Wilson began by highlighting the great variation among crops in the amount that is lost, including the marketable product left on the field and the amount that does not meet grade. He cited a study showing that this amount can range from as low as 5 percent to as high as 100 percent when a farmer chooses not to harvest (Baker et al., 2019).

Farm Production

Wilson used a visual representation of the U.S. food supply chain from a 2015 Institute of Medicine and National Research Council report to highlight points along the supply chain where loss and waste occur, as well as innovations to mitigate some of the loss. He began by discussing farm production.

Using strawberries as an example, Wilson explained that growers must consider plant maturity, product quality, price fluctuation, and labor availability in deciding when to harvest their crops or even if to harvest them at all. He pointed out the importance of ensuring that products are of high enough quality not to lose market opportunities. Strawberries are repeatedly harvested over a period of time, he observed, and their prices often fluctuate. He added that growers may use innovations that extend production in an attempt to avoid harvesting when prices are at their lowest; however, he pointed out, prices may fluctuate on a daily or weekly basis. He noted further that growers must meet quality standards established by the federal government, and many grocery manufacturers and large companies have their own higher standards (Hsu-Flanders et al., 2019).

Accordingly, Wilson continued, innovation has focused on creating new crop varieties that can better sustain pests and diseases and thrive with varying water levels. He explained that innovations in shipping also can help crops like strawberries last longer once picked, while innovations in production timing can help farmers time when to harvest and when to expect the highest prices. Alternatively, he said, a producer may choose to vary production timing over the course of the season (Hsu-Flanders et al., 2019).

Considering the role of charitable innovations, Wilson noted that the ancient tradition of gleaning is still practiced by 282 organizations, the largest of which recovered 28.5 million pounds of produce in 2018. He stated,

however, that there are often challenges in accessing farms for this purpose. Wilson described an innovation in the for-profit sphere that involves commercial peer-to-peer mutualization systems, organizations that aggregate and sell product that would not otherwise be sold or marketed in a manner similar to a community-supported agriculture program. He observed that research in this area has focused on whether these organizations are successfully distributing benefits within the system or profiting off of farmers' errors (Gallagher et al., 2019).

Logistics

With respect to logistics, Wilson explained that fruits and vegetables, in particular, can be lost as the result of failure in the cold chain, leading to lower quality, a shortened shelf life, and possibly food safety concerns. He cited a study finding that 12 percent of food is lost because of poor refrigeration (Gunders, 2012). Innovations targeting this problem, he said, include forced air tunnels and cold walls used to cool products; temperature monitors; and management strategies such as "first expired, first out." Additional packaging innovations include the use of radio frequency monitoring and other sensors that evaluate temperature, pH, and gases within a product to detect cold chain failures.

Retail Sector

Turning to marketing strategies for "ugly produce" developed by the retail food sector, Wilson noted that these strategies have not been as effective as expected (Choi and McFetridge, 2019). He also shared the example of a nonprofit grocery store in a low-income community in Boston that sells products that are about to expire or would otherwise be wasted (Gallagher et al., 2019).

Consumer

Wilson suggested that the consumer should, in theory, be able to send information back to the farmer and influence future production. He acknowledged, however, that this flow of information does not always take place.

Date Labels

Wilson pointed out that on the consumer end of the supply chain, package size and date labels impact food waste. Therefore, he suggested, innovative ways to reduce package size could also reduce food waste.

Wilson referenced research showing that consumers are confused by date labels, and reported that legislation to standardize date labels to include a "use by" safety label and a "best if used by" quality label has been introduced at the state and federal levels (Wilson et al., 2017, 2018; McBreen, 2018). And, he added, the Food Marketing Institute and the Grocery Manufacturers Association have encouraged their members to use this approach to simplify labels.

Wilson then described his research examining how consumers understand different date labels across various products. He and his colleagues found that consumers expected to waste 15 to 30 percent of a product when it had only a date (Wilson et al., 2018). However, the addition of the words "best by" or "use by" before the date on the label impacted food waste in either a positive or negative direction, depending on the product and the consumer. Wilson noted that different consumers responded differently to the "best by" or "use by" labels, depending on their loss aversion.

Final Remarks

In summary, Wilson reiterated that food loss and waste occur throughout the supply chain, with the amount varying significantly by product. He stated that potential solutions include new market structures, charitable institutions, and new technologies, each of which has its own challenges and unintended consequences. At the consumer level, he said, date labels affect perceptions of food waste. He also stressed the importance of considering feedback loops and system dynamics, as innovations or changes in one part of the supply chain may affect other parts.

MODELING THE NUTRITIONAL IMPLICATIONS OF FOOD WASTE MITIGATION

Bradley Rickard, Cornell University, expanded on the issue of date labeling, including the economic and nutritional implications of the $200 billion in food waste in the United States and the impact of potential changes.

Food Waste Research Topics

Rickard began by outlining four areas of economic work related to food waste: (1) measurement of the amount of food waste and definition of what is considered waste; (2) information and industry initiatives, such as the impact of behavioral nudges designed to help people reduce their food waste across food products and categories and messaging, such as date labels; (3) determination of the optimal level of food waste, given the costs involved in getting food waste close to zero; and (4) the impact of reduction

or changes in food waste on future prices, production, and nutrition, which is the topic of Rickard's research.

Rickard shared a framework for how changes in food waste or loss could impact price, quantity, and available nutrients in the household. Based on cost, he reported, the majority of the $200 billion in global food waste comprises fruits, vegetables, dairy, and meat; broken down by calories, however, most food waste is in the form of fats and sugars. Rickard expressed concern that if food waste were to be reduced, people might consume more added fats and sugars, reducing the nutritional quality of their diets. Thus, he questioned whether efforts to reduce food waste could inadvertently increase consumption of unhealthy foods and promote adverse health outcomes.

Date Label Research

Rickard and colleagues conducted consumer research to determine how people respond to behavioral nudges and what the larger market effects would be of a change in food waste and consumption. They surveyed consumers to assess how different date labels, including date only, "use by" date, "best by" date, "sell by" date, and "best if used by" date would affect their likelihood of discarding 15 different products from nine food groups 1 day past the date. They also assessed the impact of a green circle smart label identifying the freshness of a product using a biosensor in combination with the "use by" and "best if used by" date labels. The nine food groups were cereal, meat, eggs, fruits and vegetables, dairy, beverages, other foods, alcohol, and food away from home. Rickard explained that consumer responses to the survey were then used to determine how behavioral changes would affect prices, quantities, and nutrients available in the household.

According to Rickard, the study found that with just the date on the label (the control), 27 percent of consumers said they would be likely to discard the product; with the "best by" date label, this percentage fell to 22 percent. With the green circle smart label plus the "best if used by" date, the percentage fell further to 18 percent. However, Rickard pointed out that the change in percentages varied significantly by product and by label (Wilson et al., 2017).

Rickard further argued that changes in food waste based on date label changes would impact the nutrient availability of foods in the household. As he explained, if less food were wasted, less new food would be purchased. The change in purchasing would impact some food types more than others, he added. He presented nutrition simulations when shifting to a "best by" label, highlighting that overall nutrient availability in the household would fall. More specifically, households would eat relatively

more cholesterol, protein, and calcium because meat and dairy products are some of the most likely to be wasted, and would eat relatively fewer carbohydrates and sugars; therefore, household availability of carbohydrates and sugar would increase. Results were similar for use of both the "best if used by" label and the color-coded biosensor. In response to a question from an audience member, Rickard responded that overall, the "best if used by" label plus biosensor led to a 10 percent reduction in food waste compared with the date label only.

In conclusion, Rickard stated that overall, date labels work, and consumers do respond to them. The labels with the greatest impact are "best by," "sell by," and a biosensor smart label. However, Rickard reiterated, the level of response varies by food item. Improving date label information would be expected to decrease food waste, impacting the relative availability of foods and nutrients in the household so that there would be less fat, cholesterol, and protein and more carbohydrates and sugar.

AUDIENCE DISCUSSION

An audience member opened the discussion by stating that for low-income consumers, the value of a product is based on how long it can be saved in the household without being wasted. Rickard was asked whether he had conducted research on consumers' decisions to purchase products based on their shelf life. He responded that he and Wilson had done some point-of-purchase research and that the findings generally align with those he had presented. Wilson added that he had done research comparing a shelf-stable product (spaghetti sauce) with a similarly priced fresh product (deli meat) and had not found consumers to be less likely to choose the deli meat because it would spoil faster. However, he noted that research has not sufficiently examined the response of low-income consumers specifically.

Another audience member asked Wilson about challenges in accessing labor for the harvesting of fruits and vegetables. Wilson acknowledged that a lack of available labor or the cost of labor at harvest time can be an issue, and when this is the case, farmers may leave the product on the field. He agreed that addressing labor issues is important to the food supply chain and to reducing food waste.

With regard to some of the solutions for reducing food insecurity and food waste that Wilson had described, Wendy Johnson, Nestlé, commented that initiatives to bring produce from more affluent to low-income areas have been disliked by the communities on the receiving end. Wilson acknowledged her concerns and noted that the project that he had described in his presentation was led by the community and did not involve a large retailer "dumping" its unwanted products in a low-income community. He

also noted that the store committed to hiring workers from the community. Johnson added that it is important for such initiatives to be purposeful and community-driven.

9

Innovations in Food Access and Affordability and Implications for Food Systems

The final session on innovation addressed innovations in food access and affordability. Roni Neff, session moderator, opened the session by explaining that it would focus on equity considerations, a recurrent theme throughout the workshop, with respect to people's food-related choices, their ability to make those choices, the affordability of food, food insecurity, and food-related outcomes. She added that the session would also examine power dynamics, leadership, and who is involved in decision making.

REDESIGNING FOOD ACCESS

Nevin Cohen, City University of New York School of Public Health, spoke about the way food access is conceptualized, measured, and addressed, including limitations of existing approaches and innovative strategies.

Root Causes of Poor Food Access and Research Challenges

Cohen began by explaining that the term "food access" is used to describe a wide range of conditions involving diverse social movements focused on food sovereignty, food system control, and environmental justice activism. He asserted that a legacy of racism in the United States has led to spatial disparities in housing, economic development, and food deserts, and that great wealth disparities caused by racism, gender oppression, and other discrimination have contributed to large numbers of Americans living

in poverty and experiencing food insecurity as a result. Cohen suggested further that overweight and obesity are due in part to poverty and targeted marketing of ultraprocessed foods to communities of color.

Cohen explained that hunger and food insecurity have been conflated with physical food access as a result of technological innovations that facilitate the identification of food deserts, as well as policy approaches that frame hunger as market failure and point to popular policy solutions, such as food retailer subsidies, as an economic development tool. Considering the relationship among healthy diet, overweight and obesity, and cardiovascular disease risk, he added that public health experts have used supermarket access, with supermarkets as a proxy for the availability of healthy food and the likelihood of fruit and vegetable consumption, in ecological theories to explain the current high rates of overweight and obesity and race- and class-based health disparities.

Cohen, however, presented a contrasting view—that supermarket access is inadequate to fully explain the reasons for hunger and poor nutrition—arguing that the research supporting that explanation is flawed in several key ways. First, he observed, U.S. obesity rates have increased steadily since the 1960s across all age groups, genders, and ethnicities, suggesting that the likely cause is environmental changes rather than poor individual dietary choices. He pointed out that this explanation is consistent with research showing that since the 1970s, increased energy density has been associated with weight gain across countries. He also he pointed out that researchers typically focus specifically on the locations or density of food outlets using spatial or geographic analysis to assess the proximity of retail food establishments to residential locations. However, he said, small ethnic grocers or other retailers that do not respond to surveys are often not included in these studies, and they analyze only a very specific aspect of the food environment. In addition, he noted that supermarkets also offer many unhealthy options, that retail sales data may not be considered, that most studies are cross-sectional rather than longitudinal and fail to capture changes over time, and that most of the research takes place in major U.S. cities. Cohen suggested further that measures of food quality are also flawed. He observed as well that research often measures accessibility, availability, price, prominence in shelf positioning, and healthfulness of products without clearly defining what is healthy versus unhealthy. He cited additional methodological limitations with measuring what people eat, noting that self-reported dietary intake data are subject to recall bias, and that body weight is often self-reported.

As a result of these limitations, Cohen explained, most studies of food environments, diet, and health outcomes have found weak or inconsistent associations among supermarkets, fast food outlets, and obesity. However, he said, there continues to be a focus on geographic proximity to food

outlets, including in the Milan Urban Food Policy Pact, signed by about 200 cities, which requires tracking the number of households living in food deserts as a measure of food access.[1]

Cohen acknowledged that some research has attempted to consider people's daily activity patterns and how they buy food citywide in the course of their daily activities, as well as nontraditional food sources such as ethnic grocers and even vending machines. Nonetheless, he asserted, "Food environments and the way people interact with them are much more complex" than is captured by most existing research.

Potential Solutions for Challenges of Research on Food Access

Cohen then presented potential solutions to address some of the challenges he had described. First, he suggested using longitudinal studies to assess the relationship between the food environment and health outcomes over time. For example, using Google Maps' Street View, he and his colleagues measured all existing food retailers in the Bronx in 2007 and 2017, observing growth in retail food outlets over the time period, most of which occurred in areas with more development and with government incentives for their establishment. The study also found growth in dollar stores that sell less expensive, mostly processed, shelf-stable food.

Cohen also suggested that social practice theory can be useful in understanding how people's practices related to food buying and cooking are shaped by their material conditions, their knowledge, and the meaning they associate with particular practices, as well as how those practices have evolved over time. He described a study he conducted that used focus groups to understand how organizations for seniors could better help older adults eat more food at home rather than in meal programs. The study found that people's practices in this regard are designed around their food environments and become normalized over time. Another project Cohen described uses deidentified data aggregated from location-tracking apps to monitor the locations of individuals as they travel to and from food retailers.

Innovations to Increase Food Access

With respect to innovations to increase food access, Cohen focused on the design of strategies that use technological and social innovations to address the economic conditions and scheduling constraints that impact

[1]The Milan Monitoring Framework defines food deserts as disparity in the geospatial distribution of the food retail establishments and of socioeconomic population groups (Milan Urban Food Policy Pact, 2018).

people in low-income communities. He described three types of such innovations: (1) social supermarkets, (2) food buyers' clubs, and (3) meal kits.

Cohen defined social supermarkets as nonprofit or socially oriented ventures that provide both community services, such as nutrition education, and lower-priced food in low-income communities. The stores may rely on donated food and services, negotiated discounts with utility companies and suppliers, or lower-cost financing. Cohen shared an example of a social supermarket in Baltimore created by the Salvation Army that offers low prices on food, free weekly items for Supplemental Nutrition Assistance Program (SNAP) participants, nutrition education, and meal planning assistance. The store is conveniently located near an elementary school in a low-income neighborhood and relies on donations of nonperishable food, negotiated discounts with distributors, discounted utilities, donated labor, and government-funded coupons to enable customers to buy fresh produce at a discount. Cohen pointed out that other food retailers, such as a dollar store, fast food restaurants, and a traditional grocery store, exist nearby, but the social supermarket is still needed to provide low-cost food to price-sensitive shoppers. He added that research shows that low-income consumers often shop at multiple stores to get the best prices, so customers of the social supermarket may also shop at some of the other nearby food outlets.

Turning to his second example of an innovative solution, Cohen described a food buyers' club that has encouraged neighborhood residents to take advantage of a pilot project in New York City allowing people who receive SNAP to use these benefits at online grocers. Residents of a housing development in a Brooklyn neighborhood were engaged in a 7-month co-design process to identify potential options for food shopping. They decided to take advantage of the U.S. Department of Agriculture's (USDA's) pilot project to allow SNAP participants to use their electronic benefit transfer cards to shop online at Amazon. Cohen pointed out that sales data are not yet available with which to determine whether the intervention has been cost saving or whether it has affected the kinds of products purchased, but participants have stated in interviews that the initiative saves them time compared with shopping at stores far away, and they are happy with the quality, value, and convenience. Cohen added that the food club also has encouraged residents to discuss their shopping experiences with each other, and the food is delivered to their development's community center run by a nonprofit organization, providing an opportunity for additional health and budgeting programming in the future. He suggested that this model could be replicated and scaled across the New York City Housing Authority, which has about a half million residents.

Finally, Cohen described a company that offers an inexpensive meal kit to low-income consumers. The kit is sold at a price of $2 per serving and is

targeted at parents of children in Head Start and public housing residents. The company keeps costs down by using conventional distributors, inexpensive packaging, volunteer assembly, and just-in-time delivery.

Final Remarks

In conclusion, Cohen recommended shifting toward theories of food access that focus on changing food practices and that explicitly address social inequities. He suggested using multidisciplinary approaches to measure food access. He also recommended better engaging study populations in the research and using co-design methods to develop and test interventions. In sum, he argued, moving beyond conventional methods of food distribution and marketing may be useful in increasing knowledge sharing, reducing disparities, and empowering communities.

BLACK CHURCH FOOD SECURITY NETWORK

Reverend Dr. Heber Brown III, Pleasant Hope Baptist Church, Baltimore, Maryland, described the work of the Black Church Food Security Network and his church in Baltimore in growing food and empowering others to use farming and gardening as a strategy for achieving food sovereignty.

Brown is focused on asset-based approaches to advancing food and land sovereignty among African Americans in rural and urban communities. He defined food sovereignty as "the right of peoples to healthy and culturally appropriate food produced through ecologically sound and sustainable methods and their right to define their own food and agriculture systems," putting people who produce, distribute, and consume food at the heart of food systems and policies (La Via Campesina, 2013). He suggested replacing the term "food desert" with the term "food apartheid," which considers the racial, geographic, faith, and economic aspects of a food system.

Pleasant Hope Baptist Church Story

Concerned that many of his congregants were suffering from diet-related diseases, Brown initially considered establishing a partnership with a fresh food market nearby. However, he decided the prices were too high, and he did not want his congregation to be in a position of subservience and dependency on the market. Instead, he rallied the congregation around creating a garden on a small plot of land adjacent to the church. He was grateful that the partnership with the congregation was the solution for the community, and the 1,500 square foot garden was established in 2010.

The garden grows about 1,200 pounds of produce each year. According to Brown, older members, many of whom had grown up on farms in the South and had expertise in agriculture, were particularly pivotal in maintaining the garden.

Historical Context and Examples

Brown explained that he realized that African American church communities have many assets, such as land, parking lots, commercial kitchens, classrooms, and facilities that are frequently underutilized, and saw opportunities to connect these assets, resources, and people in a systemic response to the systemic problem of food inequity. He learned that historically, African Americans such as Marcus Garvey and other members of the Universal Negro Improvement Association (UNIA) had organized to create their own grocery stores.

Brown described several historical church leaders who led initiatives to use the church's land and assets to cultivate and provide food for their congregation and further food sovereignty in their community. For example, UNIA President James R. Stewart established a farm in Ohio based on the ideology that food, liberation, and freedom go together, and Reverend Vernon Johns was a farmer as well as a pastor, preacher, scholar, and seminary president. Brown explained how he integrated farming into his preaching and regularly sold crops in front of the church on Sunday. Johns started the Virginia Farm and City Enterprises and raised livestock on land in Prince Edward County, Virginia. He encouraged urban and rural African Americans to work together to create their own food system and related industries.

Brown also described how Fannie Lou Hamer furthered food sovereignty efforts in her community, arguing that food may be used as a political weapon. She stated, "If you have a pig in your backyard and you have some vegetables in your garden, you can feed yourself and your family and nobody can push you around." Brown explained that she was part of an African American social–political movement that recognized that liberation, freedom, and opportunities for self- and community actualization may come through agriculture and control of the food system. Hamer worked with the Freedom Food Co-op, which owned 640 acres of land and had a pig bank in Sunflower County, Mississippi. In partnership with the National Council of Negro Women, the organization trained and taught families how to use the pigs to feed their families. As part of the agreement, families had to give piglets back to the bank for others to use. Brown noted that the National Council of Negro Women was focused at the time on helping people meet their own needs on their own terms.

Finally, Brown explained how Reverend Albert Cleage worked to connect urban and rural African Americans to advance food sovereignty. His goal was to ensure that African Americans would not be subject to the sometimes discriminatory or racist policies of local neighborhoods and communities. According to Brown, his strategy for pursuing this goal involved the church purchasing land, and noted that Cleage's congregation owned 3,750 acres in South Carolina, even continuing with the vision of buying land after Cleage died.

Work of the Black Church Food Security Network

Brown articulated how his organization, the Black Church Food Security Network, also organizes the resources of the African American church community for an assets-based approach to food insecurity. The organization has two main objectives, he said, one of which involves working with black churches to help them grow food on their land. It engages in congregational organizing, identifying local leaders and organizers to champion the establishment of a garden and members to maintain it. Brown emphasized the organization's focus on church-owned land because of his concerns regarding the potential for gentrification, dispossession, and displacement of government-owned land once value is added to the land through the gardens. In collaboration with the Johns Hopkins Center for a Livable Future, Brown has as a goal that the church gardens will overcome the food apartheid in the city of Baltimore, using the strength of the black churches as anchor institutions.

Brown also described efforts of the Black Church Food Security Network to bring pop-up farmers' markets to churches on days of worship. He explained that doing so allows congregants to meet and directly support the black farmers from whom they purchase food.

Brown then described how he created a pipeline for young adults interested in the intersection of spirituality and food systems. He takes young people to see other churches that are advancing initiatives around such issues as food security and climate change, and works to inspire them to lead similar efforts in their own community. The organization is also developing a Young Adult Residential Fellowship Program, which will be located in a house owned by the church that Brown currently pastors, Pleasant Hope Baptist Church in Baltimore. Young adults will have the opportunity to live in the house for 18 months while studying food sovereignty, liberatory education, and social justice.

In closing, Brown emphasized that his role is to weave a network of local organizers and local leaders and provide them with resources and support.

FOOD QUALITY IN FOOD ASSISTANCE/EMERGENCY FOOD

Rhonda Gonzalez, Community Food Bank of Southern Arizona, discussed initiatives focused on food quality in the food bank/food rescue sector.

Overview of the Community Food Bank of Southern Arizona

Gonzalez began by describing the Community Food Bank of Southern Arizona, which serves five primarily rural counties spanning 23,000 miles just north of the Mexican border. The organization serves as a food bank—sourcing, warehousing, and distributing food—and a food pantry, delivering food in partnership with 350 to 400 partner agencies. Culinary training in the form of an 11-week free program for un- or underemployed clients is also offered in a community commercial kitchen. The organization also operates a 6-acre urban farm.

Gonzalez explained that for the past 20 years, the organization has considered how to transition from a charity organization to a justice organization. For the past 5 years, she said, this effort has involved incorporating into the organizational culture the recognition that food and health are human rights.

The organization is also working to better incorporate clients' perspectives into its work, Gonzalez added, a university partner surveyed about 250 clients and identified their top priorities as nutrition, cooking, and managing chronic diseases. Gonzalez reported that 72 percent of survey respondents indicated that they or someone in their household had high blood pressure, high cholesterol, or type 2 diabetes. She noted that, overall, the incidence of type 2 diabetes is higher in low-income populations.

Finally, Gonzalez stated that the organization also helps to reduce food waste by obtaining unwanted produce from distributors in Mexico. The majority of the food received by the food bank is donated, she said, through either USDA commodity programs, private donations, or grocery rescue. Of the 63 million pounds of donated products, 52 million pounds consists of produce, mainly vegetables from the Mexican border.

Redefining Success

In its shift to becoming a social justice organization, Gonzalez continued, the food bank is looking at moving away from a focus on pounds of food distributed in how it defines success. Instead, she said, metrics are focused on (1) a combination of food and health; (2) education; and (3) community development, emphasizing client engagement.

As Gonzalez explained, the organization decided about 5 years ago in response to client surveys to increase its focus on health, and a formal

nutrition policy was adopted by the board in 2017. This policy states that all of the food the organization sources and distributes must align with the *Dietary Guidelines for Americans*, emphasizing nutrient density, food variety, and healthy eating across the lifespan (HHS and USDA, 2015). Gonzalez also pointed out that, consistent with the recommendation in the *Dietary Guidelines for Americans* to reduce consumption of sugar-sweetened beverages, the organization no longer accepts large-scale soft drink donations.

According to Gonzalez, the food bank is also considering how to implement the recommendation in the *Dietary Guidelines for Americans* that the majority of grains consumed be whole grains. She pointed out that this is a challenge, given that the majority of its food supply is donated. Her group is working to determine how to increase the distribution of whole-grain products, as well as the overall healthfulness of their food supply, in a way that is consistent with the preferences of their clients. Change in a complex organization such as a food bank is challenging, Gonzalez emphasized, as change in one area has impacts on others. For example, a change in just one food item affects how the bags are packed and how many bags go in each tote.

Gonzalez explained that the food bank has formed a nutrition advisory task force that includes both internal and external expertise. Additionally, it is engaged in educating internal and external stakeholders, including staff and donors, on why it is focused on nutrition and health.

Nutritional Analysis of Distributed Food

Gonzalez next described how the food bank partnered with the Mel and Enid Zuckerman College of Public Health at the University of Arizona to have a student analyze the nutritional quality of the food bags distributed by The Emergency Food Assistance Program (TEFAP) run by the food bank. The nutritional analysis of 25 bags found that they were high in sodium and low in whole grains and certain vitamins, including vitamin C and vitamin D. In partnership with the university, Gonzalez reported, an analysis was also conducted to estimate the proportion of donated bread-based products that were whole grain. Overall, 20 percent of the grains were found to be whole grain, short of the 50 percent minimum target recommended by the *Dietary Guidelines for Americans*.

Gonzalez explained that the food bank is working to empower clients through nutrition education classes, school pantries with in-class nutrition education, recipe sampling, and parent engagement. For example, it works with schools to identify parents who are engaged in the community. It then trains these individuals to serve as peer educators in working with other parents and children. Gonzalez noted that participating parents are provided with a stipend.

Gonzalez added that the food bank leads programs involving volunteer-led nutrition education and recipe sampling, particularly for products less commonly used by the food bank's client base. It has also established partnerships with nearby federally qualified health centers (FQHCs) serving similar populations in three of its five counties.

In partnership with the nutritional sciences department at the University of Arizona, Gonzalez continued, the food bank has also completed two of three phases of developing a model food box based on TEFAP, assessing the quality of their clients' diets, and asking about their preferences regarding which products to provide in the box. As Gonzalez described, phase 1 involved having about 200 clients complete a dietary recall survey to assess overall diet quality. The responses showed that clients' current diets were slightly worse than the average U.S. diet overall and were low in greens, beans, seafood, plant proteins, dairy, and whole grains and high in added sugars and fats. According to Gonzalez, a key lesson from these findings was that clients' diets were not low in protein, yet the food bank had emphasized the donation and distribution of protein-rich foods.

Phase 2 of the effort involved interviews with 10 English-speaking and 10 Spanish-speaking clients to obtain feedback on which items in the TEFAP box they liked and which they would prefer to replace. Gonzalez reported that overall, clients wanted the boxes to contain items that would help them make a meal and reduce their overall grocery bill. She pointed out that TEFAP orders must be placed 18 months ahead in 3-month increments, so it is challenging to make changes. As a result of the interviews, however, the food bank was able to substitute black beans for split peas and remove a high-sodium tomato soup. Gonzalez added that clients stated their preference to also add canola oil and oatmeal in place of other items.

Gonzalez described Phase 3 as involving a diabetes education intervention building on the lessons learned from Phases 1 and 2. As part of a future project, she said, the organization is also considering a feasibility study on how best to roll out the model TEFAP box and incorporate health outcome data with its federally qualified health center partners.

Finally, Gonzalez explained additional ways in which the food bank is working to engage clients. For example, through a grant from Feeding America focused on addressing hunger among seniors, it created a core team of seniors to help in planning additional programming in that area.

AUDIENCE DISCUSSION

An audience member commented that she was disappointed that the food club participants described in Cohen's presentation chose to use Amazon as their food delivery source because she believes the company has poor labor practices, and a stated goal of the food club is to empower

community members. She suggested that a more empowering option could have been to link with a national food co-op movement. Cohen responded that the original hope was to source food from a wholesale producer or distributor, but that a larger number of customers would have been required to ensure sufficient demand to allow for efficient delivery. The requirement that low-income consumers be able to use SNAP dollars to purchase the food also eliminated other options. Cohen pointed out that the community's top criterion was easy access, and online purchasing through Amazon best met that need in the short term.

Another audience member asked Brown how best to apply a systems approach to his work. He responded that while his work is focused in Baltimore and the mid-Atlantic region, his goal is to create a model that could be used across the country to lift up examples of leadership and partnership through the local black church, the most sustainable institution in the black community.

An audience member asked Gonzalez about how the food bank manages spoilage of produce, given the large proportion of donations that consist of fresh fruit and vegetables. Gonzalez responded the food bank has a fairly low spoilage rate of 2–3 percent, and that the spoiled produce is disposed of through pig farming and composting in the food bank's gardens.

Finally, Wilson asked the panelists whether they are evaluating the impact of their work. Cohen, Brown, and Gonzalez all responded that they are working toward that goal, but there is much more work to be done in that regard.

10

Closing Discussion: The Evolution and Revolution of Food Systems

PANEL DISCUSSION

In the closing session of the workshop, moderator Naomi Fukagawa asked each of the panelists to share his or her key takeaways from the workshop.

Christina Khoo shared that she had gained an appreciation of the complexity and interdependence of food systems, including the trade-offs that must occur as progress is made toward goals in a particular area. She also emphasized the importance of using data and analytics to understand the ripple effects of a change to one part of the system. She stated as well that, given her position in the industry sector, she is particularly interested in packaging innovation because of the lack of recognition of the trade-offs between the sustainability of packaging and the need to protect the food supply. She emphasized the importance of packaging in maintaining the oxygen barrier to prevent the quality of food from being compromised.

Helen Jensen said she appreciated the focus of the workshop on the integrated, holistic nature of the entire food system, which provides a framework for considering interactions, understanding and anticipating change, acknowledging trade-offs, and identifying where there is a need for new data and technology. She also noted that many innovations were taking place in and being funded by the private sector, and stated that she sees opportunities for additional public funding and infrastructure. She also pointed to the importance of scale, observing that challenges and trade-offs differ depending on whether an initiative is operating on a small or a large scale.

Roni Neff highlighted the contrast between the urgency of the issues and the time and money required to implement appropriate interventions. She suggested that the data, tools, and funding needed to accomplish goals may not be readily available. She also stressed the importance of understanding and learning from the past, including how past ideas and initiatives can be expanded, customized, or modernized in coordination with new ideas and technology.

Jean Halloran stated that she liked the idea of social innovations and innovations focused on sustainability in addition to those involving technology and driven by economic purposes. Fukagawa agreed, and said she also appreciated the acknowledgment of the importance of prevention in the food system, similar the recognition of its importance in the health care system. She also highlighted the emphasis on transgenerational and transdisciplinary interactions focused on improving people's well-being and food access and on engaging those targeted by interventions and reaching within communities.

AUDIENCE DISCUSSION

To close the workshop, Jennifer Otten asked audience members to share their takeaways as well. Considering the systems perspective, one audience member asked whether if food waste were reduced and food access increased, production would decline as well to correspond with lower demand. Neff responded that an alternative to reduced production could be increased exports, but considering the whole system, there could also be other unforeseen consequences. Other speakers emphasized the importance of reducing food waste, echoing Steven Finn's comments in an earlier session about the importance of prevention. The point was made that people are more willing to discard food the less effort they put into maintaining it. Another speaker noted the importance of involving diverse voices in developing solutions within the food system to ensure that it works well for all people.

Another audience member who works on packaging solutions to reduce food waste expressed the realization that packaging solutions could also be used to improve food access for different populations and communities. Returning to the question raised earlier, this audience member also suggested that if there is increasing success at reducing food waste and improving food access, it will indeed be necessary to produce less food. Panelists and audience members were asked for their thoughts on the implications for the supply chain:

- Neff responded that there have been limited systems-level analyses to model the potential impacts, but more work needs to be done. Key questions still exist, she said, such as what the implications are for exports, whether production would decrease or more food be exported, and how the implications vary across types of foods.

- Eric Decker, University of Massachusetts Food Science, argued that the food industry does not want to reduce food waste because it makes money if food is wasted and more must be purchased.
- Jensen added that agriculture is a dynamic system that is subject to weather and other disruptions. She suggested it is important for the food system to do a better job at storing or processing excesses when they occur.
- Vivica Kraak, Virginia Tech, argued that when using a systems approach, there is a need to "change the rules of the game" and incorporate more policy. She suggested that innovation may involve redefining the problem so policies can successfully be brought forward as potential solutions.
- Kristi Reimers, Conagra Brands, expressed surprise that there had not been more discussion about the importance of food processing in keeping meat and produce fresh and safe long term. She noted that while ultraprocessed foods have negative connotation, the processing is often necessary to preserve their freshness and safety. She suggested that when there is an excess of tomatoes, for example, an option could be to establish a culinary program to freeze and can them. Khoo agreed that there are important innovations taking place in food processing. She added that processing is important not only for preventing food waste, but also for preserving the nutrient content of foods.
- Finn pointed out that while there is growing momentum on reducing food waste, it still is not a mainstream issue. He believes more education in schools regarding proper valuation of food is needed, as is broader culture change. He also emphasized the need to act with urgency, as numerous high-level reports are pointing to the severity of the environmental harm caused by the global food system. He expressed concern that the ease of obtaining food in U.S. society makes it easier for people to waste it, and also pointed out that a cultural shift to reduce food waste would advance progress toward multiple Sustainable Development Goals.

Following this discussion of food waste, Kate Clancy pointed to the problem of using the dichotomous language of small versus large farms and businesses. She suggested that size could better be described using a continuum, as there are also medium-sized entities that function quite differently from small or large farms.

In closing, two audience members highlighted the importance of including more diverse participation in future workshops, as a way of allowing for better identification of solutions that work in communities facing a variety of disparities.

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A

Workshop Agenda

Innovations in the Food System:
Shaping the Future of Food: A Workshop

August 7–8, 2019

National Academy of Sciences Building, Lecture Room
2101 Constitution Avenue, NW, Washington, DC

DAY 1, AUGUST 7, 8:30 AM–5:30 PM

8:30 AM **Welcome and Opening Remarks**
Sylvia Rowe, Food Forum Chair, SR Strategy, LLC

8:40 AM **SESSION 1: Taking a Broad Look at the Food System**
Moderator: Jennifer Otten, Planning Committee Member, University of Washington

The Usefulness of Systems Approaches in Addressing Food Systems Innovations
Kate Clancy, Johns Hopkins University

Future of the Future of Food Systems
Roni Neff, Planning Committee Member, Johns Hopkins University

10-Minute Discussion/Q&A

9:30 AM **SESSION 2: Game-Changing Innovations in Food Production, Processing, and Packaging, and Implications for Food Systems**
Session Moderator: Helen Jensen, Planning Committee Member, Iowa State University

Food Systems Linkage to Rural Economic Development
Becca Jablonski, Colorado State University

Urban Food System Innovations—Multiscale Modeling and Action Analysis
Anu Ramaswami, Princeton University

Blockchain and Implications for the Food System
Dawn Jutla, Peer Ledger Inc.

15-Minute Discussion/Q&A

10:45 AM **15-Minute Break**

11:00 AM **SESSION 3: Game-Changing Innovations in Alternative Food Production and Implications for Food Systems**
Moderator: Naomi Fukagawa, Planning Committee Member, U.S. Department of Agriculture

How Game-Changing Is Alternative Food Production for the Entire Food System?
Jan Dutkiewicz, Johns Hopkins University

Alternative Food Production Systems: The Science and Implications
James Reecy, Iowa State University

Alternative Food Production: Consumer Concerns
Michael Hansen, Consumer Reports

15-Minute Discussion/Q&A

12:15 PM **Lunch**

1:30 PM **SESSION 4: Game-Changing Innovations in Food Distribution and Implications for Food Systems**
Moderator: Helen Jensen, Planning Committee Member, Iowa State University

Innovations in Logistics
Michelle Miller, University of Wisconsin

Innovations in Food Packaging
Claire Sand, Packaging Technology and Research, LLC

Considerations for the Use of Autonomous Vehicles and Drones in Sustainable Food Distribution
Brent Heard, University of Michigan

15-Minute Discussion/Q&A

2:45 PM **15-Minute Break**

3:00 PM **SESSION 5: Game-Changing Innovations in Food Marketing and Food Value Chains and Implications for Food Systems**
Moderator: Christina Khoo, Planning Committee Member, Ocean Spray Cranberries, Inc.

Water/Land Use: Considerations for Feasibility of Value Chains and the Food System
Christian Peters, Tufts University

Innovations for Supporting Contracting in Supply Chains
Jill McCluskey, Washington State University

Production Claims and Consumer Behavior/Marketing Channels
Brenna Ellison, University of Illinois at Urbana-Champaign

15-Minute Discussion/Q&A

4:15 PM **Exploring Cases of Food System Evolution: Federal Government and Business**
Moderator: Jennifer Otten, Planning Committee Member, University of Washington

How Food Systems Are Evolving Within Federal Programs
Tricia Kovacs, U.S. Department of Agriculture

The Food Asset Potential
Thomas McQuillan, Baldor Specialty Foods

~30-Minute Discussion/Q&A

5:30 PM **Adjourn Day 1**

DAY 2, AUGUST 8, 8:30 AM–12:00 PM

8:30 AM **Welcome and Opening Remarks**
Sylvia Rowe, Food Forum Chair, SR Strategy, LLC

8:35 AM **Brief Recap of Day 1**
Jean Halloran, Planning Committee Member, Consumer Reports

8:45 AM **SESSION 6: Game-Changing Innovations in Food Data and Analytics and Implications for Food Systems**
Moderator: Christina Khoo, Planning Committee Member, Ocean Spray Cranberries, Inc.

Scaling Food Waste Prevention Globally Through Measurement and Analytics
Steve Finn, Leanpath

Innovations to Mitigate Food Waste: From the Farm to the Consumer
Norbert Wilson, Tufts University

Modeling the Nutritional Implications of Food Waste Mitigation
Brad Rickard, Cornell University

15-Minute Discussion/Q&A

10:00 AM **SESSION 7: Game-Changing Innovations in Food Access and Affordability and Implications for Food Systems**
Moderator: Roni Neff, Planning Committee Member, Johns Hopkins University

Redesigning Food Access
Nevin Cohen, City University of New York

Black Church Food Security Network
Rev. Dr. Heber Brown III, Pleasant Hope Baptist Church, Baltimore, MD

Food Quality in Food Assistance/Emergency Food
Rhonda Gonzalez, Community Food Bank of Southern Arizona

15-Minute Discussion/Q&A

11:15 AM **15-Minute Break**

11:30 AM **Workshop Closing Discussion: Evolution and Revolution of Our Food Systems**
Moderator: Naomi Fukagawa, Planning Committee Member, U.S. Department of Agriculture

Panelists:
Jean Halloran, Planning Committee Member, Consumer Reports
Helen Jensen, Planning Committee Member, Iowa State University
Christina Khoo, Planning Committee Member, Ocean Spray Cranberries, Inc.
Roni Neff, Planning Committee Member, Johns Hopkins University
Jennifer Otten, Planning Committee Member, University of Washington

12:00 PM **Adjourn Workshop**

B

Acronyms and Abbreviations

CAFS	Center for Agriculture and Food Systems
CO_2	carbon dioxide
CSA	community-supported agriculture
EFSNE	Enhancing Food Security in the Northeast
EPA	U.S. Environmental Protection Agency
FAA	U.S. Federal Aviation Administration
FAO	Food and Agriculture Organization of the United Nations
FDA	U.S. Food and Drug Administration
FQHC	federally qualified health center
GHG	greenhouse gas
GMO	genetically modified organism
GRAS	Generally Recognized As Safe
HHS	U.S. Department of Health and Human Services
IOM	Institute of Medicine
IPCC	Intergovernmental Panel on Climate Change
LAMP	Local Agriculture Markets Program
LFPP	Local Food Promotion Program

NAMI	North American Meat Institute
NCSA	National Center for Statistics and Analysis
NFSN	National Farm to School Network
NRC	National Research Council
PET	polyethylene terephthalate
PPS	Project for Public Spaces
SDG	Sustainable Development Goal
SNAP	Supplemental Nutrition Assistance Program
TEFAP	The Emergency Food Assistance Program
UNEP	United Nations Environment Programme
UNIA	Universal Negro Improvement Association
USDA	U.S. Department of Agriculture
WEF	World Economic Forum

C

Biographical Sketches of Workshop Speakers and Moderators

Reverend Dr. Heber Brown III, M.Div., is the founding executive director of the Black Church Food Security Network, which represents an asset-based approach to advancing food and land sovereignty by organizing the vast resources of historical African American congregations in both rural and urban communities. The organization works with congregations to establish gardens and agricultural projects on black church–owned land. It also links farmers with congregations for niche farmers' markets that are housed inside places of worship. Reverend Dr. Brown earned a B.S. in psychology from Morgan State University, his M.Div. degree from the Samuel DeWitt Proctor School of Theology at Virginia Union University in Richmond, and a doctor of ministry degree from Wesley Theological Seminary in Washington, DC.

Kate Clancy, Ph.D., is currently a food systems consultant; a visiting scholar at the Center for a Livable Future at the Johns Hopkins Bloomberg School of Public Health; an adjunct professor at Tufts University; a visiting teaching professor at the Falk College at Syracuse University; and a senior fellow in the Minnesota Institute for Sustainable Agriculture at the University of Minnesota. Her resumé includes positions at Cornell University and Syracuse University and sabbatical appointments at the University of Wisconsin and the University of Minnesota, the latter as a rotating endowed chair in 2007. She has worked as a nutrition and policy advisor at the Federal Trade Commission and at several nonprofits, such as the Wallace Center. Dr. Clancy developed a graduate course on food systems in 1982 and since then has published, taught, spoken, and consulted widely on sustainable agriculture,

food systems, and food policy with government agencies, universities, and nonprofits around the country. She coined the term "sustainable diets" in 1983 and continues to work on that issue. She has served on many boards, including those of the Society for Nutrition Education and Behavior, Bread for the World, and the Henry A. Wallace Institute for Alternative Agriculture. She was the deputy director of the U.S. Department of Agriculture–funded 7-year Enhancing Food Security in the Northeast systems project in the Northeast United States and engages with many initiatives, including Agriculture of the Middle and It Takes a Region. She publishes a column in the *Journal of Agriculture, Food Systems, and Community Development* on topics related to the application of systems concepts to food systems. Dr. Clancy earned her doctorate in nutrition at the University of California, Berkeley.

Nevin Cohen, Ph.D., M.C.R.P., is an associate professor at the City University of New York (CUNY) Graduate School of Public Health and Health Policy and the research director of the CUNY Urban Food Policy Institute. His research explores the policies, governance systems, practices, and infrastructure needed to support socially just, healthy, ecologically resilient, and economically viable urban and regional food systems. Current projects include a five-country analysis of urban agriculture; research on food retail access; a study of the intersections of zoning, planning, and food gentrification; and the effects of social equity policies on food systems. Dr. Cohen is the co-author of *Beyond the Kale: Urban Agriculture and Social Justice Activism in New York City* (University of Georgia Press), which examines the potential of urban farms and gardens to address racial, gender, and class oppression. He holds a Ph.D. in urban planning and policy development from Rutgers University; a master's degree in city and regional planning from the University of California, Berkeley; and a B.A. from Cornell University.

Jan Dutkiewicz, Ph.D., M.Phil., M.A., M.B.A., is the Connie Caplan postdoctoral fellow in American politics at Johns Hopkins University. His research examines the relationship between corporate and political power in the American food system. Dr. Dutkiewicz's scholarly work has been published in an interdisciplinary range of academic journals; he has also written for newspapers, including *The Guardian* and *The Washington Post*; and his research has been covered by *The Wall Street Journal*, CNN, and NPR, among other major news outlets. He just completed the manuscript of his first book, *An Industry Like Any Other*, which examines how the American meat industry shapes policy and politics, food choices, and ethical debates about farmed animals in the contemporary United States. Dr. Dutkiewicz holds an M.A. from Victoria University, an M.B.A. from Carleton University, and a Ph.D. and an M.Phil. in politics from the New School for Social Research.

Brenna Ellison, Ph.D., is an associate professor in the Agricultural and Consumer Economics Department and a faculty affiliate in the Division of Nutritional Sciences at the University of Illinois at Urbana-Champaign. Her research and teaching programs focus on how people make food choices, particularly how information and other environmental factors impact those choices. More recently, her research portfolio includes work on how people decide what not to eat or waste. She has published more than 25 peer-reviewed articles and delivered more than 45 presentations to academic, industry, and policy audiences. Dr. Ellison received her Ph.D. from Oklahoma State University.

Steven Finn, M.B.A., M.S., M.Phil., is the vice president of food waste prevention for Leanpath, the global leader in integrated hardware and software solutions for food waste prevention, where he helps clients take control of their food waste while engaging employees in creating a culture of food waste prevention. Mr. Finn combines 25 years of strategy and control experience in the supply chain sector with a passion for sustainability and conscious capitalism. He has conducted extensive research into the problems of global food waste and food security while developing innovative public–private partnerships to capture and redistribute excess food to mitigate hunger. He is a frequent speaker on food waste issues; served as the co-chair of The Last Food Mile conference in Philadelphia; and was a steering committee member for Feeding the 5000 in Portland, Maine. Mr. Finn teaches "Global Pennovation"—a project-based graduate class focused on innovation for sustainability, which engages students to address the world's most pressing sustainability problems. He is the author of several articles on food waste and has served as director for three nonprofit organizations in the food sector. He is the author of the blog FoodForThoughtfulAction. Mr. Finn holds a B.A. in economics from the University of Delaware, an M.B.A. in finance from West Virginia University, and an M.S. and an M.Phil. in organizational dynamics from the University of Pennsylvania.

Naomi K. Fukagawa, M.D., Ph.D., is the director of the U.S. Department of Agriculture's (USDA's) Beltsville Human Nutrition Research Center in Maryland. She previously served as a professor of medicine and an acting director of the Gerontology Unit at the University of Vermont in Burlington. Dr. Fukagawa is a board-certified pediatrician and an expert in nutritional biochemistry and metabolism, including protein and energy metabolism; oxidants and antioxidants; and the role of diet in aging and chronic diseases, such as diabetes mellitus. She has served on numerous National Institutes of Health (NIH) review panels, served as the chair of the NIH study section for General Clinical Research Centers, and completed a 5-year term on the NIH Integrated Physiology of Obesity and Diabetes

Study Section. Her national and international recognition is illustrated by her membership in the American Society for Clinical Investigation; election as the president of the American Society for Clinical Nutrition (American Society for Nutrition); and service as an associate editor for the *American Journal of Clinical Nutrition*, as the editor-in-chief of *Nutrition Reviews*, and as the vice-chair of the 2010 Dietary Guidelines Advisory Committee of USDA and the U.S. Department of Health and Human Services. Her clinical training included residency at the Children's Hospital of Philadelphia, University of Pennsylvania; chief residency at the University of Vermont; and nutrition/gerontology fellowships at the Children's Hospital and Beth Israel Hospital, Harvard Medical School. Dr. Fukagawa has maintained an active research laboratory, where her work ranges from cells and animals to in vivo studies in human volunteers. Her present work focuses on the impact of environmental stressors (metabolic or physical) on human health, specifically the health effects of exposure to petrodiesel and biodiesel exhaust. She received her Ph.D. from the Massachusetts Institute of Technology and her M.D. from Northwestern University.

Rhonda Gonzalez, M.S.P.H., is the director of health initiatives at the Community Food Bank of Southern Arizona (CFB), located in Tucson. In addition to overseeing the development, implementation, and evaluation of CFB's health and nutrition education projects and nutritional analysis activities, she leads the teams responsible for community health care partnership building for the organization. In this role, she plans and develops strategies, actions, research, and/or interventions aimed at linking healthy food with health outcomes and increasing the implementation and sustainability of health initiatives across CFB's five-county service area, as well as the organization's farm and garden programs and the Community Organizing team. With more than 15 years of combined experience in health and community development, Ms. Gonzalez has worked at the local, national, and international levels. She began her career in maternal and child health policy at a national nonprofit organization and worked in Australia for an indigenous community development organization. She has also served as the executive director for a nonprofit organization facilitating binational physician and medical researcher exchanges between Australia and Israel. Ms. Gonzalez received a B.A. from the University of Arizona and an M.S.P.H. from the University of Colorado.

Jean Halloran is the director of food policy initiatives at Consumer Reports. At Consumer Reports, she has led many projects on food safety, sustainable consumption, and trade issues. She is currently responsible for developing policy and staff initiatives on reducing antibiotic use in livestock and antibiotic resistance, as well as labeling of genetically engineered food. As

director of the Consumers Union Consumer Policy Institute from 1981 to 2005, Ms. Halloran developed and supervised conferences, reports, and input to government agencies on pesticides, sustainable agriculture, organic labeling, toxic chemicals, and waste recycling, as well as intellectual property issues and health care, funded by the National Science Foundation, government agencies, and numerous private foundations. She previously served on the U.S. Department of State's Advisory Committee on International Economic Policy; the National Academies of Sciences, Engineering, and Medicine's Board on Agriculture and Natural Resources; and the U.S. Food and Drug Administration's Food Advisory Committee. Ms. Halloran helped organize the TransAtlantic Consumer Dialogue, a coalition of groups in Europe and the United States, and serves as its U.S. liaison point. She represented Consumers International at Codex Alimentarius in the development of standards for safety assessment of genetically engineered foods. Ms. Halloran received her B.A. with honors from Swarthmore College.

Michael Hansen, Ph.D., is the senior scientist of advocacy with Consumer Reports, where he has worked for more than 25 years. He develops policy; testifies at hearings in Washington, DC, many states, and Canada; and has prepared comments on many proposed U.S. governmental rules and regulations on a variety of critical food safety and environmental health issues, including genetic engineering, mad cow disease, and antibiotic use in agriculture. He also speaks on Consumer Reports' concerns on these issues at meetings and conferences around the world. Additionally, he represents Consumers International, a federation of more than 200 consumer organizations in 110 countries, at Codex Alimentarius, the food standards–setting organization of the United Nations, and other international fora. Dr. Hansen has served as an international expert on three different Food and Agriculture Organization/World Health Organization Joint Expert Committees (1998, 2003, and 2007) dealing with genetic engineering and food safety assessments for food derived from genetically engineered animals. Dr. Hansen received his undergraduate degree from Northwestern University and his doctorate from the University of Michigan. He did postgraduate work at the University of Kentucky on the impacts of biotechnology on agricultural research.

Brent Heard is a Ph.D. candidate with the Center for Sustainable Systems at the University of Michigan's School for Environment and Sustainability. Mr. Heard's work examines the sustainability implications of emerging technologies in the food system. He recently published a comparative life-cycle assessment of meal kits and grocery store meals, and he has also published research assessing the environmental impacts of autonomous vehicles in the food supply chain, as well as the effects of refrigerated supply chain introduction in developing food systems. Additionally, he has worked as a

consultant and sustainability fellow for the National Academies of Sciences, Engineering, and Medicine's Science and Technology for Sustainability Program. Mr. Heard's Ph.D. advisor is Dr. Shelie Miller, and he received a B.S. from Carnegie Mellon University with a double major in economics and environmental policy and a minor in technology and policy.

Becca Jablonski, Ph.D., is an assistant professor and a food systems extension economist in the Department of Agricultural and Resource Economics at Colorado State University. In this position, she facilitates the Colorado Governor's Food Systems Advisory Council and is a co-leader of Colorado State University's Food Systems Extension Team. Dr. Jablonski's research and extension program comprises two primary components: (1) evaluating the farm and ranch profitability impacts of sales through noncommodity markets (e.g., local food markets, certification, or other product differentiation strategies); and (2) assessing the community economic impacts of food system policies, investments, and programs. Dr. Jablonski holds a Ph.D. from Cornell University.

Helen H. Jensen, Ph.D., is a professor emerita of economics at Iowa State University and is affiliated with the Center for Agricultural and Rural Development (CARD), an internationally recognized research center that addresses issues of the food, agriculture, and natural resource sectors. Her research addresses the economics and design of food and nutrition programs and policies, food insecurity, food demand and markets, and food safety regulations, building on strong, interdisciplinary collaborations. For nearly 30 years, Dr. Jensen led a research program in CARD that applies economic theories to problems related to food and nutrition policies, including evaluations of the costs and effectiveness of nutritional and dietary interventions and policies. She was elected a fellow of the Agricultural & Applied Economics Association in 2012. She has served on several committees of the National Academies of Sciences, Engineering, and Medicine, including the recent committees on science breakthroughs to advance food and agricultural research and the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) food packages. She was also a member of the World Health Organization Initiative to Estimate the Global Burden of Foodborne Diseases, Foodborne Disease Burden Epidemiology Reference Group (Policy Subgroup). Dr. Jensen holds a B.A. in economics from Carleton College, an M.S. in agricultural economics from the University of Minnesota, and a Ph.D. in agricultural and applied economics from the University of Wisconsin–Madison.

Dawn Jutla, Ph.D., M.Sc., is the founder, president, and board chair of Peer Ledger, a company founded in 2016. The company makes the MIMOSI

SaaS application for responsible sourcing, which is built on Hyperledger Fabric, an open-source blockchain platform in the Hyperledger family. MIMOSI on Hyperledger Fabric enables organizations to collaboratively track and trace food, livestock, and other items across all tiers of their supply chains in seconds. Leveraging the blockchain's single source of truth and immutability properties, complementary materials authentication, and Internet-of-things technologies, the MIMOSI application's new multitier supply chain transparency and smart contracts provide further controls to help counteract food or materials fraud and fight modern slavery and environmental harms. Dr. Jutla spent more than 20 years doing multidisciplinary research and development (R&D) in computer science and business at the Sobey School of Business, where she founded the Master of Technology Entrepreneurship and Innovation program 7 years ago. She currently holds the post of the Scotiabank professor of technology entrepreneurship and innovation. Over her career, she has co-authored more than 90 peer-reviewed scientific publications and earned a World Technology Award for IT Software in the Individual Category for her R&D contributions to online privacy. She is the co-author of a Pearson IT Professional Series book titled *e-Business Readiness: A Customer-Focused Framework*. Dr. Jutla has 15 years of cumulative board experience across several industries. She has served as a director of OASIS, a U.S.-headquartered international standards consortium; a governor of Saint Mary University (Canada); and a director on the Board of the IWK Health Centre. Dr. Jutla received her master's and Ph.D. degrees in computer science in the areas of distributed shared memory and multiview access control, respectively, from the Technical University of Nova Scotia/Dalhousie University.

Christina Khoo, Ph.D., is the director of scientific affairs, Ocean Spray Cranberries, Inc., having joined the farmer-owned cooperative in 2007. Dr. Khoo has been instrumental in directing Ocean Spray's research activity to help address the public health issue of urinary tract infection, cranberry benefits, and antibiotic resistance. At Ocean Spray, she has been responsible for managing nutrition science, regulatory, and analytical teams; co-leading health communication strategies and outreach; and actively participating in government affairs initiatives. She is currently responsible for leading the review of functional ingredients and technology to support the growth of Ocean Spray's health and wellness portfolio. She is on the board of the Juice Products Association and the National Berry Crops Initiative, a partnership of industry, academia, and government formed to develop a strategic plan for the continued growth and sustainability of berry crop production in the United States. As a science and technology leader in industry, Dr. Khoo has played an active role in cross-sector collaboration. She is currently chair of the International Life Sciences Institute's Bioactives Committee and is former

chair of the American Heart Association's Industry Advisory Panel. Dr. Khoo has published in many peer-reviewed journals, including the *Journal of Nutrition*, *American Journal of Clinical Nutrition*, and *Journal of Agriculture and Food Chemistry*, and has also written several chapters for two volumes of *Polyphenols in Health and Diseases*. As a postdoctoral fellow at the Harvard T.H. Chan School of Public Health, her research focus was in the area of diet and cardiometabolic conditions, studying the effects of diets on the metabolism of triglycerides using kinetic modeling. Dr. Khoo received her doctorate with emphasis on nutritional biochemistry at the Food Science and Human Nutrition Department at the University of Florida.

Tricia Kovacs, M.Sc., is a local and regional food systems policy advisor in the Agricultural Marketing Service of the U.S. Department of Agriculture (USDA), where she coordinates efforts across USDA to support the local and regional food sector—including direct-to-consumer; farm-to-institution; and regional processing, aggregation, and distribution. She also works on food safety priorities and represents USDA as a convener on the Food Safety Modernization Act Collaborative Training Forum. Prior to joining USDA, Ms. Kovacs managed regional markets programs at the Washington State Department of Agriculture, where she was founding program manager for the state Farm to School Program and also led the Small Farm Direct Marketing Program. Ms. Kovacs was lead author on publications that help farmers and buyers understand complex market requirements, including *Bridging the GAPs Farm Guide: Good Agricultural Practices and On-Farm Food Safety for Small*, *Mid-Sized and Diversified Fruit and Vegetable Farms*, and *A School's Guide to Buying Washington-Grown Food*. Ms. Kovacs holds a B.A. from the University of Virginia and an M.Sc. in sustainability, planning, and environmental policy from Cardiff University in Wales.

Jill McCluskey, Ph.D., is the Regents professor and a distinguished professor of sustainability in the School of Economic Sciences (SES) at Washington State University. She is the director of SES and served as the associate director from 2015 to 2019. Dr. McCluskey's research focuses on product quality and reputation, sustainable labeling, consumer preferences for new technology, and representation of women in science, technology, engineering, and mathematics. An award-winning researcher, she has published more than 100 journal articles, many of which are highly cited. Her research has been funded by private foundations, the National Science Foundation, and the U.S. Department of Agriculture. She has served as major professor to 37 Ph.D. graduates. She is the past president and a fellow of the Agricultural & Applied Economics Association and a fellow of the Western Agricultural Economics Association. She is a member of the Board

on Agricultural and Natural Resources of the National Academies of Sciences, Engineering, and Medicine. Her research has been highlighted by various media outlets, including *The New York Times*, NPR, and *Newsday*. She received her Ph.D. in agricultural and resource economics in 1998 from the University of California, Berkeley.

Thomas McQuillan, M.B.A., is the vice president of strategy, culture, and sustainability at Baldor Specialty Foods, Inc. From 2002 to 2014, he managed the finances of the IDC Corporation and subsequently became its president. As the president, he transformed a distressed, privately owned construction materials distribution company with negative profits into a best-in-class enterprise. Over his more than 10 years with IDC, Mr. McQuillan created and executed strategic initiatives that reduced debt and cash flow challenges while increasing sales, enhancing operational efficiency, and elevating customer satisfaction. In 2012, he sold IDC to Distribution International, based in Houston, and he remained as president of IDC until March 2014. In 2015, Mr. McQuillan joined Baldor Specialty Foods, Inc., located in the Bronx, New York, for which he serves on the executive team. As the director of food service sales and sustainability, he was tasked with creating the strategic plan to make Baldor's practices more sustainable. He spearheaded the SparCs ("scraps" spelled backward) initiative to reduce food waste throughout the company. Baldor's sustainability initiatives are also focused on overall waste reduction throughout the organization, and to that end, the company also launched a number of initiatives to become more energy-efficient. In 2016, Mr. McQuillan assumed the role of the director of food service sales and sustainability. Servicing the restaurant trade for more than 25 years is the core of Baldor's business; delivering world-class customer service and the highest-quality produce and specialty food items on time and completely is its mission, as well as Mr. McQuillan's number one priority. In 2018, he was promoted to the vice president of strategy, culture, and sustainability. The primary sustainability objective this year is to achieve the goal of zero organics waste to landfill company-wide. Mr. McQuillan earned his M.B.A. from St. John's University.

Michelle Miller, M.S., is the researcher and the associate director at the Center for Integrated Agricultural Systems, the sustainable agriculture research center on the University of Wisconsin–Madison campus. She is a practicing economic anthropologist engaged in participatory action research with farmers and their communities. She was in the first cohort of the Donella Meadows Leaders Fellowship at the Sustainability Institute. In the 1990s, Ms. Miller worked for the World Wildlife Fund on agricultural pollution prevention. Since 2000, she has worked with fruit growers to assist them in their efforts to reduce pesticide risk and build regional

markets. Her current projects focus on agriculture of the middle and regional food economies, food freight transportation and logistics, labor and land tenure, perennial agriculture, resiliency, and climate change. She serves on the standing committee on agriculture and food transportation of the National Academies of Sciences, Engineering, and Medicine's Transportation Research Board and on Google's Refresh: Food + Tech panel. Ms. Miller holds an M.S. in environmental studies from the University of Wisconsin–Madison.

Roni Neff, Ph.D., Sc.M., is an associate professor in the Departments of Environmental Health and Engineering and Health Policy and Management at the Johns Hopkins Bloomberg School of Public Health. She also directs the Food System Sustainability and Public Health program at the Johns Hopkins Center for a Livable Future, an academic center focused on food systems and public health. Dr. Neff's work is driven by concern about the challenges of meeting future food needs, about food's outsized impact on global environmental challenges, and about the inequities that threaten current and future food security. Her research, policy, and practice efforts focus in three main areas: (1) wasted food, (2) sustainable and plant-based diets, and (3) urban food system resilience. She has worked closely with the city of Baltimore to support its food system resilience planning, and is currently working to develop indicators for use in modeling and for enabling cities to track progress. She uses qualitative and quantitative tools to explore the social and policy questions involved in understanding and addressing these food system challenges, with particular focus on consumer behavior and communications. She is especially interested in grappling with the complex social realities that complicate well-meaning public health efforts. Dr. Neff edited the first-ever textbook on food systems and public health. She is a member of the National Academies of Sciences, Engineering, and Medicine's Food Forum and is currently serving on its panel on preventing consumer food waste. She is on the board of the Agriculture, Food and Human Values Society, among other leadership roles. She received her A.B. from Brown University, a master's degree from the Harvard T.H. Chan School of Public Health, and a Ph.D. from the Johns Hopkins Bloomberg School of Public Health.

Jennifer Otten, Ph.D., M.S., R.D., is an associate professor in the Department of Environmental and Occupational Health Sciences, core faculty and the food systems director in the Nutritional Sciences Program, and affiliated with the Center for Public Health Nutrition at the University of Washington. Between 1998 and 2006, Dr. Otten served in various capacities for the Institute of Medicine (IOM), including as a study director and as the organization's first communications director. During this time, she

managed and staffed the inaugural years of the Kellogg Health of the Public Fund and served as a study director and the co-editor for the IOM report *Dietary Reference Intakes: The Essential Guide to Nutrient Requirements*. Dr. Otten received her B.S. in nutritional sciences from Texas A&M University; her M.S. in nutrition communications from Tufts University; and her Ph.D. in animal, nutrition, and food sciences from the University of Vermont. She completed a postdoctoral research fellowship at the Stanford Prevention Research Center in the Stanford University School of Medicine and a dietetic internship at Massachusetts General Hospital, Boston.

Christian Peters, Ph.D., M.S., is an associate professor at the Friedman School of Nutrition Science and Policy at Tufts University. Dr. Peters studies the sustainability of food systems using computational modeling and through interdisciplinary research. He is interested in understanding how dietary patterns influence sustainability, how much food can be supplied through locally and regionally scaled systems, and how transdisciplinary approaches can help design and study such systems. Since joining the faculty of the Friedman School in 2010, Dr. Peters has been engaged in multiple collaborative research projects on regional food systems and sustainable diets. Some of his best-known work includes development of a framework for estimating the land requirements of diets and human carrying capacity and a spatial modeling approach for mapping potential foodsheds. Dr. Peters teaches in the Agriculture, Food, and Environment program, where he offers courses in agricultural science and policy and food systems modeling. He received his B.S. in environmental sciences from Rutgers, The State University of New Jersey, and his M.S. and Ph.D. in soil and crop sciences from Cornell University.

Anu Ramaswami, Ph.D., is a professor in the Departments of India Studies and Civil and Environmental Engineering and at the Princeton Environmental Institute at Princeton University. She is an interdisciplinary environmental engineer recognized as a pioneer and a leader on the topic of sustainable urban systems. Her work takes a whole urban systems approach, exploring how seven key sectors that provide water, energy, food, buildings, mobility, connectivity, waste management, and green/public spaces shape human and environmental well-being from local to global scales. She brings expertise across multiple disciplines—environmental science, engineering, industrial ecology, public health, and public affairs—with a human-centered and systems approach. She was appointed in August 2019 as the inaugural director of the M.S. Chadha Center for Global India at the Princeton Institute for International and Regional Studies. She is also the lead principal investigator and the director of the National Science Foundation (NSF)-supported Sustainable Healthy Cities Network, which

spans nine universities and engages with several cities across the United States and internationally on topics related to urban infrastructure. Dr. Ramaswami is a member of the United Nations Environment Programme's International Resource Panel and NSF's Advisory Committee for Environmental Research and Education, and she has been elected the chair of the 2020 Gordon Research Conference on Industrial Ecology. She received her B.S. in chemical engineering from the Indian Institute of Technology Madras in Chennai and her Ph.D. in civil and environmental engineering from Carnegie Mellon University.

James Reecy, Ph.D., M.S., currently serves as an associate vice president for research, overseeing the Office of Sponsored Programs Administration and internal funding programs and fostering the development of interdisciplinary teams at Iowa State University. He joined the faculty of Iowa State University in February 1999 and is currently a professor in the Department of Animal Science. He served as the director of the Office of Biotechnology, which administered 10 fee-for-service core facilities for 10 years. Dr. Reecy currently is the NRSP-8 database coordinator, where he leads national efforts to improve the computational resources available for genomics research on livestock species. In addition, he is currently serving as a 2018 fellow of the Association of Public & Land-grant Universities' Council on Research. During his career, Dr. Reecy has worked on problems in ruminant nutrition, skeletal muscle growth and development, embryonic heart development, beef and mouse molecular and quantitative genetics, and livestock bioinformatics. His lab has worked on beef cattle molecular genetics, with a focus on improving the nutrient content of beef and the health of cattle, as well as on the development of database resourced to facilitate genomics research. Dr. Reecy received a B.S. from South Dakota State University, an M.S. from the University of Missouri, Columbia, and a Ph.D. from Purdue University.

Bradley Rickard, Ph.D., is the Ruth and William Morgan associate professor in the Charles H. Dyson School of Applied Economics and Management at Cornell University. He has published widely in the area of food and agricultural economics, with a specific interest in addressing contemporary marketing and policy issues in specialty crop markets. His recent work has examined consumer response to changes in nutrition and health information, food labeling practices, promotional efforts, the role of information on food waste patterns, agricultural policy reform, and the introduction of new technologies. His research has been highlighted by various media outlets, including *Buffalo News*, *The Economist*, Freakonomics.com, NPR, *The Wall Street Journal*, *The Washington Post*, and *Wine Spectator*. Dr.

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Norbert Wilson, Ph.D., M.Sc., is a professor of food policy in the Friedman School of Nutrition Science and Policy at Tufts University. His research centers on food choice and food waste. Dr. Wilson uses experimental economics to explore how date labels influence future food waste, as well as behavioral underpinnings of food choice. He studies differences in food security across groups in the United States. Additionally, he has worked on food safety and quality issues in international trade and domestic food systems. He has also published analyses of coffee quality and prices. Dr. Wilson has published in *American Economic Review: Papers and Proceedings*; *World Development*; *American Journal of Agricultural Economics*; *Journal of Public Health*, *Food Policy*, and *Agricultural Economic*s, among others. Before joining the Friedman School, Dr. Wilson was a professor of agricultural economics at Auburn University (1999–2016). He was an economist/policy analyst in the Trade Directorate (2004–2006) and the Agriculture Directorate (2001–2002) of the Organisation for Economic Cooperation and Development in Paris. In 2014–2015, he was on sabbatical leave at the Charles H. Dyson School of Applied Economics and Management at Cornell University. Dr. Wilson earned his doctorate in agricultural and resource economics from the University of California, Davis, and completed his master's in agricultural economics from Wye College, University of London, United Kingdom, where he was a Rotary international fellow.