Institute on Science for Global Policy (ISGP)

Food Safety, Security, and Defense: *Food Security and Diet-Linked Public Health Challenges*

Conference organized and convened by the ISGP in partnership with North Dakota State University, Fargo, North Dakota, United States
September 20–23, 2015

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An ongoing series of dialogues and critical debates
examining the role of science and technology
in advancing effective domestic and international policy decisions

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Introduction

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Preface

The contents of this book were taken from material presented at an international conference convened by the Institute on Science for Global Policy (ISGP) on September 20-23, 2015, in partnership with North Dakota State University, in Fargo, North Dakota. This ISGP conference, the first on Nutrition, Sustainable Agriculture, and Human Health in the ISGP series on Food Safety, Security, and Defense (FSSD), focused on Food Security and Diet-Linked Public Health Challenges.

The process underlying the organization of all ISGP conferences begins with the recognition that there are significant advances and changes in several scientific fields (e.g., FSSD) that can be anticipated to have a major impact throughout societies worldwide. The significance of these advances internationally depends on how they affect the human condition as viewed through different cultural, ethical, and economic systems. Decisions within each society concerning how to appropriately incorporate such transformational science into public and private sector policies rely on candid debates that highlight the credible options developed by scientists and technologists. Since FSSD can potentially have such significant impact worldwide, it deserves attention from both domestic and international policy makers from a wide range of disciplines. ISGP conferences offer one of those rare environments where such critical debates can occur among credible scientists, influential policy makers, and a broad range of societal stakeholders.

Based on extensive interviews conducted by the ISGP staff with an international group of subject-matter experts, the ISGP invited eight highly distinguished individuals with expertise in nutrition, sustainable agriculture, and human health to prepare the three-page policy position papers to be debated at the Fargo conference. These eight policy position papers, together with the not-for-attribution summaries of the debates of each paper, are presented in this book. The areas of consensus and actionable next steps that were developed by all participants in the caucuses that followed the debates are also presented. The debate summaries and caucus results

were written by the ISGP staff and are based on contributions from all conference participants.

Current realities

While the material presented here is comprehensive and stands by itself, its policy significance also can be viewed within the context of how domestic and international science policies have been, and often currently are being, formulated and implemented. While many of our most significant geopolitical policy and security issues are directly connected with the remarkably rapid and profound S&T accomplishments of our time, many societies struggle to effectively use S&T to address their specific challenges. Consequently, it is increasingly important that the S&T and policy communities (public and private sectors) communicate effectively. Recent history suggests that most societies would benefit from improving the effectiveness of how scientifically credible information is used to formulate and implement governmental policies, both domestic and international.

Specifically, credible S&T information needs to be concisely presented to policy communities in an environment that promotes candid questions and debates led by those nonspecialists directly engaged in decisions. Such discussions, sequestered from publicity, can help to clarify the advantages and potential risks of realistic S&T options directly relevant to the societal challenges being faced. Eventually, this same degree of understanding, confidence, and acknowledgment of risk must be communicated to the public to obtain the broad societal support needed to effectively implement any decision.

The ISGP has pioneered the development a new type of international forum designed to provide articulate, distinguished scientists and technologists opportunities to concisely present their views of the credible S&T options available for addressing societal issues.

All ISGP programs rely on the validity of two overarching principles:

1. Scientifically credible understanding must be closely linked to the realistic policy decisions made by governmental, private sector, and societal leaders in addressing both the urgent and long-term challenges facing 21st century societies. Effective decisions rely on strong domestic and global public endorsements that motivate the active political support required to implement progressive policies.
2. Communication among scientific and policy communities requires significant improvement, especially concerning decisions on whether to embrace or reject the often transformational S&T opportunities

continually emerging from the global research communities. Effective decisions are facilitated in venues where the advantages and risks of credible S&T options are candidly presented and critically debated among internationally distinguished subject-matter experts, policy makers, and private sector and community stakeholders.

Historical perspective

The dramatic and rapid expansion of academic and private sector scientific research transformed many societies of the 20th century and is a major factor in the emergence of the more affluent countries that currently dominate the global economic and security landscape. The positive influence of these S&T achievements has been extremely impressive and in many ways the hallmark of the 20th century. However, there have also been numerous negative consequences, some immediately apparent and others appearing only recently. From both perspectives, it would be difficult to argue that S&T has not been the prime factor defining the societies we know today. Indeed, the 20th century can be viewed through the prism of how societies decided to use the available scientific understanding and technological expertise to structure themselves. Such decisions helped shape the respective economic models, cultural priorities, and security commitments in these societies.

It remains to be seen how the prosperity and security of 21st century societies will be shaped by the decisions made by our current leaders, especially with respect to how these decisions reflect sound S&T understanding.

Given the critical importance of properly incorporating scientifically credible information into major societal decisions, it is surprising that the process by which this is achieved by the public and its political leadership has been uneven and, occasionally, haphazard. In the worst cases, decisions have been based on unrecognized misunderstanding, overhyped optimism, and/or limited respect for potentially negative consequences. Retrospectively, while some of these outcomes may be attributed to politically motivated priorities, the inability of S&T experts to accurately communicate the advantages and potential risks of a given option must also be acknowledged as equally important.

The new format pioneered by the ISGP in its programs seeks to facilitate candid communication between scientific and policy communities in ways that complement and support the efforts of others.

It is important to recognize that policy makers routinely seek a degree of certainty in evaluating S&T-based options that is inconsistent with reality, while S&T experts often overvalue the potentially positive aspects of their proposals. Finite uncertainty is always part of advanced scientific thinking and all possible positive

outcomes in S&T proposals are rarely realized. Both points need to be reflected in policy decisions. Eventually, the public needs to be given a frank, accurate assessment of the potential advantages and foreseeable disadvantages associated with these decisions. Such disclosures are essential to obtain the broad public support required to effectively implement any major decision.

ISGP conference structure

At each ISGP conference, internationally recognized subject-matter experts are invited to prepare concise (three-page) policy position papers. For the September 20-23, 2015 ISGP conference near Fargo, these papers described the authors' views on current realities, scientifically credible opportunities and associated risks, and policy issues concerning Food Security and Diet-Linked Public Health Challenges. The eight authors were chosen to represent a broad cross section of viewpoints and international perspectives. Several weeks before the conference convened, these policy position papers were distributed to representatives from governments, societal organizations, and international organizations engaged with the ISGP at this conference (the United States, Canada, Costa Rica, Italy, and Germany). Individuals from several private sector and philanthropic organizations also were invited to participate and therefore, received the papers. All participants have responsibilities and/or make major contributions to the formulation and implementation of domestic and international policies related to Diet-Linked Public Health Challenges.

The conference agenda was comprised of eight 90-minute sessions, each of which was devoted to a debate of a given policy position paper. To encourage frank discussions and critical debates, all ISGP conferences are conducted under the Chatham House Rule (i.e., all the information can be used freely, but there can be no attribution of any remark to any participant outside the conference setting). In each session, the author was given 5 minutes to summarize his or her views while the remaining 85 minutes were opened to all participants, including other authors, for questions, comments, and debate. The focus was on obtaining clarity of understanding among the nonspecialists and identifying areas of consensus and actionable policy decisions supported by scientifically credible information.

The not-for-attribution summaries of the debates, prepared by the ISGP staff from notes and recordings, are presented here immediately following each policy position paper. These summaries represent the ISGP's best effort to accurately capture the comments and questions made by the participants, including the other authors, as well as those responses made by the author of the paper. The summaries are, and should be read as, an overview of the areas of agreement and disagreement that emerged from all those participating in the debates.

Following the eight debates, small groups representing a cross section of the participants caucused to identify areas of consensus and actionable next steps to be considered within government, the private sector, and civil society. Subsequently, a plenary caucus was convened for all participants. While the debates focused on specific issues and recommendations raised in each policy position paper, the caucuses focused on overarching views and practical conclusions having policy relevance both domestically and internationally.

Concluding remarks

ISGP conferences are designed to provide new and unusual (perhaps unique) environments that facilitate and encourage candid debate of the credible S&T options vital to successfully address many of the most significant challenges facing 21st century societies. ISGP debates test the views of subject-matter experts through critical questions and comments from an international group of decision makers committed to finding effective, real-world solutions. Obviously, ISGP conferences build on the authoritative reports and expertise expressed by many domestic and international organizations already actively devoted to this task. As a not-for-profit organization, the ISGP has no opinions nor does it lobby for any issue except rational thinking. Members of the ISGP staff do not express any independent views on these topics. Rather, ISGP programs focus on fostering environments that can significantly improve the communication of ideas and recommendations and are designed to help ensure that S&T understanding is integrated into those real-world policy decisions needed to foster safer and more prosperous 21st century societies.

Conference Conclusions

Area of Consensus 1

The diverse economic conditions characterizing most societies fundamentally affect the degree of food insecurity, malnutrition, and health disparities found in different groups. Thus, all policies designed to improve public health, including preventing diet-linked negative health outcomes (e.g. chronic diseases such as colon cancer and diabetes), must significantly expand economic access to safe, nutritious food.

Actionable Next Steps

- Expand resources from all parts of society to (i) enhance public access to adequate quantities of nutritious, high-fiber, low-fat foods (e.g., vegetables, fruits, fermented foods) shown to support the human microbiome and (ii) promote lifestyles that routinely integrate healthier food choices.
- Foster the production and marketing of nutritious foods through governmental and private sector incentives (e.g., encourage communities to sustain access to needed nutrients) and disincentives (e.g., restrict food options available from governmental benefits).
- Commit governmental, private sector, and advocacy group resources to improving public access to foods (e.g., extension services, land allocations, transportation subsidies) shown to inhibit chronic diseases (e.g., cancer, diabetes), especially for those living in food-insecure regions.
- Strengthen economic incentives throughout society to expand the cultivation (e.g., traditional crops) and marketing (e.g., school menus) of nutritious food options.
- Use popular media, school curricula, and public demonstration campaigns to distribute ecologically and culturally relevant information needed for the public to make personal decisions about nutrition and physical fitness.
- Develop broad public commitment for healthy food choices by engaging community-based organizations (e.g., faith, sports) to enlist trusted individuals to lead local activities (e.g., “smart food” systems, “farm to fork” networks).

Area of Consensus 2

The scientific confirmation that nutrition affects how effective microbiomes influenced diet-linked health outcomes focuses attention on the importance of formulating publicly accessible guidelines that accurately characterize how nutrition strengthens healthy microbiomes in individuals and promotes healthier nutritional choices throughout society.

Actionable Next Steps

- Emphasize research objectives focused on examining the influence of nutrition on the health of human microbiomes (i.e., studies of epigenetics, contributions to inflammation, proliferation, and cancer) in anticipation of identifying new nutritional guidelines reflecting emerging scientific understanding.
- Increase public awareness among diverse demographic groups using traditional and social media of the importance of the microbiome in human health, and the role of nutrition in maintaining microbiomes, especially as new microbiological research expands.
- Revise regulatory oversight of innovative technologies (e.g., biofortification, nanosystems) for improving human health through enhanced nutrition and microbiome functionality while using the transparent exchange of credible information to publicly confirm their safety and effectiveness.

Area of Consensus 3

Establishing a sustainable health environment within a community requires a balance between the application of scientific understanding and emerging technologies and sociocultural interventions that carefully consider the unique community mores, demographics, and characteristics. While scientific and technological advances (e.g., optimization of microbiome-supporting food production) can greatly facilitate community access to more nutritious foods, such advances cannot supplant or supersede local cultural/behavioral efforts (e.g., culturally relevant foods, community-based school meal plans, local business support, community gardens, health advisories).

Actionable Next Steps

- Incentivize the development of technologies that produce nutritious, culturally relevant, and ecologically sustainable foods, especially with

respect to increasing the variety and quality of vegetable protein (e.g., egg substitutes), and improving crop outputs (e.g., novel bio-inoculants).

- Create new and facilitate existing public-private partnerships with food producers designed to increase the nutritional value and availability of processed foods (e.g., reducing refined sugar, utilizing high-fiber, and low-fat ingredients). Emphasize financial incentives facilitating the availability of culturally preferred products in selected communities, regulatory measures ensuring children's meals (e.g., breakfast cereals) are formulated and advertised as healthy, evaluate and market ingredients consistently (e.g., trans fats), and formulate guidelines addressing specific community needs (e.g., nutritional programs for new mothers).
- Use strategies tailored for specific populations (e.g., the fostering of peer leadership among children to increase consumption of healthier foods and improve physical fitness), promote production and consumption of traditional foods in local cultures through school and/or community programs (e.g., school meals, family gardening projects), and establish and maintain fitness programs that support healthy lifestyles. Trusted community leaders need to be solicited to promote these programs to obtain broad community adoption.

Area of Consensus 4

Given the reasonable expectation that continued environmental and cultural changes will significantly affect food security, policies need to prioritize production from current and potential future sources to ensure a sustainable system of diverse, nutritious, culturally acceptable, and climate-resilient food while maintaining long-term biodiversity.

Actionable Next Steps

- Prioritize resources to promote the development of climate-resilient crops and sustainable food-production systems (e.g., plant-microbe interactions, multiple cropping systems, no-till agriculture) by incentivizing the commitment of stakeholders to meet attainable goals that recognize the impact of anticipated environmental and cultural changes on food security.
- Develop public-private partnerships focused on promoting healthier dietary habits (e.g., partner with restaurants to develop a national nutritional quality rating scale and standardize smaller portion sizes) and

incentivize the use of traditional and novel fermentation technologies for the preservation and production of health-promoting foods.

- Conserve natural resources fundamental to food security (e.g., water quality and quantity, soil health, biodiversity) through policy interventions (e.g., biorestoration) that utilize adaptive management strategies involving the nongovernmental organizations and other stakeholders.
- Develop new and improve existing domestic, public education campaigns that prepare individuals and communities to actively participate in promoting healthy outcomes through changes in dietary choices (e.g., reduced food intake, increased fiber consumption, moderated consumption of simple sugars and refined carbohydrates), and increasing physical activity (e.g., family, intergenerational activities). Collectively, these efforts are needed to help prevent negative, diet-linked health outcomes (e.g., obesity, cancer, diabetes).

ISGP conference program

Sunday, Sept. 20

15:00 – 17:00	**Registration**
16:00 – 16:30	**Conference Meeting: Science Presenters**
16:30 – 17:30	**Caucus Meeting: All presenters and participants**
17:30 – 18:45	*Reception*
19:00 – 20:00	*Dinner*
20:00 – 20:45	***Welcoming and Evening Remarks*** **Dr. George Atkinson**, Institute on Science for Global Policy (ISGP), Founder and Executive Director

Monday, Sept. 21

07:30 – 08:30	*Breakfast*
08:45 – 09:00	***Welcoming Remarks*** **Dr. Dean L. Bresciani**, President, North Dakota State University

Presentations and Debates: Session 1

09:00 – 10:30	**Dr. Katherine Gray-Donald, McGill University, Canada** *Aligning Food Security Interventions with Better Nutrition in North America* Moderated by Dr. George Atkinson, Founder and Executive Director, ISGP
10:30 – 11:00	*Break*
11:00 – 12:30	**Prof. Laurie Hing Man Chan, Toxicology and Environmental Health and Center for Advanced Research in Environmental Genomics, University of Ottawa, Canada** *Effects of Modernization, Global Pollution, Climate Change on Food Security among Indigenous Peoples in the Arctic* Moderated by Dr. Sweta Chakraborty, Associate Director, ISGP

12:30 – 14:00	*Lunch* **Presentation** **"Global Institute of Food Security and International Agriculture (GIFSIA) — a Systems-based Vision for Global Food Security Challenges"** **Dr. Kalidas Shetty,** Professor, Plant Science, and Associate Vice President of International Partnerships & Collaborations, North Dakota State University

Presentations and Debates: Session 2

14:15 – 15:45	**Dr. Larry W. Harrington, College of Agriculture and Life Sciences, Cornell University, United States** *Sustainable Agriculture, Food Security and Health* Moderated by Ms. Barbara Del Castello, Senior Fellow, ISGP
15:45 – 16:15	*Break*
16:15 – 17:45	**Dr. Linda Duffy, National Center for Complementary and Integrative Health, National Institutes of Health, United States** *Microbial Food Fermentation: Enhancing Nutritional Fitness* Moderated by Ms. Christina Medvescek, Program Administrator, ISGP
18:00 – 19:00	*Reception*
19:00 – 20:00	*Dinner*
20:100– 20:45	**Keynote speaker** **Dr. Donald Warne**, Chair, Department of Public Health, College of Health Professions, North Dakota State University Moderated by Dr. George Atkinson, Founder and Executive Director, ISGP

Tuesday, Sept. 22

07:00 – 07:45 *Breakfast*

Presentations and Debates: Session 3

08:00 – 09:30 **Dr. Michael A. Robidoux, Indigenous Health Research Group, University of Ottawa, Canada**
Building Local Food Capacity as a Food Security Strategy for Northern Indigenous Communities

Moderated by Dr. Sweta Chakraborty, Associate Director, ISGP

09:30 – 10:00 *Break*

10:00 – 11:30 **Dr. Devanjan Sikder, Science, Entertainment, and Design (SED), Coppell, Texas; and Pediatric Endocrinology, University of Florida College of Medicine, United States**
Asian Diabetes: Cause, Challenges, and Health Care Reform

Moderated by Ms. Christina Medvescek, Program Administrator, ISGP

11:30 – 12:15 *Lunch*

Presentations and Debates: Session 4

12:30 – 14:00 **Dr. Stephen J. O'Keefe, Division of Gastroenterology and Nutrition, University of Pittsburgh, United States**
Diet and Colon Cancer Risk

Moderated by Ms. Barbara Del Castello, Senior Fellow, ISGP

14:00 – 14:30 *Break*

14:30 – 16:00 **Dr. Cecilia Bartolucci, S&T Foresight Project, Topic "Food," National Research Council of Italy, Italy**
Diversified Adaptable Food: Toward Personalized Nutrition

Moderated by Dr. George Atkinson, Founder and Executive Director, ISGP

16:00 – 21:00 **Focused group sessions**

Wednesday, Sept. 23

08:00 – 08:45	*Breakfast*
09:00 – 12:10	**Plenary Caucus Session** Moderated by Dr. George Atkinson, Founder and Executive Director, ISGP, and Dr. Sweta Chakraborty, Associate Director, ISGP
12:10 – 12:30	**Closing Remarks** Dr. George Atkinson, Founder and Executive Director ISGP
12:30 – 13:30	*Lunch*
13:30	*Adjournment*

Aligning Food Security Interventions with Better Nutrition in North America**

Katherine Gray-Donald, Ph.D.
Associate Professor, McGill University, Montreal, Quebec, Canada

Summary

Food security at a household level is closely linked to poverty, but in North America the link between nutritional indicators and food security is not strong. Programs to improve food security need to be sensitive to societal needs and, where possible, take good nutrition into account to reduce the burden of chronic disease. Changes in the food environment can help reduce food insecurity and improve nutrition in numerous creative ways. Many of these come best from grass roots local initiatives, which, if successful, serve as models for other communities. Farmers' markets, mobile markets, food cooperatives, community gardens, community groups who create pressure to provide fair food prices and those helping to enhance skills on how to buy and prepare healthy foods, all offer partial solutions to the problems of food insecurity and good nutrition. Support for interventions with known nutrition and health benefits (e.g., the Breast Feeding Initiative) or decreasing the marketing of foods and beverages to children, are other ways of improving food security and health. The landscape has changed from one of concern for under-nutrition to one of food quality to prevent chronic disease. Ensuring that only healthy foods are offered in school settings and subsidizing meals where needed is a challenge in terms of acceptance. Large American flagship programs, such as the school lunch program, need to be evaluated for potential improvements related to nutritional and other health outcomes. From small community-led interventions around food to broad policies to change institutional practices, all have potential to improve the food environment for everyone.

Current realities

The 1996 World Food Summit established that "Food security exists when all people at all times have physical, social, and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active, healthy life." Access to healthy food is not always evident, even in industrialized countries, with 14.3% of Americans and 8.3% of Canadians reporting household food insecurity from 2011–'13. Food security is linked to economic prosperity

and declined during the 2008–'09 recession. Food insecure households tend to be those with low incomes and education, and single-parent families are at elevated risk. Food deserts (i.e., where food prices are high and choices are limited) and the lack of infrastructure in disadvantaged areas add to these challenges. For example, in remote areas where food is obtained from the wild (e.g., game, fruits, fish) or through small, local production, increase costs (e.g., transportation or expensive storage requirements) pose major barriers to food security and nutrition.

The problem in the United States and Canada regarding access to healthy food is not one of inadequate production or availability, but rather one of distribution. Low-income households are vulnerable to food insecurity and poor health, and distance from healthy, affordable food can compound the problem. Levels of income support and the development of programs to ease food insecurity are political issues in both countries. In Canada, there are no provincial or national school lunch programs and no food support through Supplemental Nutrition Assistance-type programs. The means of supporting families is to provide incomes that are sufficient to care for their needs, although the levels of support are not sufficient in all settings.

Scientific opportunities and challenges

Diets are changing and the transition to increased intake of sugars and processed foods coupled with the loss of traditional foods and exercise is leading to obesity and chronic disease at an alarming rate. Food insecurity is linked to many health problems in a seemingly bi-directional manner. Food insecurity from temporary or long-term inadequate income causes stress and poor diets leading to chronic disease, while those with health problems, including obesity, are at higher risk for low income and food insecurity. The link between food insecurity, as measured by the Household Food Security Survey module, and dietary intake has been thoroughly studied in Canada and the U.S. using national data. One study compared nutrient intake in the two countries, examining specific nutrients with public health significance. In this case, the dietary intake data showed that the greatest difference between food secure and insecure individuals occurred in Canada and involved the amount of calcium and magnesium consumed. This trend was likely observed due to the higher cost of milk in Canada. No differences were seen between food secure and insecure individuals over the age of nine for vitamins A and C, and folate. There has been little difference in the nutrient profiles of younger children, as they seem to be protected from deficiencies. However, this result may be a reporting bias because mothers may not admit that they are inadequately feeding their children.

In terms of growth, food insecure children grow well in terms of height but tend to be heavier. There does not appear to be any evidence of slower linear growth

or low weight-to-height ratios in food insecure children in North America. This link between growth and food insecurity is very different from that observed in other parts of the world, and the nutritional risk for food insecure households in North America includes increased risk of obesity and poorer quality diets in terms of added sugars, fewer fruits and vegetables, and greater risk of inadequate milk intake in Canadian children.

The growing problem of obesity and its impact on chronic disease is of utmost concern, and all programs addressing food insecurity must address this issue so as to not inadvertently contribute to the problem (e.g., offering high-calorie foods or extra snacks, not being able to access local produce through the *Supplemental Nutrition Assistance Program* [SNAP], low nutritional value for "food bank" foods). While much of the food security research linking nutritional indicators (e.g., obesity) uses cross-sectional data, better studies are needed to understand how to effectively decrease food insecurity and help encourage healthier diets. There are serious methodological challenges in measuring the success of different interventions. Program participants may be very different to nonparticipants in ways that are difficult to measure. Good quantitative and qualitative research studies are needed to better understand the problems of food insecurity from the participants' point of view. As an example in a recent study, among low-income participants the most commonly cited barrier to the consumption of fruits and vegetables after cost was lack of skills in preparation and preservation of these foods.

Remote areas of Canada and the U.S. have additional challenges in terms of food provision and reliance on traditional food sources. Among indigenous populations, many live far from well-stocked grocery shelves and markets. Consequently, food prices are high because of transportation costs. Traditional ways of obtaining foods also have numerous constraints (e.g., fuel costs for hunting), which is challenging for many communities experiencing high unemployment rates. Obesity rates are very high and diabetes is a major health concern. There is no one solution for the high level of food insecurity in these communities, as there are important differences in culture, traditional food systems, and geography across the many communities that require consideration. Local solutions are needed to appropriately answer the needs of community members. The rapid transition from traditional ways of eating to more market driven foods presents important challenges to food security and nutrition in indigenous communities.

In addition to having sufficient resources to purchase foods and access to healthy foods for purchase, an element of education is necessary to improve nutrition knowledge and food skills in many settings. Pressure to eat in certain ways starts early in life with advertising of nonnutritious, but highly profitable foods. The World

Health Organization (WHO) suggests a ban on advertising to children who are too young to understand the advertising. Consuming highly processed foods persists because of prevailing consumer perceptions (e.g., it is time-consuming to prepare foods, consuming processed foods results in less waste). Many food preparation skills have been lost so there is a reliance on ready–to–eat foods. Sugar drinks are ubiquitous and are blamed for current nutrition problems given their low price and accessibility. In many instances, the consumer is subject to a higher price for a healthier food choice without any clear rationale (e.g., whole wheat products are often more costly than refined grains).

Policy issues

Food security is related to income, and increases in direct financial support (e.g., higher minimum wage) do lead to improvements in food security, although not all food insecure households are in the lowest-income range. Solving problems of food security will not automatically lead to better nutrition and reduced chronic disease. There is great potential to focus on adjustments that include this aspect of preventive health in programs aimed at reducing food insecurity. In North America, food security is only very weakly related to undernutrition, but has an impact on diet quality and obesity. Nutritional evaluations of the implementation of programs to reduce the burden of food insecurity are essential. External evaluations through longitudinal studies are important tools to help improve programs or to potentially abandon unsustainable solutions for improving food security. Changes in the food environment must include the following:

- In more remote areas where food insecurity is highest, encourage sustainable local interventions developed by communities to address food insecurity (e.g., community freezers for local game, community gardens, greenhouse installations, fishing cooperatives) through funding from federal governments to address food security.
- In urban areas, local governments can provide spaces for produce markets and community gardens to reduce food costs and promote better nutrition through education around food production, conservation and preparation. Municipal planning committees need nutrition expertise to address issues of food security.
- Grocers Associations and food producers must be sensitized to the issues of offering healthier foods at noninflated prices (e.g., whole grain vs. refined; lower sodium choices) to help reduce socioeconomic inequities in health.

State (provincial) and national governments can use policies to encourage a number of beneficial actions to improve food security and nutritional health of the population by:

- encouraging the WHO recommended The Baby Friendly Initiative in more hospitals to increase breastfeeding and decrease infections.
- limiting the marketing of food and nonalcoholic beverages to children in the spirit of reducing the demand for unhealthy food choices. This currently is done in Quebec, Canada)
- tying subsidies for school meals programs to the offering of healthy food choices in all settings or disallow serving unhealthy foods in schools where subsidies are not available.

References

McCullum, Christine; Desjardins, Ellen; Kraak, Vivica I.; Ladipo, Patricia; Costello, Helen (1 February 2005). "Evidence-based strategies to build community food security". *Journal of the American Dietetic Association*. 105 (2): 278–283.

*** A policy position paper prepared for presentation at the conference on Food Safety, Security, and Defense (FSSD): Food Security and Diet-linked Public Health Challenges, convened by the Institute on Science for Global Policy (ISGP), Sept. 20–23, 2015, at North Dakota State University, Fargo, North Dakota, U.S.*

Debate Summary

The following summary is based on transcriptions of a recording made by the ISGP staff during the debate of the policy position paper prepared by Dr. Katherine Gray-Donald (see above). Dr. Gray-Donald initiated the debate with a 5-minute statement of her views and then actively engaged the conference participants, including other authors, throughout the remainder of the 90-minute period. This Debate Summary represents the ISGP's best effort to accurately capture the comments offered and questions posed by all participants, as well as those responses made by Dr. Gray-Donald. Given the not-for-attribution format of the debate, the views comprising this summary do not necessarily represent the views of Dr. Gray-Donald, as evidenced by her policy position paper, or those of the ISGP, which does not lobby on any issue except rational thinking. Rather, it is, and should be read as, an overview of the areas of agreement and disagreement that emerged from all those participating in the critical debate.

Debate conclusions

- Given that economic insecurity creates barriers not only to food security, but also to the ability to access foods with a higher level of nutrition, policy makers at all levels (e.g., municipal to federal) need to implement strategies (e.g., subsidies, community funds) that lower the higher cost of healthier foods and increase the local availability of these foods.
- Since access to higher-nutrition foods does not ensure its acceptance by consumers relative to less-nutritious options, both private- and public-sector funding needs to support culturally-sensitive education to encourage nutritional selections in food-insecure communities. Programs encouraging healthier eating also need to educate consumers to prepare these foods in appealing/palatable ways to ensure nutrition can be effectively incorporated into daily diets.
- The recognition that eating habits are formed early in life and influence later-life health outcomes strongly suggests that nutrition and food education requires a high priority be given within the school environment and curricula. Schools need to be responsible for both educating children about nutrition through innovative programs (e.g., food tasting, group cooking) and for creating an environment where healthy food choices are available (e.g., school meal programs, healthy vending machine options, etc.).
- Since increasing the consumption of higher-nutrition foods requires that consumers receive convincing evidence confirming these foods improve health outcomes, research focused on the impact of discrete nutritional interventions on different populations is essential. Attention needs to be given to isolating the impact of poor nutrition from other factors that negatively affect one's health.
- The connection between consumer food choices and cost, convenience of access, and taste underlies the importance of nutritionists and food scientists working more closely together to improve the nutritional content of processed foods that incorporate these desired qualities.

Current realities

Individual and community food choices are based on behaviors that are difficult to alter, and pose complicated challenges to nutritionists, the agricultural sector, private and public institutions, and consumers alike. Currently, high-sugar, high-fat foods are consumed in excessive quantities, leading to obesity and diet-linked

health problems (e.g., diabetes, high blood pressure) that strain government health care budgets. Meanwhile, food that is culturally and nutritionally appropriate is not reaching those who need it. This is especially true among indigenous populations in North America, which often are located in remote areas with high rates of food insecurity.

Although cultural norms tend to be a central reason people are unwilling to alter their eating habits, there also is a lack of scientific knowledge about the best nutritional choices to recommend for individuals based on their genetic phenotype. While programs may provide nutritional guidelines to food-insecure communities, they often fail to educate community members about how to prepare these healthier food choices, thereby impeding their adoption. Consequently, the issue of promoting nutritional food choices may not necessarily be a lack of science, but a failure in knowing how to implement it.

Annual U.S. Department of Agriculture (USDA) studies on the forces driving consumer food choices consistently find that decisions are based on (i) cost, (ii) convenience, and (iii) taste, all of which generally conflict with choosing the most nutritious foods.

Food choices also are influenced by what is, and isn't, available. While people want to make healthier food choices, and effective educational interventions can improve consumer food decisions, if healthy options are available alongside tempting but less-healthy alternatives, then less-healthy choices typically are made. Because U.S. food assistance programs generally provide monetary assistance rather than food, such aid is often (but not always) spent on less-nutritious, more-fattening options, resulting in some individuals eating nutritionally while many others fail to do so.

Since nutritional messaging often is not relevant or understandable to the target group, those nutritional guidelines often are ignored. One-size-fits-all nutrition messages don't motivate behavior change because the target audiences each are unique (e.g., different indigenous communities, children of different ages). Adding to the difficulty is the problem of defining and communicating the benefits of nutrition, as the markers available only crudely measure nutritional sufficiency (e.g., measures of human growth), and these may not be appropriate measures for all populations of children.

Compared with children in less-affluent countries where food is very limited and malnutrition can stunt growth, children who experience food insecurity in North America still manage to get the nutrients they need, and research indicates that early food insecurity does not affect childhood development in this population. However, it is very difficult to isolate the effects of nutrition from other factors that impact

development (e.g., mental stimulation, air and water quality, active play outdoors). A study in Jamaica that investigated whether breakfast affects children's ability to learn found that in reasonably well-nourished children, breakfast had little effect on learning, but it did make a difference in the learning abilities of under-nourished children. More information is needed in this area.

Although early nutritional intervention (e.g., in elementary school) is important both for the prevention of obesity and disease, and for instilling lifelong healthy eating habits, current school nutrition programs have fallen short both in educating children to make positive changes in their diets and in offering foods with proper nutrition. School environments often provide children with access to a variety of less-healthy options through vending machines and school stores, and sometimes through the foods offered in the school meal programs themselves. Likewise, the poor food choices offered in office buildings where adults sit for the majority of the day (e.g., private companies, governmental agencies) contribute to obesity and diet-linked problems. It is widely agreed that nutrition information is largely lacking in public health outreach.

Nutritionists face a difficult task in advocating for healthier food choices, as they are working against the efforts of skilled food scientists who are constantly improving the taste and sensory quality of less-nutritious processed foods. In North America, food science and nutrition departments (e.g., academic, governmental, private sector) do not work together, as is the case in other countries. Food scientists typically focus on issues such as shelf life, taste, and packaging, and sometimes seem to be at odds with the concerns of nutritionists. There is also a significant difference between the large marketing budgets of processed food companies and the limited advertising budgets of public health agencies.

Although locally grown produce is considered one way to improve access to nutritious foods, taste preferences are constantly evolving, especially among youth, making it difficult for local food production to meet demand. Even in areas that are growing local produce, crops often are transported to cities and sold at higher prices to urban customers. While community activities and infrastructure (e.g., community freezers, gardens, biogardening, greenhouses, food cooperatives) can help increase the availability of nutritious foods in food-insecure communities, there is a limited variety of foods that can be grown, especially in Northern communities. Although it is expensive to ship fresh produce — and it is not as fresh once it arrives — a less expensive but still nutritious option are dried fruits, which have a longer shelf life than fresh fruit and can therefore be transported via slower methods (i.e., boat rather than airplane).

Obtaining nutritious foods is largely considered an issue of economics, not

only in rural areas, but in urban homes as well. Although there may be increased production costs associated with producing healthier foods (e.g., whole-grain bread vs. bread made with processed flour), the marketplace likely plays a larger role in determining price. Since a portion of the population will pay more for healthier food, food producers and grocers are incentivized to raise the prices of these foods. However, there are many who do not have the means to pay this inflated price. Government funds currently do not underwrite the production and distribution of nutritious food options to make them more affordable, and instead public support is spent on health care challenges linked to poor diet.

Scientific opportunities and challenges

Research opportunities exist to (i) characterize nutritious diets for different populations, (ii) better understand what motivates consumers to choose healthy foods, and (iii) develop effective strategies for convincing people to choose nutritious diets over less-nutritional, processed foods.

Encouraging new food choices, and developing the food preparation skills that enable these choices, will require education, incremental change, and high levels of commitment from food-preparation experts. Experiential learning may be more effective in changing habits than simple dissemination of abstract nutritional concepts (e.g., adding sampling stations in grocery stores so people can taste different foods and see them being prepared). However, nutritionists must study and understand a community so that messages regarding food and nutrition are tailored to cultural norms.

A central challenge is finding foods that harmonize with the environment and culture of unique food-insecure communities, and that potentially can create livelihoods for community members. There is a great need for creative solutions that preserve cultural heritage by preparing traditional foods in a healthier manner that is still palatable to local tastes and that can compete with highly processed foods.

Demonstration studies are needed that evaluate the health outcomes of different dietary interventions (e.g., frozen orange juice vs. Tang powdered crystals), and experiments need to be designed that can pinpoint whether children's health challenges are the result of dietary practices or related to other environmental factors. Early life nutritional interventions need to be creatively incorporated into childhood education (e.g., tasting experiences, group cooking), and nutritional messaging (e.g., governmental advertisements, childhood education programs) must be redesigned to be as effective as food industry advertisements. The challenge is to combine consistent messaging with nutritional expertise to be presented from a local perspective. Parallels with antismoking legislation and advertising need to be

studied, and the broad success in changing public attitudes toward smoking (e.g., eliminating smoking in bars and many public spaces) needs to be remembered when change seems impossible.

To increase consumption of nutrients, food scientists and nutritionists need to work together to put nutrients back into processed food products (e.g., adding wheat bran to white flour).

Given the lack of emphasis on nutrition in public health programs, students need to be encouraged to go into the field of public health, and dieticians need to expand their perspectives beyond calorie counting to consider the widespread incorporation of nutritional goals in community health plans.

Policy issues

While it is widely agreed that communities, especially those with large health disparities, must have access to healthy foods, policies are needed that improve not only access, but encourage consumption of more nutritious food options.

Given that the U.S. federal government plays a primary role in promoting food security, government subsidies (e.g., crop insurance subsidies) need to incentivize the production of nutritious options beyond wheat, corn, and soy, and to offset the higher cost of these more-nutritious options to consumers. Federal policies need to support traditional dietary patterns that utilize nutritionally appropriate local crops (e.g., although traditional Native American foods include corn, beans, and squash, many tribes receiving federal subsidies are growing wheat, and now have increased pasta consumption, a nontraditional food for this population). To improve access to nutrition in so-called "food deserts," lessons can be learned from other successful government programs (e.g., USAID's Feed the Future program).

Since a majority of harvested crops often are not consumed locally, but instead are shipped to other regions and sold at a high cost, community funds need to be established that subsidize the sale of local crops within their communities at lower, or even below-market prices. More municipal support is also needed for other local initiatives that increase food access and healthy food choices (e.g., community education programs, mobile vegetable shops, and community vegetable gardens). The outcomes of these initiatives need to be more widely shared among communities and others concerned with nutritional security.

Although it is deemed that schools never will be, or should be, 100% junk-food free, policies need to be tightened about what foods can be made available on public school campuses (e.g., in vending machines, school stores, school breakfast programs) and about appropriate portion sizes (e.g., while offering fruit juice in

school vending machines is a more nutritious option than soda, large containers of juice have a high calorie count that contributes to obesity).

To promote lifelong health, school curricula need to be amended to (i) include nutrition education at all age levels, (ii) give higher priority to physical education, and (iii) revitalize the teaching of home economics. Since nutrition lessons must be compelling to change student behaviors, curricula need to incorporate cooking demonstrations, tastings, and other hands-on experiences.

A larger corporate role is needed in ensuring nutritional security, and the food industry needs to be accountable to the public for promoting less-healthy choices (e.g., producers need to stop marketing foods under misleading labels that give the illusion of health, such as "fat free"). Educational campaigns need to refer to "less healthy foods" instead of "unhealthy foods" to help consumers think of their diets more holistically, as these less healthy foods need to be consumed in moderation, but not necessarily eliminated completely. To ensure that public health messaging about nutrition is effective, nutritionists need to partner with the private sector to craft compelling messages that positively influence consumer behavior.

Effects of Modernization, Global Pollution, Climate Change on Food Security among Indigenous Peoples in the Arctic**

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Summary

The importance of traditional/country food as a critical resource for the health and wellbeing of indigenous populations in the Arctic is well documented. Despite this, shifts away from traditional/country food (i.e., food that is hunted/gathered) consumption have been occuring over the past three decades largely due to modernization and environmental changes, including global pollution and climate change. These changes affect the availability and accessibility to traditional/country food, which contribute to the alarming rates of food insecurity found in many indigenous communities. Because of the complexity of the factors involved, innovative approaches in research methodology, public health intervention/adaptation programs, and integrative wildlife/food system management programs are needed. Policies at the local, national, and international levels need to be developed and implemented to enhance food security in the Arctic.

Current realities

Indigenous populations residing in the Arctic regions whose territories extend across two or more nation states (e.g., the Sami, Inuit, Dene, Aleut, and Evenk) are encountering myriad unprecedented and rapid environmental, social, and economic changes. Most of these indigenous peoples are practicing partial subsistence living (i.e., using a mix of market and country/traditional foods). Hunted and gathered country/traditional foods include a high variety of species of animals and plants (e.g., beluga whales, seal, caribou, arctic char, berries). The composition of these traditional diets can vary considerably depending on the culture, geography and ecology of these communities.

Traditional/country foods provide critical resources for the physical, mental, social, and economic health and wellbeing of individuals and communities across the Arctic. A diet rich in traditional/country food is thought by public health

professionals to protect against cardiovascular disease and diabetes due to relatively high levels of n-3, mono and polyunsaturated fatty acids, and low levels of n-6 fatty acid. Other dietary characteristics include high intakes of antioxidants, vitamins, micronutrients, and phytochemicals. Beyond the many nutritional benefits, the harvesting, processing, and consumption of traditional foods have great social and cultural importance and are deeply connected with community ethics and indigenous identities.

Indigenous populations are experiencing a nutritional shift, resulting from a set of complex modernizing, and industrial forces that have transitioned a subsistence economy to a salary/welfare based economy. Dietary patterns now include processed foods that are high in salt, sugar, and fat and also include fewer locally harvested foods resulting in lower intakes of several key nutrients (e.g., protein, iron, and zinc). Changes in diet and lifestyle are also associated with increased rates of obesity and chronic diseases (e.g., type 2 diabetes, cardiovascular disease). Living with these ailments is especially difficult under conditions of increasing food insecurity. To be food secure, individuals and households must be able to reliably access food (usually through adequate income) and the supply and production of nutritious food at the community level must be sufficient. Impediments to food security in many Arctic indigenous households exist due to issues relating to both the access to, and availability of, nutritious food. Many studies have shown that the food insecure rate in many indigenous communities can reach an alarming rate of more than 50%.

Food security is also related to the significant environmental changes resulting from ecological shifts in the Arctic. These shifts have been primarily associated with reduced confidence in food safety, due to identified threats from environmental contaminants, and more recently from changes in species availability and accessibility, due to shifting climatic conditions. For example, despite residing in locations distant from industrial activity, Arctic populations are especially vulnerable to environmental contaminant exposure. Contaminants undergo long-range transport from warmer to colder regions, making the Arctic a "sink" for contaminant deposition. Because lipophilic chemicals, such as persistent organic pollutants, collect in the fatty tissues of animals and accumulate at the higher ends of the food chain, the consumption of fish and marine mammals by Arctic populations leads to direct contaminant exposure.

Climate related changes and variability in the Arctic have been associated with changes in animal, fish, and plant population health and distribution. Changes in environmental factors influence human travel and transportation, and thus access to wildlife resources. It is clear that climate change and variability have the potential

to influence nutrition and health statuses among indigenous populations through availability, accessibility, and quality of traditional/country food.

Scientific opportunities and challenges

Processes of modernization, global pollution, rapid and sometimes unpredictable environmental change, economic transitions and material poverty, changing demographics, and current logistical challenges are some of the factors that shape this modern version of food insecurity. The complexity of the interactions of all these factors points to the need for multidisciplinary approaches to understanding and resolving the issues. New frameworks and paradigms that cross traditional disciplines need to be developed, and international collaborations are needed for sharing experiences and methodologies. A number of health studies conducted in Canada, Greenland and Alaska in the last decade provide baseline data relating diet and health statuses of indigenous populations. This data provides opportunities to study the impacts of climate change on food security and nutrition over time and in a circumpolar context.

Exposures to global pollutants (e.g., mercury) from the consumption of traditional/country food have been associated with subclinical, biochemical effects and increased systolic blood pressure in adults, as well as sensory function impairment in children in some Arctic communities. Consequently, food consumption advisories warning the public of contaminant risks from marine mammal consumption have, in some instances, been found necessary for the protection of public health. However, given the chronic food insecurity issues, wholesale reductions in traditional food consumption to limit contaminant intake are likely to dramatically and negatively effect nutrient intakes. Consequently, it is important that food advisories pertaining to the presence of contaminants in traditional foods are designed to lower contaminant exposure while minimizing the adverse effects associated with lower nutrient intakes. This requires comprehensive risk and benefit assessment paradigms to be developed and applied.

Research results have indicated that both positive and negative changes across different communities were reported in regards to climate change and variability affects on traditional/country food harvests. However, the impacts are not homogenous among all hunter-gathers and communities, and both individuals and households demonstrate differing abilities to adapt successfully. Factors such as access to economic resources and equipment, experience, and the nature of the adaptive strategy used, appear to influence the success of hunter adaptations to climate conditions. Therefore, it is important to further study the differentiating factors across individuals and households.

Further, based on the available harvest and local consumption data, it is feasible to relate wildlife harvest data to traditional/country food use at both community and regional levels. Thus, it is possible to model the relationship between climate projections, impacts on key environmental variables influencing availability of wildlife and/or access to traditional/ country food species (e.g., ice conditions), and the level of viable consumption of those species in the community. This information is critical for furthering our understanding of the major determinants of traditional/country food consumption in Arctic communities and of the current and future impacts of climate variability and change on traditional/country food consumption. As the pace and variability of change increases, it is important to identify key aspects of individual and collective adaptive capacity that require enhancement to affect positive change and to also support effective responses to protect and promote traditional/ country food consumption for Arctic indigenous populations going forward.

Policy issues

- It is critical for researchers, health professionals, and policy makers to work together to identify the level and scope of food (in)security; individual, household, community, regional, and national contexts necessitate different types of analysis and engagement.
- Food sovereignty is based on the principle that decisions about food systems, including markets, production modes, food cultures, and environments, are made by those who depend on them. Support for autonomous community food systems, community-based research, and community-based solutions that respond to locally identified needs has emerged as essential steps toward meeting the goal of sustainability and local food self-sufficiency. Therefore, community engagement is key to the success of any effective policy. For example, wildlife conservation efforts and related policy measures need to consider the need for food among communities in that particular region.
- A continuum of programs and policies can be used to address food insecurity, ranging from short-term mitigation (e.g, food banks, children's feeding programs) to capacity building and skills development programs (e.g., community gardens, cooperative buying clubs), to long-term organizational changes and policy responses that focus on root causes (e.g., food policy networks, food system interventions).

- Multilevel approaches based on intersectoral collaboration among communities, local agencies, government, and institutions are important for successful and sustainable initiatives. There are a number of such initiatives at grassroots (e.g., community-led food assessments, community gardens), provincial and territorial levels (e.g., Manitoba's Northern Healthy Foods Initiative, Nunavut Food Security Strategy), and national (e.g., Idle No More). To build food security and food sovereignty, initiatives should aim to: 1) increase the affordability and availability of healthy food; 2) promote health and education; 3) enhance community wellness and intergenerational knowledge sharing; 4) provide harvester support and sustainable wildlife management; 5) reduce poverty and support community economic development; 6) support innovation in infrastructure and local food production; and 7) increase youth engagement.
- For global pollution and climate change, international efforts are needed to reach agreements on collective action to control the use and release of toxic chemicals and carbon dioxide. Arctic food security is a health as well as human rights issue that needs to be considered in a global context.

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***** A policy position paper prepared for presentation at the conference on Food Safety, Security, and Defense (FSSD): Food Security and Diet-linked Public Health Challenges, convened by the Institute on Science for Global Policy (ISGP), Sept. 20–23, 2015, at North Dakota State University, Fargo, North Dakota, U.S.***

Debate Summary

The following summary is based on transcriptions of a recording made by the ISGP staff during the debate of the policy position paper prepared by Dr. Laurie Chan (see above). Dr. Chan initiated the debate with a 5-minute statement of his views and then actively engaged the conference participants, including other authors, throughout the remainder of the 90-minute period. This Debate Summary represents the ISGP's best effort to accurately capture the comments offered and questions posed by all participants, as well as those responses made by Dr. Chan. Given the not-for-attribution format of the debate, the views comprising this summary do not necessarily represent the views of Dr. Chan, as evidenced by his policy position paper, or those of the ISGP, which does not lobby on any issue except rational thinking. Rather, it is, and should be read as, an overview of the areas of agreement and disagreement that emerged from all those participating in the critical debate.

Debate conclusions

- Although broad government engagement is necessary to effectively address food insecurity caused by environmental and economic changes within Arctic populations, it is imperative to incorporate respect for local food sovereignty, traditional cultural beliefs, and the unique nutritional needs found in Arctic communities when developing appropriate interventions.
- Since transnational competition throughout the Arctic region provides all stakeholders (e.g., governmental, private sector, and public advocacy groups) strong incentives to negotiate, the views of Arctic communities, especially with respect to access to Arctic resources and transport through sea lanes, need to be given high priority in national and international policy decisions.
- Given that economic and nutritional patterns within indigenous communities are influenced by many complex factors (some yet unrecognized), it is essential that investments in food security programs are sustained by long-range funding rather than short-term grants. Effective follow-up mechanisms to identify program flaws and successes, and to establish predictive models to assess the potential impacts of specific interventions in different communities, are essential.
- The transition of Arctic economies to wage-based models requires responsible, long-term investments by community-private sector

partnerships that address the unique nutritional characteristics of food insecurity in Arctic populations (e.g., minimizing food waste, integrated diets using traditional and local food sources).

Current realities

Eight million people live in the Arctic region spread throughout eight countries; the largest populations, mostly indigenous, are in Russia and Alaska. In Canada, about 8% of the Arctic population is food insecure, although that number increases to 70% in some regions. Food insecurity is largely rooted in the decrease of nutritious traditional foods and the high cost of market food, which often is not very nutritious. A recent study indicates that since 1970, traditional marine food resources have been depleted by 50%, with several marine food species reduced by as much as 70%–80%. An important consequence and major challenge is that whales and other marine animals that are the main food sources for indigenous peoples also depend on these depleted species for survival.

Environmental changes in the Arctic caused by pollution, the effects of climate change, and resource development (e.g., oil, minerals, metals) also significantly affect the ability of indigenous populations to find, or be able to consume, traditional foods. Because many globally circulating chemical pollutants have been found to be more harmful than previously thought (e.g., Teflon or Gore-Tex coatings rise up into the Arctic air and accumulate along the food chain), contamination of traditional food sources contributes to food insecurity even when that food source can be obtained (e.g., indigenous Arctic communities must be encouraged to not eat certain traditional foods contaminated with mercury; hydrocarbon contamination is of increasing concern in both animals and humans). Scientists also predict the effects of climate change will cause most key animal species consumed by local populations to decrease and/or change in distribution.

Simultaneously, many Arctic communities are transitioning from subsistence economies to wage- and welfare-based economies. Only about 30-50 years ago, Arctic communities were still largely subsistence economies based on sharing, but the social fabric has changed dramatically and today community members typically focus on earning incomes to purchase food in the marketplace. The relative importance of market food in an indigenous community's diet is changing at different rates in different communities, and local food systems now include multiple new stakeholders (e.g., industry, government, and welfare programs due to limited job opportunities).

Although it is recognized that a wage-based economy can improve opportunities for indigenous people (e.g., employment, education), problems arise when traditions and cultural beliefs are not respected by outside intervention and

indigenous perspectives are excluded from discussions of development strategies. When done effectively, the intelligent integration of innovation into traditional systems can provide great benefits, as evidenced by several grassroots efforts in local communities.

While the traditional diet of Arctic subsistence communities historically has been largely meat based (e.g., high in fat and omega-3 fatty acids, and low in fiber from fruits and vegetables), environmental and economic changes are causing a nutritional shift that has not yet been fully characterized. Although lifespans in Alaskan native populations have recently increased from 45 years to about 75 years, this increased longevity has been accompanied by the emergence of diseases usually associated with Western diets (e.g., Alaskan natives have the highest reported rate of colon cancer in the world). Despite widespread belief amongst native people that traditional foods are healthy, there is not yet enough scientific evidence to support this theory. It is known that omega-3 fatty acids provide nutritional benefits along with high-quality protein from marine animals, but their effects on human health have not yet been fully measured.

Scientific opportunities and challenges

Although solutions to shrinking food resources and increased food insecurity generally call for decreasing meat consumption, scientists need to recognize that this approach is not culturally appropriate for all populations. In addition to developing appropriate nutritional recommendations for Arctic populations, Arctic health issues need to be addressed through the development of studies that look at the quantity and composition of the Arctic diet, analyze both nutrients and contaminants in the food, consider local disease patterns, and communicate results to community leaders and health officials.

Since local risk management can be challenging (e.g., due to insufficient information, small sample sizes, lack of funding), additional scientific data and community information are needed to effectively assess the qualities of the traditional Arctic diet. The contamination threshold at which to ban access to a cultural food source is a difficult judgment to make, and risk/benefit assessments require collaboration among toxicologists, nutritionists, community leaders, and public officials.

Research opportunities can be found in the conservation of food resources, wildlife and fishery management, and the relationship between harvest and population size. In managing resources, scientists must consider the contending priorities of culturally appropriate approaches and conservation efforts (e.g., while certain species of whales are integral to the cultures of some Arctic populations, the

decreasing population of these species also is a conservation concern). Given the importance of both cultural and conservation factors, it is imperative to implement long-range resource management strategies that provide food supplies while considering species population growth.

Since multiple factors contribute to food insecurity, models are needed that can analyze the effects of interventions within these complex systems. An efficient, cost-effective evaluation program needs to be in place to identify innovative advances in Arctic food security worthy of investment and implementation. Since different communities have different needs, context-specific research is important in identifying successful intervention strategies, as well as strategies that effectively initiate and sustain stakeholder engagement and community buy-in. To avoid duplicating mistakes, researchers and communities need to share their experiences and intervention outcomes.

Given that minimization of waste through preservation methods traditionally has been a high priority in indigenous societies, methods that responsibly optimize the integration of traditional food supplies with modern food-chain innovations need to be developed to minimize waste.

Climate change raises the need for improved methods of food preservation because as temperatures rise, food stored outside, preserved by the cold, will suffer from spoilage.

Policy issues

Given that food security is essential for local and international stability, and therefore critical for national security, it is imperative that governments establish food security programs with adequate and sustained funding structures. Intersectoral collaboration is a key approach for developing programs and policies that address the root causes of food insecurity through long-term organizational changes (e.g., balancing traditional and modern diets requires collaboration across multiple government, private industry, community, and public health sectors).

Multilevel dialogue (e.g., municipal, local, national, and international) is imperative to increase international collaboration and establish global leadership around food security issues. The Arctic Council, currently chaired by the U.S., is a crucial channel to foster international collaboration to address global issues (e.g., dietary recommendations for indigenous communities transitioning from traditional foods). Political leadership at all levels is essential to beginning these necessary conversations. While organizations at the international level need to prioritize the establishment of streamlined long-term regional policies (e.g., pollution control), those at national levels need to prioritize co-management of interventions, resource

allocation, and funding with local leadership. With long-term national support, local communities need to have sovereignty over food subsidy systems and grassroots programs (e.g., community gardens, food exchanges). In turn, communities need to provide the federal government with information about best practices.

Since it is widely recognized that a universal solution does not exist and interventions must be adapted to each community's needs, governments and other external stakeholders need to listen to local voices and plan the pace of development accordingly. It is recognized that Arctic populations are willing to discuss the evolution of their cultural priorities as long as their health, culture, and authority are respected.

A core aspect of the discussions among governments on the Arctic Council is the competition for access to the Arctic; today about a dozen new countries (including China, Vietnam, and Japan) are applying for observer status. Given that Arctic access is necessary for industry and national security (e.g., energy extraction, sea-lane transportation), such access needs to be negotiated in public and private agreements that improve conditions for Arctic communities (e.g., respecting food sovereignty, mitigating pollution, developing guidelines for nutritious diets for Arctic communities).

As indigenous communities transition from subsistence-based to wage-based economies, governments need to support programs that recognize the importance of subsistence nutrition to the physical health of Arctic communities (e.g., enabling selected individuals to take time off work to hunt for their communities, thus avoiding the need for a hunter in each household). Advocacy groups are vital to the dialogue (e.g., the U.S. National Indian Health Board, the Canadian National Aboriginal Health Organization), and an equivalent body needs to be established to represent the Circumpolar Region.

As a result of widespread contamination of local food sources, health professionals need to issue advisories about pollutants in traditional foods, and local health officials and authorities need to address chemical poisoning, while still maintaining access to traditional foods. Although a 15-year international agreement to ban mercury was established in 2013, regular assessments regarding the effectiveness of this ban in reducing pollution are required.

On a national level, strategic planning is needed to (i) assess the ideal diet for Arctic populations, (ii) determine if it is achievable, and (iii) identify necessary alternatives. Local and national agencies need to collaborate on solutions that address the challenges of changing dietary patterns (e.g., integrating new dietary guidelines with traditional diets). If nutrition improves in the Arctic region, public

health inevitably will improve as well (e.g., lower rates of diabetes), leading to health care savings that can be directed toward food security programs.

Given that nationally subsidized food security programs often begin well but fail when funding evaporates in two to three years, national commitments to long-term funding and evaluations of program outcomes are crucial. Additionally, long-term investment into infrastructure is needed to sustain strategies based on food distribution and storage (e.g., community freezers require ongoing funding for management and repairs). As food costs increase within the marketplace, subsidies are needed to ensure an adequate, nutritious, and financially accessible food supply in low-income and/or remote communities (e.g., subsidies to individuals, shipping-cost subsidies).

While demand from restaurants and industry can drive the development of markets for locally produced foods in the Arctic, the process needs to be facilitated by private sector-community partnerships that establish regulatory systems, safety guidelines, and infrastructure in communities accustomed to subsistence lifestyles.

Given the ongoing reduction in the availability of traditional foods, infrastructure optimization is needed to reduce food waste and improve sharing of traditional food supplies. Also needed are incentives that encourage consumers and industry to minimize waste in food production (e.g., programs are in development to utilize parts of crops and animals that previously were discarded).

While it is imperative that Arctic populations are educated about safety issues (e.g., food contamination) and the importance of nutritional balance in preventing disease, indigenous traditions (e.g., food gathering) also need to be taught from a very early age to integrate the optimum qualities of traditional lifestyles with modern development.

Sustainable Agriculture, Food Security and Health**

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Summary

Agricultural practices in developing countries affect — and are affected by — health, disease, food security, and poverty. Food-secure families are physically more able to engage in productivity-enhancing agricultural practices. However, productivity growth alone is not enough to ensure food security. Equally important are equity, sustainability, and resilience. Higher productivity helps reduce food prices, making food more affordable for the poor. Opportunities for improving farm systems include climate-smart agriculture, conservation agriculture, harnessing market chains for high-value production, improved water availability and access, improved common property management, and gender-sensitive intensification strategies. Improved agriculture needs to be achieved in the context of unfolding external drivers, among them climate change, population growth, economic growth, and expanding market opportunities. Improving the productivity, profitability, sustainability and resilience of agricultural systems in developing countries depends on a favorable policy and institutional environment.

Current realities

There are relationships among agricultural practices, agricultural productivity, and factors such as health, disease, food security, and poverty. Food-secure and well-nourished farm families have a greater ability to engage in more rigorous agricultural practices that raise productivity. Higher productivity in turn fosters improved food security. Poor families, however, are less likely to be food secure. They often lack the land and water needed for farm intensification, and the cash to purchase food when home stocks run low. Higher productivity helps reduce food prices, making food more affordable for the poor.

Agricultural productivity is a measure of output per unit of input, but productivity growth alone is not enough to ensure food security. Equity (i.e., access by the poor to food and to production resources); sustainability (i.e., agriculture that meets the needs of the present without compromising the needs of future generations), and resilience (i.e., the ability of agricultural systems to recover

from a shock or disturbance by reshaping themselves to maintain functions) are equally important. Agricultural productivity has grown rapidly in some developing countries but has lagged in the poorest ones, largely in sub-Saharan Africa. Productivity improvements have come from intensification (i.e., higher yields, more crops per year) and diversification (i.e., greater diversity of crops and livestock). Some past intensification techniques are now considered unsustainable (e.g., aquifer-depleting groundwater irrigation in cereal systems in northern India.) Moreover, these techniques sometimes have led to reduced ecosystem diversity. Intensification is often hindered by lack of access to water, and by common property management practices (e.g., uncontrolled cattle grazing, residue burning) that discourage investment in resource conserving practices.

Developing productive, sustainable, and resilient agriculture needs to be achieved in the context of unfolding external drivers, among them climate change, population growth, economic growth, and expanding market opportunities. Population growth remains high in the poorest countries. These countries also have stagnating cereal yields and declining per capita cropland area. Access to domestic and international markets is improving, however, offering new opportunities. The effects of climate change vary across regions. Farmers in developing countries can expect an increased incidence in extreme weather events (e.g., droughts, flooding) and higher temperatures, leading to higher evapotranspiration and less rainwater available for cropping. Climate change disproportionally impacts vulnerable smallholders.

Scientific opportunities and challenges

It is common to hear of the importance of "doing something" to improve the productivity, sustainability, and resilience of agricultural systems in developing countries. This is easier said than done. Achieving impacts often requires technical change, policy reform, and institutional innovation, where natural resource management is as important as agricultural technology, and where multiple stakeholders need to participate in the innovation process. Agricultural innovations are only attractive to farmers when they provide direct near-term economic benefits.

There are numerous opportunities for improving the productivity, profitability, sustainability, and resilience of farm systems in developing countries. Most of these have to do with sustainable intensification and diversification. One opportunity lies in the development of climate-smart agriculture. This involves breeding crop varieties that better tolerate heat and drought. There are many scientific challenges in achieving this, but scientists in international agricultural research centers such as the International Maize and Wheat Improvement Center (CIMMYT) or the

International Rice Research Institute (IRRI) have made considerable progress. Farmer assessment can be used to ensure that stress-tolerant varieties maintain other characteristics that farmers find valuable (e.g., grain quality). Climate-smart agriculture also needs innovation in water management practices (e.g., rainwater harvesting, flexible irrigation, and water control to accommodate "on-demand" dry-season cropping).

Conservation agriculture — crop residue retention, no soil disturbance, and suitable rotations — provides a uniquely powerful approach to raising productivity while improving sustainability and resilience, largely from improved soil-water conservation, better soil health, and reduced land degradation. Successful introduction of conservation agriculture requires private sector involvement in farm equipment development and farmer involvement in local adaptation. It frequently requires modification of common property management practices.

Central to sustainable intensification is production of high-value crops and livestock for local markets, especially during the dry season. Intensification can benefit from innovations in marketing systems such as livestock auctions or the use of information technology for the dissemination of market information. In addition, sustainable intensification usually depends on improved access to water. This can be through rainwater harvesting, tapping groundwater, building small reservoirs, or through improvements in water control in existing canal systems to allow for flexible and reliable "on-demand" irrigation and drainage. A major role for research is to ascertain the profitability and sustainability of water management practices. Equity issues also need to be considered as changes in water management may benefit one social group at the expense of others.

It is surprising how frequently success in sustainable intensification depends on improving common property management. Because conservation agriculture requires permanent soil cover, it cannot be implemented when there is no control of livestock grazing or residue burning. The use of groundwater for dry-season irrigation also means tapping a common resource. Sometimes improved common property management depends on clarification of which institutions have the authority and responsibility for setting management rules.

A major challenge in developing productive, sustainable, and resilient farm systems has to do with the role of women in farm households. Sustainable intensification from high value crops or livestock often depends on women's labor. To be feasible, intensification strategies cannot place excessive demands on their time. Because intensification strategies are most effective in improving family nutrition when women retain a share of the income, strategies should focus on crops or livestock activities where women are able to keep some of the earnings.

Policy issues

Successful strategies for improving the productivity, sustainability, and resilience of agricultural systems in developing countries depend on a favorable policy and institutional environment, including policies that on the surface may seem unrelated to agriculture. There is a range of institutions that are in a position to design and implement appropriate policies.

- Promote climate-smart agriculture, including support for research on stress-tolerant crop varieties and for improvements in formal and informal seed systems. Participants include the international centers of the Consultative Group for International Agricultural Research (CGIAR) system, national agricultural research and extension programs, local NGOs, and public and private seed suppliers.
- Establish policies that favor the development and adoption of conservation agriculture (CA): (a) encourage private sector participation in CA equipment development, (b) foster the creation of private sector service providers for CA, (c) eliminate import tariffs on CA equipment, (d) develop farmer-to-farmer extension programs, (e) reform common property management to control livestock grazing and residue burning, and (f) eliminate subsidies on diesel fuel (these make conventional plowing artificially cheap). Many of these policy changes are in the hands of national and local governments, but there are regional CA networks that can also inform policy change.
- Invest in appropriate water infrastructure for sustainable water availability, including (a) farm- or landscape-level investments in rainwater harvesting, (b) streamlined approval of irrigation wells in "safe" blocks with no risk of groundwater depletion, and (c) adjustments in rural infrastructure to improve precision of farm-level irrigation control. Participants include national, provincial and local governments, and development assistance agencies working in irrigation system rehabilitation (e.g., the Netherlands), and water and sanitation (e.g., Gates Foundation).
- Reform current policies governing groundwater extraction where groundwater is being depleted, making agriculture unsustainable. Opportunities include licensing of tubewells, volumetric pricing, or rationing electricity supplies used in pumping water for agriculture.
- Invest in market and transport infrastructure to improve smallholder access to markets, including livestock auctions (e.g., Zimbabwe) and information technology approaches to the dissemination of market and

extension information. Investment is usually in the hands of national governments, supported by donors, NGOs, and private companies.

- Support the role of women in intensification and diversification of agriculture. Specific actions that can be taken include: (a) provide credit for women despite lack of collateral, (b) implement training programs so that family members understand and support women's work in intensification, and (c) prioritize crops or livestock activities in which women retain income (e.g., tomatoes in northern Uganda, goats in Zimbabwe).
- Integrate and coordinate policies relating to agriculture, nutrition, and health

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Debate Summary

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of Dr. Harrington, as evidenced by his policy position paper, or those of the ISGP, which does not lobby on any issue except rational thinking. Rather, it is, and should be read as, an overview of the areas of agreement and disagreement that emerged from all those participating in the critical debate.

Debate conclusions

- Although it has been shown that family wellbeing and health are significantly enhanced when women are afforded their fair share of earnings and benefits in the agricultural system, many women do not reap economic rewards from their agricultural labor. While the creation of infrastructures and educational programs promoting equal opportunities for men and women can address some of these issues, effectively tackling gender issues requires distinct approaches tailored to the needs of a specific region.
- To adopt new agricultural conservation practices and technologies, smallholder farmers need to receive near-term, on-farm financial support and educational resources. Therefore, long-term land-management practices that do not provide immediate, realistic benefits to farmers are best implemented through engagement and joint negotiations between policy makers and communities.
- Common property management practices that can address conflicts among multiple stakeholders over shared resources need to be supported by progressive domestic and international policies. Specifically, strategic policies supporting the right of indigenous people to control their resources by facilitating broad community engagement, educational opportunities with practical consequences, and collaboration among all stakeholders need to be identified and implemented.
- Because the potential benefits and risks of genetically modified organisms (GMOs) have not been well communicated, consumers tend to broadly reject GMO food products, and politicians are reluctant to support the implementation of these technologies in agriculture. Scientists and industry have a responsibility to foster transparent dialogues about GMOs with policy makers and consumers, and regulatory policies regarding food labeling and marketing should be designed to better inform consumers about both the benefits and risks.

- Climate-smart agriculture approaches and conservation practices need to be institutionalized and incentivized, including effective approaches for limiting soil degradation and erosion, efficiently managing water resources, and breeding crop varieties that are more tolerant to heat and drought.

Current realities

Traditional agriculture is currently under enormous pressure globally to adapt to numerous challenges related to changing climates, rapid urbanization, technological innovations, and dramatically increasing populations with dynamic demographics. Revising the significance of personal and community rights to water and land tenure are examples of such pressure. Globalization of the food supply system has resulted in a complex system of trade and government regulatory oversight. Although myriad international regulations create challenges, globalization has also created opportunities for communities to tap into new markets and improve their livelihoods. Globalization is not the only force for change; demographic changes within a country (e.g., urban migration) also dramatically change market situations and make it feasible for a larger number of small famers to enter cash crop activities. Such a scenario is occurring around Ouagadougou in Burkina Faso, where many small farmers are producing vegetables for the first time due to rapid market growth.

The most critical factors for enhancing agricultural diversification, intensification, and sustainability include (i) water management and use intensification, (ii) common property management approaches for shared resources, and (iii) the role of women in labor allocation and cash markets.

Although some of the truncated planting schedules and extended land arability afforded by conservation practices (e.g., in India and Florida) have resulted in higher long-term yields and less labor, small-holder farmers have been reluctant to adopt new practices that do not offer near-term benefits and savings. If the advantage to a particular conservation practice is potential improvement in soil health five or more years in the future, for example, there usually is little traction for the idea among farmers, especially if initial yields may be lower.

Climate-smart agricultural approaches for improving farm systems tend to be water and temperature related. They include measures such as projecting climate conditions for a particular production region, analyzing the requirements for high-yield production with respect to tolerance of abiotic stress (e.g., wind, extreme temperatures, drought), and optimizing water management (e.g., rainwater harvesting, groundwater use). Climate-smart agriculture primarily involves breeding crop varieties that better tolerate drought and mitigate abiotic stressors. Soil health

(e.g., soil microbiology, water content, depth, mineral content) is also a component of climate-smart agriculture, and several companies are now selling soil inoculants specifically developed for improved crop productivity in drought areas such as the Deccan Plateau in India.

Also critically important to sustainable food production are efforts to improve the equity of women in the agricultural workforce, particularly their roles in labor allocation and market access. In many parts of the world, women are involved in food production, but not in market sales. The International Food Policy Research Institute has developed an extensive research network around gender issues. Overall, strategies that improve women's access to sales markets have proven valuable. For example, in Zimbabwe, men traditionally manage cattle and women manage goats. There, the creation of a centralized auction system in which women could show goats to bidding buyers transformed the economics. Women were able to earn more income that then were invested in improvements and innovation on the farm. Women also were able to retain more of these earnings, which then could be used for their families. Research suggests that increased involvement of women in food sales and marketing fosters improvements in nutritional status and health. In Bangladesh, for example, women have become more involved in the enterprise aspects of agriculture, and the benefits of improved family nutrition are already apparent. Gender roles must be examined in the context of local communities and economies.

Included in the global changes occurring in agriculture is the expansion of corporate farming, especially in Africa, which comprises an estimated 25% of the world's arable land. Several large corporations (e.g., Del Monte) have established large-scale productions in Africa. African agriculture can be broadly segregated into food crops, which are mostly small-holder farms, and cash crops such as rubber and palm oil, which are produced by corporations. Consequently, there is not so much of an evolution of small-holder farmers to large corporate farming in Africa, but rather an increasing number of options for livelihood strategies. Workers also are increasingly able to choose between farm and off-farm work. It is common for some family members to work in city office jobs and send money back to the home farm, and for farming income to subsidize the education needed for nonagricultural employment. These inter-relationships are fundamental, and it is important that systems and interventions support the various livelihood options so as to facilitate upward mobility of younger generations.

Although tighter control of grazing livestock has been proposed as way to support agricultural conservation, in particular no-till conservation practices, research has indicated that grazing can contribute to the diversity and sustainability

of grasslands. Since an estimated 50% of the world's landmass is covered by non-arable or marginally arable grasslands, that land can be most efficiently utilized for food by raising ruminants (e.g., sheep, goats). Livestock also are critical to agricultural systems because they produce fertilizer and contribute to economic diversification and risk distribution.

Clear scientific evidence exists that crops based on genetically modified organisms (GMOs) can provide advantages to both small- and large-scale farming through climate and disease resilience, improved nutrient content, sustainability, and reduced demands for water and labor. GMO usage in African crops has led to positive, sustainable outcomes. For example, through the efforts of a USAID-funded GMO lab in Cameroon, Africa, the white cocoyam variety was saved from near extinction by genetic crossing with a yellow cocoyam variety that was resistant to root rot. West Africa now produces several commercial GMO crops (cocoyams, papaya, cassava).

However, many influential advocacy groups oppose the adoption of GMO crops based on ethical, moral, safety, or economic concerns, resulting in broad political resistance to the adoption of GMO crops despite a lack of scientific evidence of their negative effects. One noted downside of GMO use is that often the crop seeds cannot be saved, but rather must be re-purchased each year from corporate suppliers.

Agricultural conservation strategies do not need to rely on GMOs for success, however. Significant progress has been made in all the important performance dimensions through better soil management, crop rotations, and soil microbiology improvements. A distinction was drawn between two types of agricultural innovation. In academia, technological innovations are typically envisioned as devised by researchers or engineers and then disseminated to farmers, perhaps via agricultural extension services at universities. However, traditional agricultural systems and the environments within which they work are dynamic, and innovation is often internally driven. Communities develop new ideas, test them, and adopt the most productive. Best-practice decisions are made on a regular basis with each new season, resulting over time in dramatic changes in agricultural practice, often without outside influence, international investment, or foreign aid.

Scientific challenges and opportunities

The critical challenge of improving gender equity and enhancing women's access to agricultural enterprises defies universal solutions. Since gender roles are established through deeply rooted and unique systems of social, cultural, religious, and legal norms, examples of successful multinational interventions that can be easily

replicated or scaled are lacking. Although local successes have been realized (e.g., in family programs that address gender-related violence or train entire families on technological innovations), effectively tackling gender issues is likely to require individualized approaches within specific regions and communities.

Despite the success of GMOs in improving crop adaptability, making this technology palatable to politicians and civil society is a major challenge. As a scientific innovation, GMOs are similar to other agricultural sustainability practices in that they don't necessarily provide short-term, on-farm economic incentives, making adoption much less appealing to farmers. Some GMO opponents fear a "Trojan horse" scenario, where acceptance of any one type of GMO opens the gates to all manner of crop hybrids to enter the market. More broadly, poor communication and transparency by the food industry about GMO technology significantly contributes to consumer and government resistance. In Europe, for example, products that utilize nanotechnology are labeled as such, but consumers don't know why this technology is being used, if it offers a health benefit, or if it is even safe. Scientists have a great responsibility to communicate knowledge much more effectively, especially to improve transparency about GMO's potential benefits and risks to consumers.

Another challenge to the use of agricultural GMOs is the high cost of testing promising crops prior to making them commercially available. Large companies that can afford such testing (e.g., Monsanto, Syngenta) also are wary of the legal challenges they may encounter from GMO opponents when trying to commercialize new GMO products.

Scientists, economists, and others involved in international agricultural efforts must be aware of the consequences of bringing technological innovations to developing agricultural systems (e.g. machinery, GMOs). At each step of adaptation, ethical and/or moral issues may arise from embracing external influences.

Even when new crop varieties (GMO or not) are successfully introduced, keeping the seed stocks pure and marketable over time presents a significant challenge. The USAID-sponsored Legume Innovation Lab at the University of Michigan has generated common bean (Phaseolus) and cowpea varieties with better yields, higher disease and pest resistance, and improved nutritional quality, but the program faces significant hurdles in keeping the strains genetically pure after distribution. Seed purity issues have been debated and researched for many years, and an opportunity exists for the development of global policies that encourage the U.S. and other governments to provide some of the resources to effectively maintain seed purity.

World nutrition currently depends on a small number of staple crops, and crop

diversification represents a critical unmet need. However, diversification is unlikely to be achieved through external policy interventions, but rather through market development: As farmers are able to sell to local markets and retain some profit, they can invest in more diverse crops that can be sold to a larger customer base.

Given the need for common property management approaches that help multiple stakeholders reach agreements about the use of shared resources, an opportunity exists to utilize modeling exercises to identify acceptable trade-offs or even win-win scenarios in resource management. Crop burning and open-grazing livestock are two examples where collective action and self-enforcement are vital for the adoption of conservation practices. Free and Prior Informed Consent (FPIC), an international human rights standard, offers a possible approach to common property management that recognizes indigenous peoples' right to self-determination, and facilitates informed consent by creating arrangements that support community collaboration and education. However, common property management approaches appear to be most effective when building on existing networks and relationships, rather than as *de novo* creations by outside organizations.

Several technological advances are primed for deployment into developing agricultural systems (e.g., improved water management and soil health, GPS-enabled planting and fertilizing ["precision agriculture"], information technology that streamlines transportation, biofortification of crops, and nanotechnology approaches that do not use genetic modification to improve nutrient availability). There will certainly be challenges involved in the introduction and adoption of such technologies by different societies. In certain cases, farming communities already may have rough analogs of these high-tech interventions, such as farmers who have such an intimate knowledge of their fields' topology, irrigation, and soil characteristics that GPS units on their tractors do not improve precision.

The higher temperatures produced by climate change pose a serious challenge to the world's main food crops, as photosynthesis does not perform efficiently above a certain temperature threshold and so cannot produce enough energy for the plants to survive. Some crops (e.g., rice) currently are close to their temperature threshold. Although this challenge presents a clear scientific opportunity for technological innovation, it will be very difficult, if not impossible, to overcome, making it all the more important to continue combatting climate change.

While soil health always has been an important issue in agriculture, it is now of even greater concern in light of issues of supply, sustainability, and climate change. Although current research is beginning to better understand how certain symbiotic rhizosphere organisms can increase tolerance to abiotic stressors such as soil salinity, many climate-smart agriculture approaches lack engagement with the community

of soil microbial experts. With an estimated 60% soil loss in southern Africa alone, scientists and decision makers need to better incorporate overall soil health into the dialogue regarding agricultural conservation and adaptation.

Policy issues

Communities engaged in conservation practices need support to create stakeholder platforms where individuals can jointly reach consensus on common property management issues. This support may come formally through agreements with municipal policies or informally through farmer organizations.

Intervention programs to address gender issues in agriculture need to be designed to take into account the unique cultural, geographic, and religious aspects being faced by individual communities. Engagement with the communities must be a driving principle. Policies that aim to re-invigorate local economies can be a good context to examine gender roles.

A barrier to sustainable agriculture solutions is the difficulty of maintaining the seed purity of novel and advantageous cultivars after their distribution. International policies need to promote and incentivize the sharing of practices, technologies, and resources among governments to address seed purity issues.

Greater transparency is needed in communication and knowledge sharing regarding the benefits and risks of novel food technologies (e.g., nanotechnology, GMOs). Regulatory policies affecting food labeling and marketing need to be designed as part of a better-informed dialogue among scientists, industry, and consumers.

While GMOs offer a way to adapt crops to climate change, significant progress also can be made through advances in irrigation systems, better water management, and the introduction of different stress-tolerant crop varieties (e.g., planting more sorghum and less maize). In addition to introducing technological innovations, domestic policies and international aid programs need to identify and integrate advances that are more local and "on the margin," and that do not rely on imported technologies. Policies and practices that limit or reverse the rising global temperatures of climate change are vital to avoiding dramatic reductions in food production capacity.

Although soil degradation is reaching alarming levels worldwide, many best practices developed to address and improve soil health remain underutilized or unadopted. Concerted international efforts are urgently needed to elevate advocacy and incentives for practices that maintain and improve soil health. Soil conservation efforts by the government and farmers of Ethiopia, a region that is experiencing significant erosion and soil degradation, demonstrate that long-

term land-management practices, especially those that do not provide immediate benefit to farmers, are more effectively approached through engagement and joint negotiations between policy makers and communities.

The lack of sustainable access to food is clearly a large factor in social unrest, and therefore promoting sustainable agriculture has implications for national security interests around the world. Current migration crises in Europe and Bangladesh can be linked in part to inadequate food supplies and the threat of climate change on agricultural systems. The development and establishment of sustainable agriculture is a fundamental aspect of promoting worldwide stability. USAID has a strong track record of promoting agricultural sustainability, particularly in Africa, and these efforts need to continue and expand. As a major world power, the U.S. has a responsibility to pursue sustainable agriculture not just domestically, but internationally.

Microbial Food Fermentation: Enhancing Nutritional Fitness**

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Summary

Lactic acid bacteria (LAB) are the most widely studied microorganisms for food biopreservation. LAB play a particularly critical role in the preservation and microbial safety of fermentable foods. As world population increases, the use of improved LAB strains as probiotic cultures in industrial food fermentation is expected to have a large economic impact that attracts increasing commercial interest in preserving fresh vegetables, fruits, and a broad variety of food items for feeding populations, especially in developing countries. Many fermented fruit and vegetable products co-evolved with human nutrition, and people have lived with high and continuous loads of LAB since ancient times. Genomic and metabolomic biotechnologies are now readily available and provide molecular footprints, mapping LAB mixed strains that have co-evolved with humans and developed intimate interrelationships with our bodies. Their genomes have sparked the discovery of how functional probiotic LAB strains may play a promising role in biofortification strategies and offer the potential for addressing key public health challenges, including over- and under-nutrition. The food sustainability realities confronting science and public health require that federal agencies consider improving proficiencies of diverse stakeholders in the public and private sectors to better inform research efforts on food fermentation, streamline processes, maximize safety, and ensure benefit to public health. Large-scale sustainable strategies in which qualified experts on agriculture and nutrition issues partner with key stakeholders in the molecular sciences and emerging biotechnologies will help to decipher the "Rosetta Stone" of metabolic footprints

that are of key importance to enhancing health and longevity. Such partnerships require endorsement of core principles of mutual trust, cooperation, procedural transparency, performance criteria, and evaluation effectiveness.

Current realities

Reliably identifying functional health properties in the food chain and during biotechnological processes can be seen as common research priorities for food microbiologists and other interdisciplinary scientists and stakeholders. In the current food science and technology paradigms, biopreservation can be defined as the extension of shelf life and food safety by the use of natural or controlled microbiota and/or their antimicrobial compounds. One of the most common forms of food biopreservation is fermentation, which occurs when bacteria and enzymes convert carbohydrates into alcohol or organic acids, changing the flavor of food and preserving it. One important outcome of food fermentation is the enrichment of food with essential amino acids, vitamins, minerals, and bioactive compounds. Fermentation makes foods easier to digest and perhaps is more nutritious than raw fruit or vegetables. Notably, most fruits and vegetables contain some undesirable or toxic bioactive compounds that can be removed or detoxified by the action of microorganisms during the fermentation process.

A key result of gut digestion and fermentation is production of short-chain fatty acids, which cells need for energy. This process occurs naturally in many foods, and humans have made use of it for thousands of years by making yogurt out of milk or alcohol from fruit. Before refrigeration, humans routinely consumed fresh vegetables in season and fermented them for preservation for the winter. In fact, the earliest record of fermentation may date back as far as 6000 B.C. in Middle Eastern and Asian cultures and nearly every civilization since have included at least one fermented food in its culinary traditions. From yogurt and cheese to Korean kimchi and Indian chutneys to German sauerkraut, global cultures have crafted unique flavors and traditions around fermentation.

Although challenges remain, fermented foods, handed down for many generations, are experiencing a rapid resurgence in the global food industry. This growth is, spurred by innovative technologies that include biological antimicrobial systems, particularly LAB and their metabolites that have been combined with traditional preservation methods in food fermentation for the intended purpose of inhibiting spoilage and pathogenic bacteria. One growth market of these technologies is the exponential rise of LAB-containing food cultures being marketed as having enhanced functional (probiotic) characteristics and health benefits.

About 80% of traditional fermented foods are produced, in part, by natural

fermentation and may contain functionally beneficial (probiotic) and pathogenic microorganisms. Clearer understanding of microbial ecosystems is critical, in light of the evidence of increasing pathogen resistance to established hygienic and biopreservation techniques. Consequently, thermal and nonthermal technological processes applied to the evolution of food fermentation require continuous innovation of food safety and microbiological risk assessment tools. Effective tools for metabolic profiling (e.g., metabolomics) in supporting safe and sustainable food systems that can reliably enhance nutritional value and human health are also essential.

Scientific opportunities and challenges

Until recently, fermentation technologies have played an overlooked yet vital role in ensuring the food security of millions of people around the world, particularly marginalized and vulnerable groups. Traditional fermented weaning foods, for example, may play a preventive role in infant malnutrition, lactose intolerance, and tropical diarrhea. With increases in world populations and arid land, food security can be better achieved with improved preservation processes, increasing the range of raw materials used to produce fermented food products, and removing antinutritional factors (e.g., toxic bioactive compounds) that make foods unsafe to eat.

As evidence of improved nutritional quality and food safety of fermented foods becomes more available, the consumption of fermented food is likely to reach new milestones. Biofortification and designer foods (foods with defined health benefits other than nutritional value) are among the promising strategies to reduce micronutrient deficiencies worldwide, and food fortification with LAB probiotic properties is rapidly gaining increasing interest. Although evidence indicates that fermented dairy products are the best matrices for delivering probiotics, there is consumer demand for probiotic foods obtained from nondairy matrices. Several food materials (e.g., cereals, fruits, and vegetables) are, therefore, being studied to determine their suitability for safe, sustainable, nondairy probiotic foods.

The challenge in developing health recommendations for probiotic consumption is not a lack of scientific literature, but rather a lack of consolidated research and consistency across studies with respect to validating the safety of bacterial strains, dosages, and the specificity of their functional benefits for selected populations. Conclusive substantiation of the efficacy of probiotics is still emerging, while at the same time a growing number of consumers are interested in trying probiotics as well as increasing the levels of live active cultures in their diets. Once consumed, LAB from fermented fruits and vegetables have many potential benefits

(e.g., increased absorption of nutrients). To market enriched probiotic fermented food sustainably, it is essential that key ecological principles, food safety measures, and health indicators are rigorously tested. Product integrity, harmonized standards, and hygienic preparation of the products are crucial to success.

Policy Issues

- Create a strong training and education strategy to raise awareness of the vital importance of microbial food fermentation in secure and sustainable food systems. Existing international and domestic organizations (e.g., the Food and Agricultural Organisation [FAO] of the United Nations, and the U.S. Department of Agriculture [USDA] Nutrition Centers) possess the leadership, interdisciplinary expertise, and substantial resources to advance training programs examining interactions between microbial cells and food system complexity, as well as integrating biotechnologies, ecology principles, and deciphering food impacts on host-microbial dynamical networks.
- Develop multiscaled biotechnology and harmonized international food standards and guidelines for food fermentation products aligned at the U.S. and international levels through the Codex Alimentarius Commission.
- Invest prudently following the principles outlined by published frameworks (e.g., reference below), technology transfer pathways and public-private partnerships among government and nongovernment organizations, academic, and industry environments that can maximize the capacities of cross-disciplinary expertise and financial resources.
- Build ecologic frameworks wherein food webs are integrated with host-microbial metabolic networks on different spatial and temporal scales. This will involve a multi-pronged approach including U.S. departments (e.g., Department of Energy [DOE]) and multigovernment agency efforts in habitat restoration, promotion of native species, and targeted removal of invasives. Metabolic profiling of *microbial* fermentation can further advance our knowledge about its role in bioactivity of extracts, energy balance, and functional impacts on health.
- Establish appropriate safety regulations in the market by the regulatory authorities of the country that inform consumer awareness about substantiated benefits/risks. Factors include evaluating the possible effects on biodiversity, the environment, and food safety; weighing the benefits

of the product or process against its assessed risks; and tools that provide risk monitoring to ensure continued safety.

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Debate Conclusions

- Proactive, governmentally sanctioned regulations based on the highest standards need to certify the hygienic safety and the nutritional value of fermented foods if they are to be accepted by the public. The potential contributions of fermented foods in highly nutritional diets has been

confirmed by omic science (i.e., a holistic, molecular analysis of cellular and tissue structures within organisms) focused on how fermented foods affect metabolic pathways.

- Credible information on the functional benefits of fermented foods, clearly communicated through mainstream and social media (nationally and internationally) by trusted scientists to both policy makers and the public *writ large,* is essential to address the consumer resistance to fermented foods for inclusion in healthy diets.
- Maintaining healthy, stable food systems critically depends on preserving genetic biodiversity in crops and livestock, a task based on (i) identifying the specific microbes underlying fermentation in agricultural systems and (ii) sharing the resultant documentation to ensure globally standardized safety practices.
- The historical anecdotes suggesting that fermented foods provide numerous health benefits, now confirmed empirically with emerging technologies (e.g., metabolomic footprinting), highlight the need for interdisciplinary research to examine the physiology of host organisms to fully understand how fermented foods promote human health.

Current realities

As the human body has adapted over time to efficiently utilize lactic acid, nearly every culture has developed traditions involving fermented foods. Fermented foods, probiotics (i.e., the microbiota present in such foods), and the human microbiome have co-evolved. Their functional roles and influence on both human health and food security/safety are gaining increased attention from a variety of public and private interests (e.g., food manufacturers, health industry, basic science community). Omic technologies that analyze and compare small molecule metabolites to gain insight into biological systems (e.g., metabolomics) are enabling a more complete understanding of the nutritional qualities of fermented foods and their effective absorption in the body. Microbiome research has brought together multiple disciplines (e.g., microbiology nutrition, food technology, omic sciences) to identify microbial community composition and how it changes based on different human phenotypes, environmental conditions, responses to antibiotics, and other physiological alterations.

The human microbiota (i.e., the sum total of unique microbial communities living in and on humans) is acquired at birth, though its concentration can diminish over a lifetime and the community composition can change. Studies indicate certain

microbiomes are responsive to certain diets, and that the gut and the nutrients within provide an environment in which fundamental ecological phenomena occur.

Although the science is still emerging, repeated studies have indicated that the microbial colonies associated with a healthy human microbiome can be restored when imbalances exist; there is no firm agreement, however, as to how to best accomplish this or if the restored community exhibits resiliency. Researchers are investigating the possibility of "reseeding" the body's bacteria with just one or a few kinds of restorative organisms to reestablish a healthy microbiome composition, in a process similar to restoring an entire forest by replanting only one robust species of tree.

While therapies to restore a healthy microbiome exist, more research and continued/vigilant regulatory oversight are needed to ensure public safety and effectively engage public support. Since regulatory authorities are wary of approving therapies that are currently considered potentially risky (e.g., fecal transplantation), risks and benefits of potential "restorative bacterial species" can be addressed by pursuing a select number of well-characterized bacteria, in particular to avoid potential adverse effects (e.g., avoiding bacteria that possess antibiotic resistance).

Although the development of probiotics has been blocked in the past by the pharmaceutical industry, the clinical field is now embracing probiotics and some pharmaceutical companies (e.g., Eli Lilly) have begun patenting multiple microbes of interest.

There is wide agreement within the fields of food safety/security and health research that fermented foods (e.g., sauerkraut, miso, soy sauce, yogurt, natto, kimchi, kefir) offer many benefits and opportunities; their health value is epitomized by their consideration by the U.S. National Aeronautical Space Administration to address microbiome imbalances that occur during space travel that cause astronauts to be prone to *Clostridium difficile* infections. In addition to aiding health and nutrition, fermented foods are inexpensive to produce and have helped sustain communities during winter seasons and periods of famine. Food technology has advanced the bio-preservation qualities of fermented foods, giving them even longer shelf lives. Fermentation can not only increase food access but also food quality, reducing the need for added salt and decreasing the toxicity of naturally toxic foods (e.g., fermentation of the Greenland shark by native people turns a toxic nonfood into food).

While fermented foods are a $10 billion industry, the lack of precise knowledge about their effects and actions in the body increases the likelihood that product marketing will be based on unverifiable claims. Currently, testing and research are taking place in three ways: (1) By funding exploration of *in vitro* gut fermentation,

major governmental organizations (e.g., National Science Foundation, National Institutes of Health [NIH], U.S. Department of Agriculture [USDA]), are helping scientists gain insight into what is occurring at a systems level. (2) Research on animal models is seeking solutions to bacterial diseases associated with food poisoning (e.g., *Salmonella, Campylobacter*). (3) Human safety studies involving metabolomic footprinting are being conducted under the auspices of the Food and Drug Administration (FDA) Center for Biologics Evaluation and Research.

Research into genetically engineered probiotics largely has focused on preventing starter culture failure (i.e., culture collapse usually because of viral infection), and genetically engineered counter measures have been developed for this problem in dairy processing but have not been implemented. Private companies are highly interested in probiotics research and are investing in animal and human trials. Such research provides scientists with alternate ways of studying biodiversity but also creates a national security issue for food safety (e.g., contamination, toxicity, unforeseen adverse events).

To preserve important and distinct bacterial cultures, numerous culture banks exist around the world (e.g., multi-system banks, industrial banks, national banks). The U.S. Department of Energy and USDA each have their own culture banks. Although the majority of countries claim that their cultures (typically lactic acid bacterial organisms) are regionally unique, they often are genetically similar or identical to the organisms in other countries' banks, raising suspicions of piracy. The most recognized and developed culture banks are the NIH Human Microbiome Project and the European Union's MetaHit Project. The NIH holds cohort studies within the Human Microbiome Project, and it has also expanded to include projects in China, Japan, Australia, and France.

Given the projection that there will be 9 billion people in the world by 2050, it was widely agreed that fermented foods are needed to help feed such a large population. But in spite of the enthusiasm for fermented foods within the scientific, medical, and industrial communities, the public *writ large* generally does not have a high regard for such foods, often viewing them as unappetizing. Although some fermented products (e.g., kimchi, kefir) are becoming popular with health-conscious consumers, there is concern that the benefits of these foods are being superficially over-marketed, skewing consumer expectations. Despite such market exploitation, the U.S. is considered to be comparatively slow in adopting and marketing fermented foods; the nation's "throwaway mentality" also results in many foods being wasted that could be made useful with fermentation.

Scientific opportunities and challenges

Although current research is heavily focused on the compositional aspects of microbial communities, an urgent need exists to identify functional communities and their impact on the physiology of host organisms in order to understand how fermented foods create functional benefits in the human body. Too often, however, research is producing lists of organism names without incorporating omic technology to start building functional maps. Shifting the focus of research from composition to function often requires scientists to work as interdisciplinary teams.

Ensuring safety and promoting public acceptance of novel fermented products are top priorities. To build a fermented foods industry, there must be high standards of product safety, nutritional quantification and qualification, and hygiene. As probiotics are embraced, it is important that omic technologies be utilized to understand how these products affect metabolic pathways in order to better substantiate safety and address risks and benefits of fermented foods. Better marketing also is needed to overcome consumer resistance to eating these foods. Challenges also exist in getting nutritious foods to communities that need them.

Because a wasteful mentality tends to exist in more affluent nations, particularly the U.S., many foods are unconsumed that could be made useful with fermentation, and an opportunity exists to revitalize the concept of food preservation through fermentation and probiotics.

Dwindling biodiversity (including microbial diversity) has serious implications for the entire food system, including fermented foods (e.g., fish species normally fermented by native tribes of the Pacific Northwest are in decline or have disappeared altogether, causing disruption in both the tribal way of life and the environment). Greater efforts are required to preserve and document traditional food practices and study the distinct microbiome systems native peoples have sustained over time (e.g., the Sikkim community in India utilizes over 100 different fermented foods, resulting in a unique microbiome composition and specific consequences for the health of the Sikkim community). Such documentation offers culture banks an opportunity to improve data acquisition and management, and can have consequences over time for the health care and food security of a growing global population.

Policy issues

To increase consumer confidence and encourage private companies to market a wider variety of fermented products, regulatory oversight of fermented foods and microbiome projects is needed, as well as safety regulations in the national and international markets for food products, with international authorities working cooperatively regarding oversight responsibility. Regulatory vigilance also is needed

regarding engineered food products (e.g., those containing genetically modified organisms) to ensure antibiotic resistance genes are not propagated and unintended pathogen exposure does not occur.

While the fermented foods market would benefit from having its own section within grocery stores, such product placement is difficult to achieve due to competition from other products. Mainstream and social media educational infrastructures can encourage the public to incorporate new foods into their diets by changing the framework within which fermented foods are discussed (e.g., in the same way that food waste has been reframed as "garbage chic" and is served in specialty restaurants). In addition, the public needs to be educated about safe fermentation practices and safe probiotic dosages, since the common, though incorrect, public perception tends to be "more is better." Potentially lead by the WHO, the FAO, or the USDA, such educational programs need to be implemented at community, state, national, and international levels.

A functional understanding of microbial species present and genes expressed in the human microbiome is critical, and research funding directed toward interdisciplinary work in the scientific community is necessary to accomplish this. To address concerns regarding the genetic engineering of crops and foods, the development of advanced technologies must follow the food guidelines under the Codex Alimentarius Commission established by FAO and WHO. Regulatory processes can ensure fermented food ingredients, specifically probiotics, are codified as a means of ensuring consistency. Testing is needed to ensure products are not antibiotic resistant, and that there are at least two drugs to which they are susceptible in case of adverse events. To support production scale-up, new regulations must be based upon scientific data that quantifies the nutritional and health values of these foods.

To support the preservation of biodiversity, human microbiome projects operating internationally, as well as culture collection databases around the world, need to move toward greater interfacing of information. Practices among projects need to be streamlined and standardized both for safety purposes and so they can be monitored by regulatory and import authorities. Culture collection can occur simultaneously with other goals (e.g., at a center being developed in Bangalore, India, a "food for health" program is to be combined with a big data project to document food compositions in order to aid analyses of the microbial content of food). This will provide for a sustainable community government project, as well as a platform for nutrition and food security.

Building Local Food Capacity as a Food Security Strategy for Northern Indigenous Communities**

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Summary

Over the past several decades, indigenous populations in Canada have undergone dietary and lifestyle transformations that have resulted in alarming rates of obesity and obesity-related diseases, especially type 2 diabetes mellitus. Forced settlement patterns and the depletion of wild food resources as a result of Euro-Canadian colonization abruptly altered their food consumption and physical activity patterns. Even though lack of physical activity is an important contributor to the chronic disease pandemic, the dietary transition in northern communities brings substantial challenges when it comes to obtaining nutritious foods. Throughout northern Canada, the primary reasons for food insecurity include the high cost of market food, restricted availability/access to nutritious foods, and lack of government support for nutritious food programs. The exorbitant costs of market foods throughout the north have led to recent calls for a resurgence in local modes of food procurement. While it is clear that there are important benefits to traditional diets, there are critical barriers in acquiring sufficient amounts of wild food for regular consumption, despite the relative abundance of wild food sources in most northern regions. As a result, people in many indigenous communities are both struggling to harvest land-based foods and have limited access to quality market foods, thus limiting regular access to healthy foods. Communities are searching for solutions to this dietary dilemma.

Current Realities

For thousands of years prior to the westernization of food systems (e.g., better food transport, access to processed foods), indigenous populations in Canada primarily consumed plants and animals obtained from the land. Dietary practices were regionally and historically diverse, with some groups drawing almost entirely from animal food sources, while others benefited more significantly from agriculturally produced food items. Over the last 30 years, researchers have established that access to nutritious foods in remote First Nation communities of Canada is limited and

costly when compared to the obtainability of low cost, poor quality, processed foods (Pal, Haman et al. 2013). Though many of these populations may prefer to include more land-based foods in their diets, people are generally required to rely heavily on store-bought foods. The limited store options in most northern communities provide a very large selection of highly processed foods, candies, and sugary drinks, whereas the diversity of nutritious foods is extremely limited. Consequently, residents in northern communities have limited access to nutritious foods, a fact that has contributed to indigenous peoples experiencing a disproportionately higher burden of chronic disease compared with non-indigenous Canadians (Haman et al. 2010). Research by the Indigenous Health Research Group (IHRG) in northern Canada, documenting the prevalence of overweight/obesity and the incidence of type 2 diabetes, revealed numbers that exceed not only national averages but indigenous national averages as well. These numbers are of grave concern and provide a grim prognosis for improvement, especially when situated within the context of high food costs and limited availability of healthy food options.

Scientific opportunities and challenges

As health researchers, we would like to think there is value to our work in that it continues to draw attention to the health disparities indigenous peoples are facing and the various factors contributing to them. And while people should be aware of the disparities indigenous peoples are facing, identifying/researching these issues clearly is not enough. In fact, these results are having very little impact on the communities themselves and, for the most part, are not telling people anything new. Community members are keenly aware of the increasing prevalence of obesity-related diseases and their tragic health impacts. They are also aware that they do not have regular access to affordable nutritious foods and that it is increasingly difficult to get access to land-based foods for a variety of reasons, such as cost, knowledge and availability. How communities are responding to these challenges, in particular by restoring connections with the land and learning to move forward though local land-based solutions, deserves closer attention.

In 2009 our research group was provided a funding opportunity to study and support land-based food programming that our community partners wished to develop, enhance, and sustain. This opportunity marked an important change in how we began to think about and approach community-based research. In this case, it was made clear at the outset of the project that community participation was contingent on each community having ownership over the projects, that their own unique interests were being met, and that the project was being conducted according to community protocols. Land-based programming and food procurement was at

the core of all the projects in nine different First Nations across Canada, but each community envisioned distinctive strategies in achieving land-based programming goals. Funds were used to develop local food procurement infrastructure, train youth in local harvesting methods and food preparation techniques, and provide nutritional/cooking information.

To date, important strides have been made in documenting community efforts to develop local food strategies as a means of addressing high levels of food insecurity in remote northern indigenous communities. These efforts, however, must be accompanied with the acknowledgement that food access and food quality do not necessarily translate into improved dietary habits. What needs to be done, then, is to assess how local food efforts are impacting individual behaviours, and if these efforts are leading to the positive changes necessary for chronic disease prevention/reduction to occur. Are people in the community eating healthier as a result of the local food initiatives operating in their community? If there are even the slightest improvements in diet, what impact are these modifications having on individual health? Thus, researchers will need to develop, implement, and evaluate the effects of these initiatives to provide important information about the overall value of these programs from a chronic disease perspective. This will help researchers in their goal of addressing the food-related health issues that indigenous communities are facing. If evidence can be provided that local food initiatives are positively affecting the health of individuals and communities, there will be greater likelihood of ongoing support for these programs. Here we see the important role researchers can play by putting research results into action to help communities maintain and develop local food initiatives in their efforts to improve community health.

Policy Issues

- Hunter-support programs, such as the Income Security Program for Cree Hunters and Trappers, signed under the James Bay and Northern Québec Agreement, must be implemented nationally and supported by federal and provincial/territorial governments. This program puts money into the hands of families who spend at least 120 days harvesting local foods. The financial support for the harvesting of traditional food follows recommendations made by the Royal Commission on Aboriginal Peoples and reflects what was put forth in *Canada's Action Plan for Food Security* (1998). At present there are regional and provincial programs supporting the development of local food initiatives (e.g., Food Matters in Manitoba, the Remote First Nations Food Systems Project in British Columbia), but a federal commitment to support land-based food initiatives across the country is necessary.

- There are several factors influencing wild food availability in regions across Canada, two of which are climate change and the depletion of resources as a result of overfishing/overhunting. In most regions in Canada, indigenous peoples who rely on wild foods for daily sustenance are competing with commercial and sport fishing/hunting. More effective policy that ensures indigenous people's unmediated access to land based food resources and the greater enforcement of existing policies, are required to restrict access to sport and commercial fishing in indigenous territories as agreed upon by treaty or as unceded (i.e., lands not surrendered to the Crown). Both federal and provincial/territorial governments have jurisdictional obligations here and must be involved in policy creation and enforcement.
- Resource development/extraction in northern Canada is highly contentious because of the potential environmental impact and encroachment on traditional indigenous territories. Private and government interest in resource exploration provides interesting policy opportunities to support land-based food initiatives. Currently, engagement and negotiations between companies (e.g., mining companies, oil companies) and Indigenous Nations about seeking access to traditional lands emphasize economic development and job opportunities for local populations where development sites (e.g., mines) are established. These negotiations must also be accompanied with a minimal financial commitment directed towards environmental restitution, building local food capacity with Indigenous Nation partners, and land-based food programming.
- Canada is facing significant international pressure to reduce carbon emissions (based on its heavy economic reliance on fossil fuel-burning industries), which will inevitably lead to more progressive and substantial carbon taxation at both the federal and provincial/territorial level. This provides an opportunity to use a percentage of these taxable revenues for building/sustaining land-based and local food programming in regions most impacted by fossil fuel burning industry.
- In 1991, Canada developed its Northern Contaminants Program to help limit environmental contaminants in land-based foods and to assist people in making informed choices around the safe consumption of land-based foods. The program has achieved considerable success, but there needs to be more stringent sampling and testing by provincial ministries of wild food sources to ensure these foods are safe for consumption. Advocating increased consumption of locally procured food as a food

security initiative without implementing safeguards to ensure foods are safe to consume is not acceptable. In addition to testing edible wildlife, the policy must also provide remediation/contingency support in areas of potential risk.

- In 2014 Education Aboriginal Affairs and Northern Development Canada introduced its First Nations Education Act in an attempt to close the gap in education outcomes for on-Reserve First Nations Peoples. The act has been met with controversy as it serves as another example of the federal government making unilateral decisions about indigenous education without proper consultation and input from the people themselves. The public controversy points to the need to accommodate indigenous perspectives into education planning and curriculum. Part of this curriculum should consider what Wawakapewin (northern Ontario) Elder and educator Simon Frogg describes as Land-Based Education, which would reflect indigenous epistemologies while still meeting provincial standards. For Simon it is critical to build land-based education programs to provide youth with the necessary skills to get on the land and learn how to hunt/prepare foods as their ancestors have.

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***** A policy position paper prepared for presentation at the conference on Food Safety, Security, and Defense (FSSD): Food Security and Diet-linked Public Health Challenges, convened by the Institute on Science for Global Policy (ISGP), Sept. 20–23, 2015, at North Dakota State University, Fargo, North Dakota, U.S.***

Debate Summary

The following summary is based on transcriptions of a recording made by the ISGP staff during the debate of the policy position paper prepared by Dr. Michael Robidoux (see above). Dr. Robidoux initiated the not-for-attribution debate with a 5-minute statement of his views and then actively engaged the conference participants, including other authors, throughout the remainder of the 90-minute period. This Debate Summary represents the ISGP's best effort to accurately capture the comments offered and questions posed by all participants, as well as those responses made by Dr. Robidoux. The views comprising this summary do not necessarily represent the views of Dr. Robidoux, as evidenced by his policy position paper, or those of the ISGP, which does not lobby on any issue except rational thinking. Rather, it is, and should be read as, an overview of the areas of agreement and disagreement that emerged from all those participating in the critical debate.

Debate Conclusions

- Although there is great variance among indigenous communities, initiatives such as food sharing, community gardens, infrastructure building, cooperatives, and traditional food procurement need to play a role in integrating healthy practices that encourage food security within indigenous communities, particularly within First Nation communities in Canada. Each community, however, must decide which practices best suit the needs of the group.
- To foster community empowerment, food initiatives to ensure food security (e.g., food sharing and distribution, crop preferences, educational campaigns) must originate from community-driven decisions led by community members. The role of outside experts in providing assistance and knowledge needs to be included only though community-wide requests.
- While the sustainability of health in indigenous communities may be enhanced by incorporating the past traditions that shaped their cultures, a balance must be found that respects cultural norms without encouraging the adherence to practices that harm the health of a given community. The benefits of preserving cultural traditions, well documented through conservation projects, need to be expanded for the benefit of indigenous communities worldwide.

- Although funding is often not the sole barrier to food security in indigenous communities, obtaining long-term funding is essential if food programs are to be effectively sustained. The skills needed to secure such long-term funding need to be cultivated within indigenous communities (e.g., initiatives using public-private partnerships).

Current realities

Much traditional knowledge has been lost over time by indigenous communities in North America, especially in regard to the benefits of eating primarily from the land. This loss of knowledge is not simply about the food itself, but the process of procuring, preparing, and sharing (i.e., practices in which the whole community traditionally takes part). Given that food is an integral part of every culture, traditional diets are important to native communities on many levels, not just nutritionally.

With limited access to education, children in remote indigenous communities often are sent away to school, making it even less likely they will learn about traditional food system practices. Students often experience culture shock in larger cities and many do not perform well in such settings. Such separation and disenfranchisement of indigenous youth can deprive communities of the contributions of their younger generations, and also deprives youth of opportunities to gain knowledge about traditional practices. Although it's argued that modern indigenous children do not have a taste for their culture's traditional foods, many children simply have not had many opportunities to eat them. Some communities have tried homeschooling their youth, but with limited success. Because the ability to interact with community elders and see how traditions are passed on has been found to be an empowering activity for youth, local schools are now beginning to incorporate elders and their knowledge into curricula.

Economic strategies that bring food from southern Canada into the rural regions of the north (e.g., food box programs and food cooperatives) are helping improve food security in those areas, as is the creation/expansion of community markets, and education (e.g., about safe food preparation, how to utilize the whole animal for food). Replication and scalability of these food initiatives is most successful when community members accompany presenters and speak about their own community's programs.

Food-sharing programs can be a viable option for improving food availability within some communities, but the practice can be highly sensitive in communities where the concept of sharing is traditionally based on reciprocity. Since food sharing generally functions within semi-exclusive groups, giving food to someone outside

the group is thought of as charity rather than sharing. Members of a food-sharing group typically have jobs and can hunt, while the most vulnerable to food insecurity often are excluded from participation in the group. Researchers and scientists may introduce new practices such as food sharing to communities, but must be careful not to impose on traditions or dictate the conversation.

While climate change is playing an increasingly significant role in food insecurity within indigenous communities, economics remain a contributing factor. Purchasing or hunting food is expensive, and there is a lack of food availability and variety in markets. The concentration of seminomadic people into settlements has caused excessive resource extraction in confined areas, depleted local food sources and caused communities to pay more for food procured from distant locations. Even potentially sustainable and nutritious interventions (e.g., community markets) are economically challenged when local stores undercut their success by putting similar foods on sale.

Although helpful, research money and project grants provide support for only a limited number of years, leading to instability of beneficial projects such as food sharing. Applying for funding is therefore an important activity, and successfully procuring financial aid requires the full capacity of a knowledgeable and well-functioning tribal committee.

Energy and resource extraction is prevalent in many of the lands shared with indigenous communities, such as the Ring of Fire mining and smelting project in the mineral-rich James Bay lowlands of Northern Ontario. While some communities are capable of negotiating with industry partners, others lack the empowerment and means to do so. Since commercial enterprises (e.g., mining, forestry) generally prefer buy-in from the communities in which they operate, these private sector entities often attempt to form partnerships with First Nations councils, although such attempts are not always successful because of the large imbalance of power inherent in the relationship.

Scientific opportunities and challenges

International agriculture has a long history of encouraging community empowerment and farmer-led experimentation to address the challenge of food insecurity. Similar initiatives could be effective within First Nations communities. However, building new partnerships within communities is considered by some to be an unrealistic goal, as many communities are struggling to secure long-term funding and lack sufficient administrative capacity to run programs in a sustainable manner.

Since traditions and ecology are interdependent and dynamically changing, the food sovereignty of indigenous communities is an important aspect of food security

efforts. Given that community needs and preferences vary from region to region, it is imperative that programs allow individual communities to articulate what food capacity means to them and lead efforts to define their needs (e.g., greater traditional knowledge, infrastructure building, community freezers, food preservation). The difficulty is determining who most desperately needs food and if they are actually receiving it and to effectively meet this challenge requires researchers to become more integrated within communities. Having a better understanding of how food collection and hunting addresses a community's food and nutritional needs can help researchers devise solutions that are unique to specific communities and locations. Although these solutions will vary, it is important to systematize the process of identifying community wants, needs, ideas, and opportunities so that such a process may be more broadly and effectively utilized. Initiatives focusing on systematizing the collection of vital community information have already begun in some areas (e.g., adding knowledge translation components into interactions between communities and researchers at cross-regional conferences and community presentations).

Researchers must avoid imposing outside programs (e.g., food sharing) on indigenous communities that are not receptive to such practices, and abstain from advocating for a transition to fully traditional diets, as some traditional practices are neither more sustainable nor healthier. A study comparing a diet of store-bought, processed foods to land-based diets found that the source of a diet did not dictate an individual's health. Regardless of diet practices, one in three study participants was diabetic, with 98% overweight and approximately 67% obese. Those who ate traditional diets were reported to have higher rates of PCBs and mercury in their bodies compared with those who ate store-bought foods. It was noted, however, that other studies have found that traditional eating habits promote health and are requested by individuals. There have been challenges in understanding the origin of contaminants in traditional foods, although airborne pollutants and a lack of proper landfill sites are believed to be contributors.

Beyond their nutritional value, traditional diets (i) incorporate ethical codes concerning the treatment of plants, (ii) make spiritual connections between land and food, and (iii) utilize some foods medicinally. Along with studying the benefits of traditional diets, researchers need to understand these other characteristics and any potential consequences before recommending changes in community practices.

While it is important to consider traditional knowledge and diets, procure foods locally, and monitor how food initiatives impact dietary habits and outcomes, it also is widely recognized that making nutritious food accessible does not necessarily mean it will be eaten. Scientists are studying successful food interventions (e.g., community gardening, traditional food procurement) and how diets incorporating

these practices develop over time. Integrating biopreservation methods could be a way to help restore healthier eating habits absent from mainstream diets that are heavy in added sugar and contribute to higher rates of diabetes.

Researchers and scientists need to be cautious about romanticizing the notion of turning to the past for solutions to current issues. Although there is value in discovering food traditions that have been lost (e.g., understanding methods of food preparation and the types of animal tissues consumed), there also is much potential in science, innovation, and technology to effectively address nutritional deficits. indigenous communities must discover how to incorporate traditionally harvested foods with the current food distribution system, and be able to take the best practices from the past while leaving behind unhealthy habits (e.g., the overconsumption of fry bread). Scientists need to ensure they are moving forward with respect and regard for each community's past, and that they are communicating in an understandable manner with community members.

Policy issues

Community empowerment is vital to changing unhealthy eating habits and increasing food availability within indigenous communities. Indigenous people need to lead decision-making about the types of local foods they will grow and consume, and must devise and implement community systems that establish food sovereignty. This kind of control is key to establishing true empowerment. Within such a framework, federal funding for food initiatives could be one way to compensate First Nations communities for disadvantages that have been imposed upon them. First Nations peoples also need to exercise more control in deciding who takes resources from their lands and in upholding local cultural values.

While community gardens are food-security projects that do not require large amounts of monetary support to be successful and can effectively capitalize on small amounts of training and support, it is unethical for scientists and policy makers to support eating from the land if those resources are suspected to be contaminated. While scientists cannot assume they know what is best for a community, they have a paramount responsibility to identify and modify practices known to be harmful. Industries that are responsible for contaminating land, and therefore food sources, need to be held accountable for their actions, whether through remediation or prevention measures. Current remediation support, if any, is weak, as seen in Grassy Narrows in Ontario, an area poisoned with mercury. There has been an ongoing struggle to find responsible parties because the companies involved often claim bankruptcy, leaving the indigenous communities to address the contamination on their own.

Although distribution systems, rather than actual food yields, are primarily responsible for food insecurity within indigenous communities, community-led processes are needed to gauge opportunities to invest in increased availability of local foods and to secure consistent funding for food security efforts. Successful community initiatives must be shared with other communities. An example is Peru's response to water management issues, which can provide a potential model for indigenous communities seeking greater food security. To address water management concerns, Peruvians who had the resources and were willing to support community development established trust funds that were under strict fiduciary control. These funds could be used for community-led projects or cross-community communications, providing continuous funding and assurance of support as opposed to project-by-project or year-to-year funding. Peru's example suggests that communities locate investment opportunities and use resources from people who have a vested interest in development. Institutional innovation and the involvement of a third party (e.g., the World Bank) could facilitate negotiations and agreements. Crowdsourcing also could be utilized in these efforts.

Because some traditional plants and practices are viewed as having medicinal benefit, an economic rationale potentially could exist for preserving indigenous lands and practices. This perspective also could provide a strategy for obtaining sustainable monetary support (e.g., trust funds and research grants). The preservation of tradition and culture, when viewed through a medical lens, not only benefits communities, but has global implications as well.

Much-needed research into the biodiversity of the areas surrounding communities could address the lack of jobs in indigenous communities for young and educated generations by creating employment opportunities. Such opportunities could be written into negotiations of trust funds and energy extraction agreements. Through this strategy, information can be procured from community members who are familiar with the areas, as opposed to outside researchers. *Quid pro quo* negotiations between indigenous communities and corporations or governments for access to resources could also provide a way to support community development programs and stabilize communities in need of financial backing.

Conservation projects, such as the initiatives undertaken in behalf of Atlantic salmon, can help address increased competition for resources in certain regions. Currently, the Atlantic Salmon Federation purchases drift nets from native people; through selling the rights to nets, communities have rebuilt fish stocks. This effort, which is dependent on cooperation between sport fishermen and native people and has occurred in communities in Greenland, Iceland, Russia, and the Gold Peninsula, illustrates the importance of creating policies that reflect the integration of tradition and innovation.

Asian Diabetes: Cause, Challenges, and Health Care Reform**

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Summary

Type-2 diabetes (T2D) affects more than 300 million people worldwide and accounts for close to half a trillion dollars annual burden on the world economy. Asian Indians are twice as likely to develop T2D compared with the general population in the United States. Diabetes in the Asian population (Asian diabetes) epitomizes our current struggle in providing adequate care for chronic diseases because of human, social, and economic challenges. Asians frequently escape screening and intervention procedures as telltale signs of weight gain are often missing. Cultural and ethnic issues specific to Asian Indians introduce barriers to patient adherence and effective disease control. A plethora of genetic determinants makes the group vulnerable to disease through poorly understood mechanisms, which can contribute to rapid disease progression. Routine care for diabetics is expensive, but a far greater economic burden is the hospital care required for associated complications. Using Asian diabetes as the model, information will be presented on patient-, provider-, and health system-based barriers preventing implementation of evidence-based practices, as well as the opportunities and reforms applicable to the control of T2D in general.

Current realities

Diabetes is an incurable, progressive, debilitating and costly disease. In a five-year period from 2007-2012, the annual direct medical cost of newly diagnosed diabetes increased by 41%, rising from $175 billion to $245 billion in direct medical costs. Half of the medical expenditure is attributed to hospital inpatient care and prescription therapies, which would be less distressing if the high cost correlated with high-quality health care. However, when compared with other developed countries, the U.S. is ranked lowest on the list on most standard measures of health.

There are seventeen million type-2-diabetic people in the U.S. If current

trends continue, one out of three American adults will have diabetes by 2050. Rapid growth of diabetes in high-risk populations, including Asian Americans, is one reason for increased prevalence of the disease in the U.S. Asian Indians are one of the fastest-immigrating groups to the U.S., reporting a 74% increase in the last decade, second only to Hondurans. Most of the immigrants relocate to the U.S. either in their late teens or early twenties. Upon contact with mainstream culture, they quickly replace traditional cooking with convenient fast food and restaurant take-outs. This rapid shift from traditional wholesome cooking to processed food in a population with elevated genetic predisposition propels first generation Asian Indians into prediabetes. Prediabetic Asian Indians rapidly progress into diabetes as they fail to implement adequate lifestyle changes. In fact, physical inactivity is highest among Asian Indians.

Predisposition to T2D appears to be determined during prenatal growth in Asian Indians. Even though Asian Indian newborns have a lower average body weight relative to Caucasians newborns, they exhibit higher body fat percentage and insulin levels. Asian Indians exhibit lower levels of adiponectin compared to Caucasians, evident at even three to six months. In addition to early onset, T2D in Asian Indians is characterized by greater abdominal obesity despite a relatively lower body mass index (BMI), greater insulin resistance, higher fasting insulin concentrations, and an early decline in beta cell function regardless of age, gender, or BMI.

Scientific opportunities and challenges

Mechanistic, preventive, and therapeutic understanding of T2D is mostly drawn from studies sampling Caucasian patients. Because of differences in body size and physiology between Caucasians and Asians, results may not be fully applicable to Asians (e.g., Pro12Ala polymorphism of the peroxisome proliferator-activated receptor gamma gene affords protection against diabetes and insulin resistance to Caucasians, but appears not to protect Asians).

Studies have identified approximately 70 genes associated with high susceptibility to T2D and account for about 10% of the overall heritability of T2D. Of these, 29 were identified in the Asian population. Analyses of these loci improved prediction of T2D and facilitated the adoption of early diagnostic and preventative strategies to reduce the growing disease burden. However, relevance of many of these genes in Asian diabetes remains unclear. A recent 2011 genome-wide association study on South Asians, published in *Nature Genetics*, reported common variants at six loci to be associated with T2D. Polymorphisms at three of these genes are known to influence insulin and beta cell function. The results of this study opened up a host of additional questions and possibilities (e.g., How do susceptible genetic loci

participate in the pathogenesis of T2D? Mitochondrial mutations, including those in uncoupling proteins, may influence basal metabolic rate [BMR], energy efficiency, visceral fat assimilation, insulin resistance, and T2D). The immediate challenge now is to develop genetic risk score models based on inherited susceptible variants for T2D for the purpose of facilitating early interventional strategies aimed at preventing or delaying the onset of the disease in nondiabetic individuals.

Policy issues

- Empower businesses, raise patient accountability: Experience-based group education, and counseling to high-risk and youth populations are already in place and contributing to the fight against T2D. However, most prediabetic and diabetic subjects fail to commit or adhere to a healthy lifestyle due to lack of positive reinforcement. Much of this problem can be resolved by incentivizing small businesses outside of the healthcare system that are looking for business opportunities to counsel individuals on exercise and diets, as well as for opportunities to offer periodic tests for glycemia, lipids, blood pressure, and body composition. This solution cannot be viewed as a cost-saving strategy, but rather as a measure to reduce the burden of chronic disease by improving access to frequent noninvasive monitoring systems and through positive reinforcement for lifestyle transformation, while also raising patient accountability in disease outcomes. Funds must be made available through national and state level grants. Proven and skilled assistant professors devoted to solving the T2D crisis, who have been denied tenure, may find this new opportunity compelling and rewarding.
- Treatment algorithm: Clinical trials of treatment options assessing cost effectiveness, optimizing patient outcomes, and evaluating potential risk need to be conducted through partnerships between academic institutions and government agencies. Agencies like National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK) at the National Institutes of Health (NIH), focus research efforts and clinical trials in diabetes that are typically not pursued by drug companies. Based on funding availability for new research initiatives, competitive Requests for Application (RFAs) are issued. However, considerable uncertainty exists regarding the primary outcome, sample size, and the retention rate of trial participants. Therefore, the feasibility of trial design, duration, and budget are unknown throughout the RFA process. Investigator-initiated planning grants have the potential to be robust and efficient, and must be adapted by NIDDK.

- Delivery and access: As patients progress to a diabetic state, associated comorbidities inevitably arise, which cannot be adequately addressed by episodic face-to-face interactions with a single physician. Given that diabetes care has robust evidence-based guidelines, high-cost involvement, and demonstrates a quality gap, principles of Patient-Centered Medical Home (PCMH) and Patient-Centered Specialty Practice (PCSP) can be adapted by primary health care providers. The basic elements of these models are effective and comprehensive care coordination, quality and safety, patient orientation, referral arrangements, and enhanced access and payment. Referral visits to specialty consultants, diabetes educators, or dieticians can be tracked to ensure appropriate and timely care. Success will largely depend on the ability to engage physicians, both primary care and specialists, and to standardize care coordination, data integration, shared learning, and cost transparency among participating practices.
    - **Focus on outcome not volume:** PCMH projects across the country are researching ways to implement better care coordination by using information technology, improving communication between patients and care providers, and adopting a transparent, accountable, and coordinated team approach. Despite the value and enthusiasm, financial barriers have impeded large-scale integration of the PCMH model. The current reimbursement formula does not reward quality service, but rather encourages volume. This open-ended, fee-for-service payment system is the prime contributor to the high level and rapid growth in healthcare spending. Acute and chronic care pilot programs should be developed that encourage and incentivize desired outcomes in patient experience, cost, quality, and efficiency. Risk-adjusted, pay-for-performance practices must be implemented through programs promoted by the Center for Medicare & Medicaid based on evidence and focused outcomes in diabetic chronic care management. Allowances for care outside of face-to-face visits, as unveiled by Centers for Medicare & Medicaid Services (CMS), are also a step in the right direction. However to successfully implement the reform consumers demand, the open-ended, fee-for-service system also needs to be changed by educating consumers on the benefits of PCMH models in T2D control.
    - **Challenges and solutions:** In providing managed care, lower income citizens must be protected through guaranteed access and subsidies, and disparities in health outcome must be minimized. First, racial

differences in the outcome of diabetes care in PCMH settings have already been observed and must be avoided by identifying and overcoming limitations that enable better reporting of health outcomes by race and ethnicity. Second, employer-based insurance must be encouraged to transition into managed care. This can be achieved through tax breaks and by educating employers about the value of a patient-centered approach. Third, public debates and legislations must be put in place to incentivize active lifestyles and healthy nutrition habits. Discounts in health premiums could be an encouraging option for high-risk populations, such as South Asians. Incentives can also be introduced for people with known familial diabetes and cardiovascular risk for actively delaying the progression into prediabetes through physical activity and dietary alterations. Although we will likely end up spending more in prevention strategies, the cost from productivity losses associated with diabetes will offset this cost. However, if reform is to be implemented, our lawmakers need to hear our organized voice louder and more frequently. The American Diabetes Association already outlines the blueprint for the reform priorities. We need to act now.

- Therapeutic guidance: Not all diabetic patients respond favorably to generic treatments. Variations in their genomes affect their responses and outcomes. Studies strongly suggest that efficacy and response to diabetic medicines (e.g.,sulphonylurea, biguanides, glinides, glitazones) is dictated by genomic variations. These pharmacogenomic findings have yet to be implemented in T2D-clinical practice. Genetic testing must be widely employed to predict, optimize and personalize treatment in patients with T2D to improve outcomes.

*** A policy position paper prepared for presentation at the conference on Food Safety, Security, and Defense (FSSD), Food Security and Diet-linked Public Health Challenges, convened by the Institute on Science for Global Policy (ISGP), Sept. 20–23, 2015, at North Dakota State University, Fargo, North Dakota, U.S.***

Debate Summary

The following summary is based on transcriptions of a recording made by the ISGP staff during the debate of the policy position paper prepared by Dr. Devanjan Sikder (see above). Dr. Sikder initiated the debate with a 5-minute statement of his views and then actively engaged the conference participants, including other authors, throughout the remainder of the 90-minute period. This Debate Summary represents the ISGP's best effort to accurately capture the comments offered and questions posed by all participants, as well as those responses made by Dr. Sikder. Given the not-for-attribution format of the debate, the views comprising this summary do not necessarily represent the views of Dr. Sikder, as evidenced by his policy position paper, or those of the ISGP, which does not lobby on any issue except rational thinking. Rather, it is, and should be read as, an overview of the areas of agreement and disagreement that emerged from all those participating in the critical debate.

Debate conclusions

- Given the fundamental responsibilities of government at all levels to actively participate in solving the acute health crisis caused by diet-linked diseases, communities need to adopt economically feasible, culturally appropriate models for making healthy lifestyle choices widely available. Business participation needs to be part of these models (e.g., incentivize the private sector to educate, encourage, and empower consumers to make healthier choices, partner with the business community in implementing necessary infrastructural and technological measures to improve health care).
- Although most research on preventive measures and/or causative mechanisms of Type 2 diabetes are primarily based on Caucasian subjects, new efforts need to include Asian subjects since metabolic profiles vary with inherent ethnic variations. Since Asian diabetes does not correlate with excessive body fat, and onset is at a younger age, recommendations for preventive screening and monitoring need to occur at an earlier age in such populations.
- To address the rapidly spreading diabetes epidemic, a comprehensive, coordinated health care approach, based on a business model, is needed to ensure the accountability of service providers for patient outcomes. Approaches using a single physician overseeing a multidisciplinary team of

specialists for each patient are considered to be effective for coordinating and improving diabetes prevention and care, especially by providing information-sharing mechanisms to connect medical personnel.

- While educational programs focused on nutrition and diabetes management are imperative to facilitate healthy lifestyle choices at all ages, educational campaigns designed to motivate communities are required to foster life-long compliance for groups with diverse cultural perspectives (e.g., Asian Indian) that incorporate both traditional and modern medicinal therapies.

Current realities

Type 2 diabetes (T2D) is an increasing health challenge, particularly in Asian populations, which are predisposed to T2D and experience earlier onset of the disease compared with other populations (e.g., primarily between the ages of 22-39). Currently, good preventive screening for diagnosing T2D in Asian Indians is not readily available since the disease appears at an early age and often without signs of weight gain. In addition, most research studies related to treatment are conducted primarily in Caucasian populations even though the metabolic profiles of Asian populations are substantially different from those of their Caucasian counterparts. At birth, Asian children have significantly higher insulin, but lower body fat levels compared with Caucasian infants. While Western diabetes is related to a metabolic syndrome, associated with dyslipidemia (i.e., elevation of lipids in the blood) as well as general endocrine problems, Asian diabetes typically is not associated with obesity. More than 70 different genes may control the onset and progression of diabetes, but only 10% of these genes are implicated (i.e., directly involved) in cases of hereditary diabetes. While a solid biomedical foundation for the empirical relationship between body fat and glycemic control in various ethnic groups has not yet been established, a 2011 study has suggested that at least six genes control the functions of beta cells, a type of cell that seems to play a key role in the progression of T2D.

There are more than 240 million diabetics in the world, and global health care expenditures exceed $500 billion (USD). In the U.S., where it is estimated that one in three Americans will have Type 2 diabetes by 2050, the costs for health care services and treatment increased by 41% in the five years between 2007-2012, and now total more than $200 billion per year. As the number of Asians immigrating to the U.S. increases (e.g., in 2013, Asians became the largest group of new immigrants to the U.S.), the American diet and lifestyle is resulting in increased rates of diabetes and obesity within this population.

The current U.S. model of health care does not efficiently coordinate and

facilitate patient diabetes care. Although glycemic control generally is easy for a single physician to achieve upon initial diagnosis, problems arise later as the patient develops comorbidities and a single doctor cannot handle the diversified treatments that require interactions among a variety of specialists.

As a result of several factors, current preventive and treatment measures for diabetes may not be utilized to their highest potential. Studies suggest that one-third of the diabetic population may be undiagnosed because of a lack of HbA1C testing, and many patients with Type 2 diabetes have limited access to routine glucose monitoring, which is an inexpensive way to prevent the progression of the disease. Late diagnosis in Asian Indians due to lack of concomitant weight gain also diminishes the preventive benefits of monitoring. Additionally, miscommunication regarding healthy consumption choices in the media and the Internet create confusion and add to the lack of positive reinforcement for healthy lifestyle choices.

Since unhealthy consumption patterns are often deeply rooted in religious and traditional beliefs, Asian Indians with diabetes face cultural challenges at both the preventive and treatment levels. For example, during pregnancy in Indian populations, women are fed high carbohydrate and fat-rich diets that include ghee, a clarified butter that is very high in saturated fatty acids. Because ghee is burned in temples, it is believed to attract positive energy and therefore be harmless. Additionally, Asian Indians tend to utilize homeopathic remedies, and first-generation Asian Indian immigrants especially adhere to the traditional belief that uranium, phosphoric acid, and heavy metals are efficient treatments. This traditional belief hampers patients' trust and compliance with Western medicine as they struggle to follow their prescribed regimens.

Scientific opportunities and challenges

To address the challenge of coordinating specialized care in diabetes treatment and management, opportunities exist to integrate a business model of care that involves a physician coordinating and overseeing a group of specialists. The key to implementing such a model is efficient digital information transfer among medical specialists. In addition, patients must have incentives to subscribe and pay a registration fee for such a business. A model that utilizes interdisciplinary diabetes education can trigger positive reinforcement by providing real-time data in response to lifestyle behavior choices (e.g., exercise and proper consumption habits can be paired with feedback from technology about glucose data, cardiovascular data points, and gains in lean mass). Technology also can be used for (i) screening for body fat and lean mass, (ii) lipids monitoring through routine lipid tests, and (iii) fatty acid testing. Although this proposed model would be more expensive than the current

model, savings from increased productivity and decreased health complications would offset the cost. Such a model would need to reflect integrated stratified risk (i.e., service providers would be held accountable for the patient's outcome).

Strategies that individuals may adopt as preventive measures against diabetes are also needed. Since high-fiber legume systems are a central part of the Asian diet, and there is substantial epidemiological evidence that longevity is linked to high legume consumption, awareness and support for increased legume consumption could be a central strategy of prevention as Asian Indian diets shift to Western diets, especially in low-income communities. Strict screening measures must begin at an early age in Asian populations (e.g., 20-23 years old), so that those with a family history of the disease can be identified and automatically enrolled into regular profiling and preventive services.

Through the spread of information regarding appropriate dietary habits and monitoring processes, patients can be empowered to be responsible for their own lifestyles. Educational programs need to include all family members so that younger generations begin to question traditional beliefs (e.g., high consumption of saturated fats during pregnancy). There are also opportunities to implement a holistic approach to prevention and treatment that incorporates spiritual and emotional components, potentially improving compliance.

Since homeopathic medicines have a long history of use in traditional Asian Indian culture, education programs are needed that explain how these medicines fit into diabetes prevention and treatment. While homeopathic heavy metals generally are not considered viable treatments for diabetes, there are a select few homeopathic medicines that have produced some success, although they cannot be used as the sole form of treatment. To enhance Asian Indians' compliance with diabetes treatments, the scientific community needs to learn how to integrate viable homeopathic medicines with Western treatments.

Noncompliance issues also might be addressed through emerging technology (e.g., the so-called "snitch-pill," a digital sensor embedded in a pill that reports when medications are taken). Other opportunities to advance diabetes technology include improving continuous glucose monitoring, and developing a genetic disposition risk model.

Since Asian Indian populations represent different metabolic profiles, diabetes research based on Caucasian populations cannot be directly applied to Asian populations, and further research is needed to understand the mechanics, preventive measures, and efficacy of therapy in Asian Indians. Lack of high body fat among diabetic Asians poses a challenge for early diagnosis, and research is needed to identify causative genetic mechanisms.

Although pharmacological companies have invested primarily in appetite control research, they have not achieved much success in this area as the body defends against weight loss through a variety of mechanisms, making such losses difficult to sustain. As pharmacological research begins to shift towards automatic defenses, scientists are studying several mechanisms beyond genomics, including microbial interactions, ability to store fat, and the ability to elevate energy expenditures. Although no major discoveries have been made as yet, identification of the factors that control an individual's calorie-burning power is emerging as an important research target with implications for the diabetes community.

Policy issues

The key to reducing the incidence of T2D among Asian Indian populations and the American public *writ large* is empowerment of the private sector, communities, and individuals to address the problem. Such empowerment can occur through new models of health care, and through financial support by governments (local and national) and the private sector (e.g., insurance industry, local businesses) of nutrition/physical fitness education and diabetes prevention/management strategies.

A business model to be integrated into diabetes health care needs to feature managed care with a single point of contact to improve both effectiveness and cost efficiency. Such a system can provide cost-effective care coordination and improve sociobehavioral interventions as a result of increased contact with doctors. A transition to a risk-adapted model is needed in which patients are not required to pay if expected outcomes are not achieved. To integrate this model into the existing health care infrastructure, dialogue is needed among all stakeholders (e.g., providers, patients, insurers, communities). Governments need to establish funding mechanisms for this new business model of diabetes health and subsidize at least the initial development. Diabetic individuals in low-income communities also need to receive federal assistance to pay for care under the business model, which is likely to be more expensive than traditional care. Long-term governmental assistance is considered a viable option based on the perception that the increased assistance would be offset by increased savings in health care costs.

In light of the long-term financial impact of diabetes, nutritional health must be included among a community's priorities. By investing in education, health monitoring, and healthy lifestyle choices, health providers, insurers, private sector stakeholders, and communities can reap savings from lowered costs (e.g., hospitalization, lost productivity, treatment), and can simultaneously reinforce individuals' healthy lifestyle choices and increase corporate profits. One way local governments can encourage healthier behaviors is by incentivizing local businesses to

distribute information about healthy diet and exercise (e.g., a business can offer free blood-sugar tests at the front of the store, along with a coupon to purchase a healthy snack within the store). Insurance companies also can incentivize their members to pursue an active lifestyle by reimbursing or giving discounts for physical activities (e.g., gym memberships, yoga classes). When responsibility and accountability for health care strategies is borne by the affected communities, they become more invested in acting on prevention strategies.

Since citizens living in low-income areas often buy inexpensive, low-nutrition/high-calorie commodities, which can lead to obesity, and often do not have access to healthier foods within their neighborhoods, local governments need to create regulations and incentives that enable healthier lifestyle choices (e.g., blocking the establishment of fast-food restaurants in low-income neighborhoods, providing incentives and subsides to health-food distributors, taxing less-healthy commodities such as donuts and pizza, and creating "performance incentives" for stores to increase sales of healthier foods within their inventories).

Rather than banning, or taxing a food product, policies that change the way food is marketed can affect public behavior (e.g., restricting advertising of fast foods and sugary/high fat foods to children and encouraging advertising of nutritious foods instead can affect long-term lifestyle choices).

Since nutrition and fitness education needs to encourage people to actually engage in healthier behaviors, it is important to go beyond health-care messengers and tap into the influence of the surrounding community. Because positive lifestyle decisions tend to be influenced and supported by friends and family members, effective education can begin with a very small nucleus of community members whose impact then extends outward to others in their circles. Children are considered to be an especially important audience for nutrition/fitness lessons, which must include not only prevention strategies, but also education about obesity and diabetes management for those who are already diagnosed.

Although government needs to play a role in addressing the diabetes epidemic, the principle stakeholders of this health care model need to be individuals. As individuals increasingly take responsibility for preserving their own health, the more invested they become in following preventive strategies. While communities need to develop consistent policies focused on diabetes prevention, they also must incorporate holistic approaches that appropriately address the most effective entry points for different and unique communities (e.g., Asian Indians).

Diet and Colon Cancer Risk**

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Summary

Diseases prevalent in Western societies present the most serious threat to public health today. There is convincing experimental and human study evidence that the Western diet, rich in red meat and animal fat, and deficient in fiber, drives most of these diseases. These diseases include various allergies, autoimmune disease, osteoarthritis, inflammatory bowel disease, obesity, diabetes, osteoporosis, hypertension, coronary heart disease, and cancers of the colon, breast, and prostate. While much of the morbidity and mortality due to cardiovascular disease, diabetes, and the metabolic syndrome can be ascribed to excessive food consumption and obesity, it is becoming increasingly recognized that fiber deficiency on the microbiota, with suppressed butyrogenesis, plays the most prominent role in the genesis of chronic inflammatory conditions and colon cancer. The rarity of these diseases in elderly members of less affluent societies, coupled with the fact that genetic modification to environmental changes takes tens of thousands of years, suggests that the diet ideally suited to our genetically determined needs would contain higher intakes of fiber-rich foods and less meat and fat. Recent studies in high-risk westernized human volunteers provide evidence that a change to such a diet modifies the microbiota to produce metabolites that improve colonic mucosal health and suppress biomarkers of colon cancer risk within two weeks. This, taken together with the observation that it takes only one generation of westernization to increase cancer in migrants, as well as the estimation that more than 90% of colon cancer cases can be attributed to diet, provides compelling evidence that increasing the intake of fiber-rich foods in westernized populations will have an immediate effect on colon cancer risk.

Current realities

Colon cancer has a remarkable geographic variation in incidence, being common in more affluent, and rare in less-affluent countries. It is one of the so-called "westernized diseases." Migrant studies have provided strong evidence that the disease results from factors in the environment as it only takes one generation for

a migrant population from a low incidence area to assume the high incidence rate of the host country. Based on the analysis of epidemiological surveys around the world, Doll and Peto concluded that diet was the responsible environmental factor in more than 90% of gastroenterological cancer cases. In the United States, colon cancer is the third most common cancer among men and women and, perhaps more importantly, it is the second leading cause of cancer deaths for both sexes.

African Americans bear the brunt of the disease in the U.S. The age-adjusted incidence rate for cancer of the colon and rectum from 2002–2004 was 61.4 per 100,000 for white men versus 72.9 per 100,000 for black men, and 44.7 versus 56.1 per 100,000 for white and black women respectively. The age-adjusted death rate for colorectal cancer was 23.4 versus 33.4 per 100,000 for white and black men respectively and 16.2 versus 23.4 per 100,000 for white and black women respectively (see http://seer.cancer.gov/csr). Alaskan Native people have the highest recorded rate of colon cancer in the world at more than 100 per 100,000. In contrast, rural native Africans rarely get the condition, with an incidence of less then 5 per 100,000.

Westernization has been associated with a dramatic increase in expected lifespan from less than 25 years before the Industrial Revolution to 78.9 years in the U.S. today. This change cannot be attributed to genetic evolution, but it can be attributed to the remarkable ability of humans to adapt to their environment. The dramatic increases in food production, generated by the combined forces of the Agricultural and Industrial Revolutions, resulted in increased individual purchasing power that ultimately led to increases in the human gene pool. This further resulted in improved standards of living, societal development, additional time and facilities for experimentation and entrepreneurship, and ultimately led to the modern scientific era. It is this sequence of events that is responsible for the advances in sanitation, housing, vaccination, antibiotics, medical care, and political diplomacy, all of which have increased life expectancy through our current ability to avoid life-threatening events such as perinatal complications, acute infections, trauma, and war.

The quality of our current expanded lifespan has been marred by the appearance of a group of diseases termed "westernized diseases," which includes colon cancer. Westernized diseases contribute most to death and disability in the world. In 2005, at least 35 million people of all ages, nationalities, and socioeconomic levels died from heart disease, stroke, cancer, diabetes, respiratory disease, and other chronic diseases. The figures are even higher today, and increasing. For example, it has been estimated that by 2030 there could be up to 26.8 million new cases of cancer and 17.1 million cancer deaths every year, as well as 80 million people living with cancer within five years of diagnosis. While some argue that these diseases

are a consequence of lengthening lifespans, pathological studies of hunter-gatherer communities have shown that those members who escaped life-threatening events were spared these diseases in old age. While cancer is rare in Africa as a whole, there is huge concern that rates will soar with progressive westernization, which is already occurring in certain cities (e.g., Harare, Zimbabwe).

Scientific opportunities and challenges

Recent advances in genetics, microbiology, analytic chemistry, and systems biology have revealed an extraordinarily high level of mutualism between our species and the microbiota that could explain the strong association between diet and colon cancer, and could also potentially explain the genesis of other diseases prevalent in Western societies (e.g., obesity, atherosclerosis, diabetes). The challenge is to define the "ideal diet." With regard to the colon, it is likely that there is an ideal microbiome that evolved in tandem with human diet and the human digestive tract. There is good evidence that this relationship has been lost with westernization and that there has been insufficient time for us to genetically adapt to sumptuous modern diets. It is likely that our health will be better maintained by the diet that first established Homo sapiens in the Paleolithic Era in Africa, a period that lasted from about 2.5 million to 11,000 years ago. Some insight into the composition of this "ideal" diet has been gained by coprolite analysis from prehistoric deposits dating back 14,000 years in caves in southwest Arizona, which suggests that complex carbohydrates and fiber dominated the diet. Ills that can be ascribed to a Western diet can be attributed to its low content of fresh fruits, vegetables and unrefined grains, and its excess of meat and terrestrial fat. This has been supported by epidemiological surveys from around the globe, experimental studies, and most recently by study in humans, which showed biomarkers of colon cancer risk diminished within two weeks of diet change to a high fiber, low fat diet.

Policy issues

Efforts to increase the intake of fruits, vegetables, and unrefined grains, and to reduce terrestrial fat consumption, will reduce the incidence and mortality associated with colon cancer in westernized communities around the world. It is often claimed that changing someone's diet, like stopping smoking or drinking, is impossible. However, the application of evidence-based health strategies through urban planning, education, agricultural policy, and health systems development, along with health targets to focus and prioritize needed interventions at national, regional, and local levels, has been shown to be effective. Such application of evidence-based health strategies have proven robust and successful in regards to cardiovascular disease and

cancer mortality, and the reduction in cigarette smoking and physical inactivity. However, whilst these approaches have proven effective in western societies, they have not in less-affluent countries where the supporting infrastructure is absent. Strategies can be divided into local strategies and national/international public health programs. An example is "Health in All Policies," public policy and governmental interventions designed to change both the environment, as well as individual behavior to promote health and prevent chronic disease throughout society.

Local Strategies:

- Promote consumption of fresh fruits, salads, and vegetables in school cafeterias, workplaces, urban and rural cafes, and restaurants. Replace unhealthy foods in school cafeterias with increased choices of fruits, vegetables, and coarse grains, and apply restrictions to fried and fatty foods.
- Educate children and adults on the dangers of overeating and obesity, and the need to combine good eating with frequent exercise.
- Ban advertising of unbalanced calorie rich 'fast foods' on TV and other public media, and instead promote balanced diets and healthy eating.
- Advertise the benefits of a balanced diet and physical activity, and healthy lifestyle on good health and longevity.
- Promote nutrition education in supermarkets, provide appropriate information of the nutrient content of foods.
- Support community gardening to grow vegetables and fruits.
- Introduce healthier foods and beverages to local stores.
- Make farmer's markets available to urban communities.

National/international public health programs:

- Regulate food advertising and marketing to children and adults to emphasize the consumption of a balanced diet based on the above.
- Tax low fiber, fatty foods and snacks. This is feasible, just like what was done the reduce cigarette smoking.
- Impose zoning laws that regulate the location of fast food establishments.
- Transfer the ownership of dietary intervention projects to the national health authorities to strengthen national autonomy. Population-based

cancer preventive strategies are remarkably cost-effective because increasing population health is also a way to ensure continuing capacity to produce wealth.

- National leadership is required to place the eradication of westernized diseases high on national agendas (e.g., National Institutes of Health funding of studies designed to reduce western diseases).
- International organizations (e.g., World Health Organization [WHO]) should help to promote national capacity building to meet this goal. It should be noted that the portion of the WHO 2006-07 budget devoted to noncommunicable diseases accounted for just 12% of the total; 86% of WHO funds in the Western Pacific region went towards combating infectious diseases, despite the fact that these pathologies are only responsible for 14% of the mortality burden.
- Forge a common united mission between foreign (western) and national healthcare organizations through workshops and close networking. Funding for these activities could be obtained through U.S. government international cooperation initiatives, world cancer research societies, the WHO, the Food and Agriculture Organization, and the Gates Foundation.

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***** A policy position paper prepared for presentation at the conference on Food Safety, Security, and Defense (FSSD): Food Security and Diet-linked Public Health Challenges, convened by the Institute on Science for Global Policy (ISGP), Sept. 20–23, 2015, at North Dakota State University, Fargo, North Dakota, U.S.***

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Debate conclusions

- Given the strong link between the proliferation of colon cancer biomarkers and the consumption of a Westernized diet, and the compelling scientific evidence that changing to a high-fiber, low-fat diet rapidly decreases the number of such biomarkers within the colon and improves overall colon health, policies are needed that promote increased consumption of high-fiber food (e.g., fresh fruits and vegetables). Such policies must ensure that such foods are affordable and obtainable, especially in low-income and rural communities that may currently have access only to less-nutritious options.
- Health strategies, derived from research, emphasize the positive role of fiber in the prevention of cancer and chronic disease (e.g., diabetes) by recommending that an increased daily fiber intake be effectively communicated (e.g., on restaurant menus). The multiple opportunities to fortify foods in nutritious, culturally appropriate diets support national health policies deemphasizing a drug model for treating cancer and transitioning to a prevention-based approach based on long-term research into diet-adaptive genes and their role in human health.
- The general absence of public awareness of the preventive benefits of a high-fiber diet motivates a commitment to developing effective educational programs that (i) inform consumers about the human microbiota, its

relationship to the development of disease, and its susceptibility to dietary influences; (ii) encourage healthier food choices through robust marketing strategies similar to those used by the food industry; and (iii) discourage unhealthy diets by realistically portraying the consequences such diets (e.g., through graphic images of diseased colons).

- Although governmental regulation restricting diets in the public *writ large* is not acceptable in a free society, governments do need to encourage the adoption of healthier eating habits. Local, state, and national government regulations are needed to ensure that school menus provide a nutritious balance between meats, fats, sugars, and high-fiber foods, and incentives (e.g., taxes on foods with low nutritional value and financial rewards in restaurants and stores providing access to healthier food choices) may be effective.

Current realities

Given the global disparity in the incidence of colon cancer (e.g., high rates in Westernized countries, especially the United States, and low rates in Africa), it is recognized that diet plays a critical role in the development of colon cancer. Studies have found that diets high in meat and fats are associated with increased cancer biomarkers (i.e., markers of proliferative cells), while diets high in fiber, fruits and vegetables are associated with reduced cancer biomarkers. However, it is not specifically the dietary fiber itself that affects colon cancer risk, but rather the microbiota found in the human gastrointestinal tract.

While 90% of food is absorbed in the small intestines, about 5% passes into the colon, primarily as carbohydrate fiber, and undergoes saccharolytic fermentation by gut microflora to produce butyrate, a short-chain fatty acid that has been shown in experiments and human studies to reduce cancer biomarkers (through mechanisms that reduce neoplasia and chronic inflammation, and increase the integrity of the mucosa). Metabolites such as butyrate also have been shown to reduce the risk of lung cancer, breast cancer, prostate cancer, and possibly pancreatic cancer, and to suppress appetite, helping to limit obesity. However, studies that have attempted to determine if a high-fiber diet can reverse intestinal polyps or precancerous tissue have not been conclusive.

Although it is possible to increase butyrate within the colon through supplementation products, the results are not more effective than consumption of natural fiber, and the nutritional preference is for whole-food diets that naturally improve butyrate production. Since food nutrients, as well as the different microbes within the human microbiota, tend to work together in a complex system, healthy

diets must be both diverse and balanced. With the exception of those with metabolic abnormalities (e.g., phenylketonuria), most people have the metabolic capacity to deal with normal foods. Even foods deemed "unhealthy" (e.g., potato chips) present some degree of nutritional benefit and can be consumed in moderation. However, foods can become unhealthy depending on how they are prepared (e.g., while dried salmon is nutritious, smoked salmon can contain numerous carcinogens, especially home-smoked salmon, and may contribute to colon cancer rates among Alaskan natives).

The dietary changes that can improve colon health are not supported by food industry marketing (e.g., high prevalence of TV ads for fast food) or even by medical practitioners, who will remove a patient's intestinal polyps without recommending dietary changes. Other limiting factors include access to fresh fruits and vegetables by rural and/or low-income citizens and the perceived cost of these items (especially organic produce) compared with fast food. Consumer confusion is exacerbated by the plethora of "healthy" diets being promoted, which may or may not be based on scientific evidence of efficacy. Due to the perception that nutritional guidelines and policy keep changing, new ideas often are met with consumer skepticism.

While the United States Department of Health and Human Services releases new dietary guidelines every five years, their effect on health is limited by the U.S. population's tendency to overeat and become obese, and by the individualized nutritional needs of different segments of the population. Although current Dietary Reference Intake (DRI) guidelines are based on the appropriate diet for healthy individuals, only about 30% of the U.S. population is considered healthy because about 60% is overweight. The 2015-2020 edition of the dietary guidelines characterizes the DRIs in terms of healthy dietary patterns to reduce obesity and improve health.

The national public education campaign to reduce cigarette smoking is an example of a successful strategy in changing behavior. Antismoking campaigns have combined a number of influences (e.g., warning labels, a ban on TV advertising, increased taxes, and graphic photos of diseased lungs and other physical consequences of smoking). Similar campaigns may use analogous strategies to change unhealthy dietary habits.

Scientific opportunities and challenges

Given the demonstrated rapidity with which diet can influence colon cells (e.g., reduced cancer biomarkers within two weeks of diet change), enormous potential exists to improve public health through the increased consumption of fiber, as well as the consumption of resistant starch, a semi-insoluble but liquefiable metabolite

of starch derived from foods (e.g., beans, Thai or Basmati rice) that tends to reach the right side of the colon, where polyps occur, and is fermented like fiber. Since experimental evidence indicates that combining soluble and insoluble fiber causes the fermentation process to go throughout the entire colon, opportunities exist to include both these fibers in effective diets.

Significant opportunities exist in the field of developmental chemistry (e.g., engineering versions of supplemental butyrate that make it to the colon) and in developing fortified foods with increased fiber content. Although fortification can help improve fiber intake, experience has shown that sometimes fortification has unintended side effects (e.g., cancer concerns related to water fluoridation).

A noninvasive, effective, and affordable test for colon cancer biomarkers is needed that can lead to lower cancer rates by alerting consumers to the consequences of their diet before cancer develops (e.g., a stool sample test developed at the Mayo Clinic can identify premalignant DNA changes in the colon). Challenges, however, stem from financial costs, as measuring DNA currently is expensive (though becoming less expensive over time), and measuring short-chain fatty acids such as butyrate, while less expensive, takes time to perform.

While studies in Africa show that the diets correlated with very low incidence of colorectal cancer contain more than 50 grams of fiber per day, U.S. dietary guidelines recommend less (e.g., approximately 30 grams). Although the "deficiency model" for determining nutrient DRIs and establishing U.S. dietary guidance focuses on amounts needed to prevent nutritional deficiency, there is no clearly defined level or disease state that constitutes a fiber deficiency. Dietary models need to incorporate the prevention of cancer and chronic disease into the process of establishing nutritional guidelines. Taking into consideration exposure, intake, and target levels, scientists need to develop more conclusive fiber-intake recommendations, as well as tests for fiber deficiency, so values that confidently reduce colorectal cancer rates can be established. An additional area for development is individualized guidelines for fiber intake (e.g., personalized daily requirements, timing of consumption).

Multiple strategies will be required to change individual dietary habits that are both culturally and popularly supported. While an approach that focuses on a genetic predisposition to cancer can prevent personal action (i.e., "I'm going to get colon cancer anyway, so what's the use of fighting it?"), an approach that focuses on diet-adaptive genes (e.g., the beneficial effect of fiber on colon cancer biomarkers) can motivate preventive actions. Whereas in the past doctors removed polyps and released patients without any dietary dialogue, doctors now know that improving diet can improve colon health and reduce colon cancer risk, and such a dialogue can promote a proactive behavior change in patients. Such an empowering approach

needs to be part of a reformed health system that is not totally allopathic. Originally based on a drug-discovery model in the pursuit of new therapeutic knowledge, the National Institutes of Health (NIH) are focusing greater attention on diet-adaptive genes and the health benefits of microbiota metabolism and fermenting foods, and are funding long-term studies on the effect of diet on cancer.

Since consumers often perceive nutritional information as clichéd and meaningless (e.g., advertisements for sugary fortified cereals that are "part of a balanced diet"), science communicators need to borrow strategies from other successful public education campaigns (e.g., the antismoking campaign) and find ways to capture the public's attention (e.g., broadcasting pictures of diseased colons). However, scientists need to perform studies with results that clearly demonstrate that the proposed dietary changes can protect against colon cancer.

Given that consumers can be confused and discouraged by the number of scientifically credible dietary recommendations (e.g., diets that focus on protein, fermented foods, or fiber), a critical scientific challenge is to combine multiple proven dietary guidelines into culturally appropriate diets.

Policy issues

A public health perspective is needed to address the urgency of chronic diseases related to a Western diet and to help communities make dietary choices that can curtail costly healthcare challenges in the future.

Improved access to fruit and vegetables is integral to nutritious dietary change. Even though the current recommended daily fiber intake is not being met by most Americans, the target needs to be set even higher, with specific recommendations for ways to reach the goal (e.g., increased intake of beans).

Although some consider a diet high in vegetables to be more expensive than one high in meat (e.g., fast foods), this is not necessarily the case if the vegetables are self-grown. Increased access can be supported by establishing more community farmers' markets and by ensuring that supermarket chains that charge extra for organic foods continue to provide lower-cost nonorganic options, as there is no appreciable difference in nutrient content between organic and nonorganic foods.

It is imperative that communities, critically lacking in fresh fruits and vegetables because of their location (e.g., rural Alaskan communities), are provided access to practical alternatives (e.g., fortified foods; smoothies, and juices containing multiple servings of fruits and vegetables in one reasonably priced bottle). In addition, developing countries that are experiencing an increase in Western food products (e.g., a proliferation of fast-food restaurants) need to receive assistance to establish a health care infrastructure (e.g., health monitoring, public education)

that can address the consequent effects of a Western diet.

Even if appropriate nutritional choices are widely available, education is needed to encourage the adoption of a healthy diet. The media (television in particular) are considered vital to such education, with enormous potential to change societal attitudes. Healthy diets need to be marketed with the effectiveness found in fast-food and processed-food advertising, incorporating both proactive approaches (e.g., encouraging fruit/vegetable consumption) and behavior deterrents (e.g., attention-grabbing images of the effects of an unhealthy diet).

Dietary regulation can and needs to occur in school lunch programs. In addition, restaurants need to be incentivized and perhaps required by policy to communicate nutritional information to customers. While governments may raise taxes on high-fat, high-sugar products in the same way as cigarettes were taxed to help decrease smoking, such an approach is not popular with the public and in isolated case studies (e.g., New York) has not yielded significant behavior change. Absent a demonstrated and significant danger to public health, government regulation of dietary intake is not appropriate in a free society. Instead, policy makers need to market, persuade, and educate, with the goal of changing behaviors over time.

Diversified Adaptable Food: Toward Personalized Nutrition**

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Summary

In the next decades, we will be facing an increase in world population. Some of the greatest challenges will be to sustainably and equitably provide better living conditions, to deliver vital goods and services, and to support human health and wellbeing. Few studies consider the interaction among all these challenges. However, in the future it will be imperative to address them in a concerted way and design strategies that will support a more holistic approach. Advances in human genetics and genomics have allowed the use of emerging knowledge to diagnose and treat patients. In the future, the application of converging technologies such as biotechnology, nanotechnology, information technology, and cognitive science will achieve personalized, predictive and preventive healthcare. Integral parts of this framework are nutrition and food. A nutritious, diversified diet is the ultimate goal for the improvement and maintenance of health. In order to achieve this, an interdisciplinary approach will be necessary. Furthermore, it will be mandatory to address not only the issue of tailored food consumption, but also of food production and distribution. Guided by the identification of future needs, and based on the acquisition and convergence of knowledge and technology, pushing the boundaries of research and innovation is a major goal.

Current realities

Food is a necessity for all, making each of us a stakeholder in this important sector. The implications for food availability and food quality are enormous and extend from health and wellbeing to development and the economy. While the demand for food may increase 70% by 2050, 60% of the world's major ecosystems that help produce these resources have already been degraded or are used unsustainably. It is clear that one of the greatest challenges of our time is to address both food security and sustainability. However, increased production of food, even if done in a sustainable way, is not the solution. Currently we produce more than enough food to feed the entire world population, nonetheless, more than 800 million people face

hunger daily, and over 2 billion still suffer from vitamin and mineral deficiencies. An estimated 162 million children experience stunted growth, reflecting chronic undernutrition during early stages of life. This phenomenon, which predominantly occurs from the time of conception to the second birthday (i.e., the first 1,000 days), causes mental and physical growth failures. Simultaneously 42 million children under five years of age are overweight, and two-thirds of these children reside in low- and middle-income countries. Globally, 2.1 billion people are overweight or obese, conditions that are linked to an increase in chronic diseases such as diabetes, cardiovascular disease, and cancer. There are 51 nutrients essential to sustaining life. The most common form of micronutrient malnutrition is due to deficiencies in iron, vitamin A, or iodine, followed by zinc, folate, calcium, proteins, and other vitamins.

The production of food worldwide has a high impact on natural resources. If we want to ensure food security while maintaining healthy ecosystems, we need to consider climate change as well as habitat loss and weather variability. Furthermore, constraints in available water and energy resources, competition for arable land and urbanization, as well as the use of fertilizers and other inputs, constitute huge challenges on the resilience of the food system. While there is a greater awareness of the complexity of the food system(s) and the necessity to address all processes starting with the production of raw materials and running through the whole food chain to the disposal of food waste in the environment, there is still a need to bridge the gap between theory and implementation in this crucial sector.

Scientific opportunities and challenges

The grand challenge of providing healthy and sustainable food for all requires a forward-looking approach that considers the whole food chain (i.e., a *food chain approach)*, which stimulates a constant evaluation of how the introduction of a new technology or any other innovation is going to affect the rest of the food chain. It is a global challenge requiring internationally cohesive and coordinated actions, while also supporting awareness and consideration of local realities. The involvement of experts with specific disciplinary skills working in a highly multidisciplinary context, chosen to promote the transfer of knowledge across unique situations and contexts, will be necessary to deal with specific issues, while still maintaining a broad view of the bigger picture.

Within the *Science and Technology Foresight Project,* launched by the National Research Council of Italy (CNR) and the Trieste Area Science Park Consortium with the support of the Ministry of Education, University and Research, a "face to face" workshop on "Converging Technologies for Sustainable and Healthy Food" was organized in May 2015. This event focused on "Diversified Adaptable Food" and

attracted more than 50 participants, including international experts representing relevant academic disciplines, policy makers, politicians, and NGOs.

The concept of "Diversified Adaptable Food" developed from the search for a common denominator for analogous problems within different food systems. This approach would support the engagement in research and the development of technologies able to address common issues, and avoid trying to find individual solutions for each problem. The importance of diversification is widely recognized at both ends of the food chain. Diversification is emphasized in agriculture by an effort to reestablish and maintain biodiversity and it is recognized in nutrition by the fact that a low diversity diet is one of the main causes of malnutrition. On the other hand, adaptability is necessary if different realities, such as geographical, socio-economical, cultural, and political are to be considered.

The general consensus at this workshop was that the highest priority should be given to food quality and not quantity. In particular, it is the nutritional quality of food that needs to be the main goal, enabling the production of a more tailored, and eventually even personalized food supply as advocated by the newly developing sciences of nutrigenomics and nutrigenetics. These take into consideration that people are metabolically different due to genetic and epigenetic variations as well as microbiome differences, and they aim at obtain a better understanding of nutrient-gene interactions with the goal of developing nutrition for optimal health and disease prevention at the population and eventually at the individual levels.

The use of converging nanoscale technologies (e.g., biotechnology, systems biology, information and communication technologies) has the potential to effectively support the transition toward a food system that recognizes food quality as the main driver for production, as well as has a disruptive impact at every step of the food chain. This requires transferring the knowledge acquired at the macro- and micro-level, toward a convergence at the nano level, supporting nanotechnological innovation. In agriculture, nanoencapsulation of pesticides and fertilizers allows for the intelligent control of pests and diseases, and a controlled uptake of nutrients, decreasing the quantity needed with a beneficial effect on sustainability and the environment. A similar nanosystem can be used to produce crops with higher nutritional value, while nanocapsules can be an efficient way of preserving nutrients and improving their uptake and bioavailability. Micro- and nanoencapsulation can also improve or control the release of active substances such as vitamins (e.g., vitamin A) or minerals (e.g., iron, zinc) allowing for the addressing of specific health issues. This is an important step toward the production of more personalized food intended for groups of people or individuals suffering from specific conditions, for example, due to their societal background (e.g., anemia caused by malnutrition)

or their genotype and phenotype (e.g., diabetes and allergies). Furthermore, nanostructuring, (e.g., emulsification) enables us to reduce or even substitute components in food (e.g., fat-, salt-reduced products) and is yet another tool to tailor food to specific nutritional needs. New multifunctional materials can also contribute to the sustainable production and better storage of food through more efficient processing and smarter packaging, supporting a change in the commercial food supply, which is necessary for more efficient distribution of nutritious food to all societies. In fact, significant changes in food distribution and the supply chain in all societies will be needed to ensure that nutritious quality food reaches all societies. This will require integration of existing technologies and the development of converging technologies.

Policy issues

- **Nutrition**: Human nutrition must be a key criterion in the assessment of the food value chain. Governments and food industries must support the purchase of nutritious raw materials and production of nutritious commodities, hence greatly contributing to a shift toward quality rather than quantity. Policy makers must also recognize the benefits of food fortification. Additional costs should not be targeted to consumers, but should instead be handled by the governments, which must in particular support those farmers who want to enhance the contents of essential nutrients through biofortification. Furthermore, new business and delivery models should shape markets for diverse diets, enabling nutritious products to reach a larger public. The cultural changes necessary to develop better dietary habits; however, must be adequately supported by education and communication strategies.
- **Interdisciplinarity**: Interdisciplinarity requires the sharing of knowledge and information, the willingness to engage in the language and customs of other disciplines, and the acceptance of different values. This can and must be supported by the following institutions: 1) at an academic level, inter-departmental courses and activities must be organized; 2) governments must form commissions with representatives of all ministries to address complex challenges such as food; and 3) industries must have a dialogue with researchers and consumers' associations. Participatory research should involve many stakeholders throughout all stages of innovation and development. Policy makers need to see this involvement as a necessity if they want to address the multi-faceted challenges posed by food security and nutrition.

- **Assessment**: A responsible, evidence-driven adoption of converging technologies in the food chain can greatly contribute to addressing different needs. However, to increase public acceptance, it is imperative to carefully evaluate the use of new technologies, particularly of nanotechnologies, and to assess the risk of new nanomaterials. An open database, shared among countries, with information regarding characterization, nomenclature, methodologies, effects and safety assessments on human health and environment, could represent a major breakthrough towards a widespread use of converging technologies in the food sector. The assessment of food value chain sustainability should integrate natural, social and political sciences and consider "non-traditional" sustainability dimensions such as health and ethics. Including a broader perspective, supported by scientific comparisons, can help differentiate between various systems. For example the so-called "local trap", which illustrates the common belief that local food is a priori more sustainable, even though local food systems are likely to be as unsustainable as other systems.

*** A policy position paper prepared for presentation at the conference on Food Safety, Security, and Defense (FSSD): Food Security and Diet-linked Public Health Challenges, convened by the Institute on Science for Global Policy (ISGP), Sept. 20–23, 2015, at North Dakota State University, Fargo, North Dakota, U.S.*

Debate Summary

The following summary is based on transcriptions of a recording made by the ISGP staff during the debate of the policy position paper prepared by Dr. Cecilia Bartolucci (see above). Dr. Bartolucci initiated the debate with a 5-minute statement of her views and then actively engaged the conference participants, including other authors, throughout the remainder of the 90-minute period. This Debate Summary represents the ISGP's best effort to accurately capture the comments offered and questions posed by all participants, as well as those responses made by Dr. Bartolucci. Given the not-for-attribution format of the debate, the views comprising this summary do not necessarily represent the views of Dr. Bartolucci, as evidenced by her policy position paper, or those of the ISGP, which does not lobby on any issue except rational thinking. Rather, it is, and should be read as, an overview of the areas of agreement and disagreement that emerged from all those participating in the critical debate.

Debate conclusions

- To ensure that the increasing world population is fed in a sustainable and equitable manner, the existing food system needs to be reformed to focus on nutritional quality rather than quantity. Collaboration is required among all stakeholders in the food chain to prioritize the production of diversified, adaptable foods by supporting the opportunities offered through new technologies (e.g., nanotechnology, biotechnology, systems biology, information and communication technologies).
- While governmental funding is necessary to advance the development of emerging biotechnologies and nanotechnologies, as well as to increase their usage across the food chain, there is a need to adopt economic incentives for big industry and farmers to transition from the current production approach to one that applies technological advances.
- Given that nutritional requirements vary across human populations, food distribution must reflect the appropriate diets for different locations. An accessible "smart grid" that facilitates information exchange along the food production chain can decentralize food distribution and assist governments and the scientific community in ethically addressing unique cultural challenges across different communities as well as eventually aiding in the assessment of optimum diets for individuals based on their unique genetic dispositions.
- To successfully integrate bio- and nanotechnologies into food production, efficient safety regulation and risk assessment infrastructure is needed. Governments must cooperate in supporting the creation of a streamlined regulatory framework that will in turn increase public support for the integration of these technologies into the food system.
- To successfully shift the focus of the food system toward nutritional quality and decentralized distribution, consumer educational programs must be established to provide information about nutrition (e.g., components of a quality diet) and the processes used by integrated biotechnologies.

Current realities

During the next 20-30 years, the world will be challenged to sustainably and equitably provide enough food to support its steadily increasing population. Although current food yields are sufficient to feed a growing population, the food system is focused on producing higher yields rather than higher-quality food, and therefore, is considered

unsustainable with respect to global societal development and resource management.

To increase food security, the growing population also requires a food system that decentralizes food production and distribution. Although new decentralized distribution methodologies have been implemented, they approach distribution from the end of the food chain rather than from the beginning, and exist only in a few locations.

Sustainable and equitable production focuses on diverse foods that are adaptable to increased nutritional value. Emerging bio- and nanotechnologies, as well as conventional breeding, are helping to increase the nutritional value and quality of existing produce. Although these methodologies are being introduced at various market levels, current regulatory frameworks around the globe lack consistency concerning the safe use of biotechnology. For example, the United States and the European Union share similar definitions of the term "nanomaterials," while the corresponding definition in Asia varies greatly.

Apart from regulatory inconsistency, the integration of biotechnology into food production also faces financial restraints. In both affluent and less-affluent nations, economic incentives tend to emphasize quantity over quality, causing many populations to experience simultaneous undernourishment and obesity. The food industry often does not invest in the development of higher-quality crops because of the small projected return on such investments. As a result, nutritionally enhanced crops and food products that could be released to the market if companies had the means to recover their investments are not available to consumers.

Although consumers have demonstrated their ability to influence the marketplace, the scientific community does not empower them by providing clear and unambiguous guidelines to facilitate healthy food choices. Dietary suggestions in the popular media that are not based on scientific evidence further hinder the public's perspective of a quality diet. While it was generally agreed that an ideal diet would be personalized with respect to an individual's microbiome and genetic information, and take into account epigenetic, economic, social, and other environmental factors, the necessary tools to personalize nutritional value are not yet fully developed.

Scientific opportunities and challenges

Opportunities exist for nutritious food production through the use of emerging technologies in a reformed food system. A comprehensive interdisciplinary approach is required to realize these opportunities.

Rather than solely prioritizing nutrient density, food production must maximize both quality and diet diversity. To achieve this goal, measures are needed that ensure high quality throughout the food chain. Great potential was seen for

the production of nutritious foods through the adoption of new technologies (i.e., nanotechnology, systems biology derived from advanced biotechnology, and information and communication technologies). Nanotechnology can be used at various production stages to deliver higher production yields and enhanced nutritional values. Bioengineering techniques can produce diversified, adaptable, and resistant crops. Opportunities also were identified in food preservation, processing, packaging, and delivery. Particular emphasis was placed on emergent strategies that combine traditional methods (e.g., fermentation, drying) with new technologies (e.g., biofortification, the breeding of crops to increase nutritional value) and metabolomics to preserve, protect, and process food. Probiotic-enhanced foods, soils, and crops were cited as examples of emerging technologies that can enhance quality and improve global health. Environmental concerns can also be addressed by using emerging technologies in a reformed food system to manage waste streams, water, and natural resources.

A clear challenge to the integration of nano- and biotechnologies in the food system is public skepticism surrounding these technologies. However, wide public acceptance of nanoscale systems in medicine (e.g., as a delivery vehicle for medication) was highlighted as a positive sign for change. Nanotechnology can be used in similar ways at different levels of the food chain (e.g., in agriculture as nanofertilizers, nanopesticides, and to protect nutrients). Although such state-of-the-art methodologies for the production of quality foods are currently not widely available, they hold great potential for further development.

Regulatory frameworks for emerging technologies represent both a challenge and an opportunity to integrate such technologies into the food system. Streamlining regulatory frameworks between countries and regions is necessary to create a diversified, adaptable food system that operates at a global level. Additionally, infrastructure that differentiates among nutritionally varying types of crops is needed for consumer choice to be reflected over time. Such infrastructure could be based on the method used to enhance a crop's nutritional value. It is important that regulatory frameworks ensure safety in the public perception, thereby increasing public trust in the use of biotechnology in the transition from quantity to quality food production.

To fundamentally transform the food system, emerging and emergent technologies must facilitate the decentralization of food production and distribution. Smart grid technologies are critical to this effort, since they enable the food chain to improve transportation efficiency, reduce waste, and better utilize local resources. Given the unique requirements and capacities that exist across cultures, societies, and economic levels, it is important to ensure such technologies are affordable, adaptable, easy to understand, and driven by society.

A smart grid could also accommodate the genetically distinct nutritional needs of differing populations. While the ability to effectively assess these unique needs is still emerging, it was predicted the scientific community will be able to assess optimum diets for single individuals and provide personalized food within 30 years.

To facilitate the transition to quality-based food production, scientists will need to collaborate with farmers and the private sector. Successful harvests with minimum waste can be supported during the transition period by helping farmers acquire and integrate new technology, and by ensuring a robust data exchange regarding traceability, climate, consumer needs, and other factors. Industry will require scientific assistance in adapting their technological processes to methodologies that optimize nutritional quality. The role of the private sector needs to be highlighted in fostering a decrease in the environmental impact of introducing biotechnology while promoting its added value. Such a shift in public understanding can increase consumer support for their products.

Widespread unreliable public information about quality diets was identified as a significant challenge to implementing a quality-based food system. Opportunities exist for science-based knowledge to be shared with the public at all levels. Programs such as Italy's "Foresight Project" need to continue searching for knowledge gaps to facilitate the integration of existing and emerging technologies. To retain support for the development of integrated biotechnologies, the scientific community needs to openly provide information about the processes of such technologies. Because levels of support and understanding may vary among consumers in different countries, information also must be open transnationally. Educated consumers can shape the market through their purchases, and the market reciprocally can shape societal perceptions.

Policy issues

Since the transition from a quantity-driven to a quality-driven food system is likely to face initial opposition from various stakeholders, dialogue between the scientific community and the public regarding existing technologies, future needs, and risk assessment was seen as essential to building support for the development, introduction, and acceptance of emerging bio- and nanotechnologies at all levels of the food chain.

Government supports and incentives will be required for food-system stakeholders (e.g., farmers, industry) during the transition from quantity to quality. In addition, private sector participants require a mechanism to recover their investments in developing quality crops.

Because global intervention into food production requires streamlining

regulatory frameworks, the scientific community was encouraged to propose regulatory schemes derived from evidence-based research to governments at state and national levels. Safety analyses and measurements need to be applied with the utilization of new biotechnology. Such guidelines could follow the regulatory examples of the National Nanotechnology Initiative in the United States. The effective implementation of safety regulations, risk/benefit analyses, and policy can increase consumer support and acceptance of emerging technologies introduced into the food industry.

The success of system reforms will depend on interdisciplinary collaborations at every level (regional, national, international) among governments, researchers, policy makers, private sector stakeholders, and consumers. University research institutions can actively support interdisciplinary agricultural projects that focus not only on yield, but also on nutritional quality; the International Food Policy Research Institute was suggested as a potential collaborator for work on nutrient enhancement. To support agricultural producers and industry during the transition from quantity to quality, governments need to create internationally accessible data banks for knowledge transfer. Although governments often view secrecy as conferring a competitive advantage, this practice also stifles innovation and impairs cooperation among nations attempting to reform the system. Rather, agencies must engage in communication and explore the application of new knowledge in communities around the world.

Since reforming the food system requires consumers to be knowledgeable about quality foods, governments need to establish educational programs that address the components of a quality diet, including consumption patterns and portion sizes. Initiatives to limit sugar consumption also are necessary (e.g., prohibiting the placement of sweets at the cashier).

To create a sustainable, adaptable food system that can respond to varying levels of supply and demands, policy needs to support communities in producing and distributing food locally, and in connecting through information and technology when additional food is required. The differing nutritional needs of genetically distinct populations must be considered in production and distribution networks. To support food security, government agencies can identify and aid populations requiring specialized nutrients and personalized foods. While decentralized production and distribution could provide some people access to quality foods, but financially exclude others, it is important for governments to view global food security as vital to their own national interests. Government and private sector entities need to jointly commit to making quality foods available to all 9 billion people in 2050, rather than just the wealthiest 2.5 billion.

Acknowledgment

Numerous individuals and organizations have made important contributions to the Institute on Science for Global Policy (ISGP) Food Safety, Security, and Defense (FSSD) program in general and to the conference entitled *Food Security and Diet-Linked Public Health Challenges.* This conference was organized and convened September 20–23, 2015, in partnership with North Dakota State University. Other contributions aided the ISGP in preparing the material presented in this report, including the eight invited policy position papers prepared by invited presenters and the not-for-attribution summaries of the views presented in the discussions, critical debates, and caucuses that ensued.

The ISGP greatly appreciates the willingness of those in the scientific and policy communities who agreed to be interviewed by the ISGP staff in their efforts to organize the content of this ISGP conference. Of special significance were the efforts of those invited by the ISGP to present their views of how diet-linked public health challenges can be anticipated to impact food security throughout society. Their willingness to engage policy makers and other scientists in the vigorous debates and caucuses that comprise all ISGP conferences was especially appreciated. The biographies of these eight authors are provided in this ISGP book.

The success of every ISGP conference critically depends on the active engagement of all invited participants in the often-intense debates and caucuses. The exchange of strongly held views, innovative proposals, and critiques generated from questions and debates fosters an unusual, and even unique, environment focused on clarifying understanding for the nonspecialist. These debates and caucuses address specific questions related to formulating and implementing effective public and private sector policies. The ISGP is greatly indebted to all those who participated in these not-for-attribution (Chatham House Rule) debates and caucuses.

The members of the ISGP Board of Directors also deserve recognition for their time and efforts in helping to create a vital, increasingly relevant not-for-profit organization focused on addressing many of the most important societal questions of our time. Their brief biographical backgrounds are presented at the end of this book.

The energetic, highly professional interviewing, organizing, and writing skills of the ISGP staff were essential to not only structuring the conference itself, but also to recording the often-diverse views and perspectives expressed in the critical debates, accurately capturing the areas of consensus and actionable next steps from

the caucuses, and persevering through the extensive editing process needed to assure the accuracy of the material published here. Their biographies are provided in this report.

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Dr. George H. Atkinson
Founder and Executive Director
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March 1, 2016

ISGP books from ISGP conferences listed below are available to the public and can be downloaded from the ISGP Web site: www.scienceforglobalpolicy.org. Hardcopies of these books are available by contacting info@scienceforglobalpolicy.org.

ISGP conferences on, or related to, Emerging and Persistent Infectious Diseases (EPID):

- *EPID: Focus on Antimicrobial Resistance,* convened March 19–22, 2013, in Houston, Texas, U.S., in partnership with the Baylor College of Medicine.
- *21st Century Borders/Synthetic Biology: Focus on Responsibility and Governance*, convened December 4–7, 2012, in Tucson, Arizona, U.S., in partnership with the University of Arizona.
- *EPID: Focus on Societal and Economic Context*, convened July 8–11, 2012, in Fairfax, Virginia, U.S., in partnership with George Mason University.
- *EPID: Focus on Mitigation*, convened October 23–26, 2011, in Edinburgh, Scotland, U.K., in partnership with the University of Edinburgh.
- *EPID: Focus on Prevention*, convened June 5–8, 2011, in San Diego, California, U.S.
- *EPID: Focus on Surveillance*, convened October 17–20, 2010, in Warrenton, Virginia, U.S.
- *EPID: Global Perspectives*, convened December 6–9, 2009, in Tucson, Arizona, U.S., in partnership with the University of Arizona.

ISGP conferences on Food Safety, Security, and Defense (FSSD):

- *FSSD: Equitable, Sustainable, and Healthy Food Environments*, convened May 1–4, 2016, in Vancouver, Canada, in partnership with Simon Fraser University.
- *FSSD: Food Security and Diet-linked Public Health Challenges*, convened September 20–23, 2015 in Fargo, North Dakota, in partnership with North Dakota State University.
- *FSSD: Focus on Food and the Environment*, convened October 5–8, 2014, in Ithaca, New York, in partnership with Cornell University.
- *FSSD: Focus on Food and Water,* convened October 14–18, 2013, in Lincoln, Nebraska, U.S., in partnership with the University of Nebraska–Lincoln.
- *FSSD: Focus on Innovations and Technologies,* convened April 14–17, 2013, in Verona, Italy.
- *FSSD: Global Perspectives,* convened October 24, 2012, in Arlington, Virginia, U.S., in partnership with George Mason University.

ISGP Academic Partnership (IAP) conferences

- *The Socioeconomic Context of Sustainable Agriculture*, to be convened mid-October 2016, in Danbury, Connecticut, U.S., in partnership with Western Connecticut State University.
- *Water and Fire: Impacts of Climate Change*, convened April 10–11, 2016, in Sacramento, California, U.S., in partnership with California State University, Sacramento
- *Communicating Science for Policy, convened August 10–11, 2015, in Durham, North Carolina, in partnership with Sigma Xi, The Scientific Research Society.*
- *Food Security: Production and Sustainability*, convened April 24–25, 2015, in St. Petersburg, Florida, in partnership with Sigma Xi, The Scientific Research Society, and Eckerd College.
- *FSSD: Safeguarding the American Food* Supply, convened April 10–11, 2015, in Collegeville, Pennsylvania, in partnership with Sigma Xi, The Scientific Research Society, and Ursinus College.
- *EPID: Focus on Pandemic Preparedness,* convened April 11–12, 2014, in Collegeville, Pennsylvania, U.S., in partnership with Ursinus College.

ISGP conferences on Science and Governance (SG):

- *The Genomic Revolution,* convened September 6, 2013, in cooperation with the Parliamentary Office on Science and Technology of the British Parliament within the House of Lords. London, United Kingdom.

ISGP reports from ISGP conferences on Global Challenges are available to the public and can be downloaded from the ISGP Web site: www.scienceforglobalpolicy.org:

- ISGP Climate Change Program (ICCP): *The Shore's Future: Living with Storms and Sea Level Rise*, November 20–21, 2015, in cooperation with several local partners, including the Barnegat Bay Partnership, the Barnegat Bay Foundation, the Jay and Linda Grunin Foundation and local government.
- ICCP: *Sea Level Rise: What's Our Next Move*, convened Oct. 2–3, 2015, in St. Petersburg, Florida, in cooperation with the St. Petersburg/Pinellas County Working Group and the Institute for Strategic Policy Solutions at St. Petersburg College.
- ISGP Climate Change Arctic Program (ICCAP): *Sustainability Challenges: Coping with Less Water and Energy,* convened June 5, 2015, in Whittier, California, in cooperation with the Whittier Working Group.
- ICCAP: *Living with Less Water*, convened February 20–21, 2015, in Tucson Arizona, in cooperation with the Tucson Working Group.

Biographical information of Scientific Presenters and Keynote Speakers

Scientific Presenters

Cecilia Bartolucci, Ph.D.

Dr. Bartolucci is Researcher and Coordinator of the Science and Technology Foresight Project, Working Group "Food," for the National Research Council of Italy, Rome. A Chemistry graduate of the University "La Sapienza" in Rome, she was awarded a scholarship from the Ministry of Foreign Affairs and started her research activity at the Institut de Chimie Therapeutique in Lausanne, Switzerland. As postdoctoral fellow, with a NATO-CNR Advanced Fellowship, she spent 18 months at the Max Planck Institut für Medizinische Forschung in Heidelberg, Germany, and in 2000 received a fellowship from the Humboldt Foundation to work as Postdoctoral Research Associate in Protein Crystallography at the Max Planck Institut für Biochemie, Martinsried, Germany, where she continues to collaborate to the present day. Her current research, which incorporates a highly interdisciplinary approach, focuses on agricultural biotechnology and the role of nanotechnology in food.

Laurie H.M. Chan, Ph.D., F.C.A.H.S.

Prof..Chan is Professor and Canada Research Chair in Toxicology and Environmental Health and the Director of Center for Advanced Research in Environmental Genomics at the University of Ottawa. His research in environmental and nutritional toxicology includes developing new techniques for contaminant analysis, and participatory research in the community on the risk and benefits of traditional foods and the impact of environmental change on food security. He has published over 190 peer-reviewed scientific papers and supervised more than 70 graduate students. He has also served as an advisor for international and national governments and organizations and numerous Aboriginal communities on environmental health issues. He is a Fellow of the Canadian Academy of Health Sciences.

Linda Duffy, Ph.D., M.P.H.

Dr. Duffy is a Health Scientist Administrator at the U.S. National Institutes of Health (NIH)/National Center for Complementary and Integrative Health. She also serves as the Trans-NIH and Inter-agency Scientific Chair of the Probiotics/Prebiotics and Microbiome Working Group under the NIH Office of the Director on partnering initiatives with federal government agencies and the White House

Office of Science and Technology Policy. Her position focuses on building programs as Centers of Excellence in natural products research, with special emphasis on probiotic/prebiotic foods and pharmacologic safety studies on gut microecology and microbiome. Her research includes health impacts on immunologic inflammatory responses, maternal-child health, brain-gut interactions, obesity, and aging. She formerly served as Professor in the School of Medicine at the University of Buffalo. She has published over 100 articles and recently co-authored an article addressing progress and challenges in developing metabolic footprints from diet in human gut microbial cometabolism.

Katherine Gray-Donald, Ph.D.

Dr. Gray-Donald is Associate Professor in the School of Dietetics and Human Nutrition at McGill University. She was trained as a professional dietitian working in the community and went on to study epidemiology at McGill University. She served on the Expert Advisory group of the 2015 Canadian Community Health Survey – Nutrition, and is past president of the Canadian Nutrition Society. Her research focuses on the relationship between different dietary components and health, and on ways to improve diets and lower risk of disease. The most current project focuses on the nutritional health of different children being followed in a large cohort to identify how diet and other lifestyle factors affect disease risk. Previous studies throughout her career have focused on vulnerable subgroups of the population on food and nutrition security with the aim of improving health through improved dietary intake.

Larry Harrington, Ph.D.

Dr. Harrington is Adjunct Professor in the Soil and Crop Sciences Section at Cornell University, and a Faculty Fellow at the Atkinson Center for a Sustainable Future, Cornell University. Formerly, he conducted farming systems research in Asia for CIMMYT (International Maize and Wheat Improvement Center), and served as CIMMYT Program Director for the Natural Resources Group, where he focused on conservation agriculture projects in Africa, Asia and Latin America, and helped plan and develop the Rice-Wheat Consortium for the Indo-Gangetic Plains. Until recently, he served as Research Director in the CGIAR Challenge Program on Water and Food (CPWF), in charge of planning and technical oversight of 40 research projects on water, food, poverty and resilience in the Andes, Ganges, Limpopo, Mekong, Nile, and Volta river basins. He is principal editor of a book describing the activities and achievements of the CPWF since 2004.

Stephen J.D. O'Keefe, M.B.B.S., M.D., M.Sc., F.R.C.P.

Dr. O'Keefe is Professor of Medicine in the Clinical Nutrition Service, Division of Gastroenterology, Hepatology, and Nutrition, at the University of Pittsburgh, Pennsylvania. Former positions include Professor and Head of the Gastrointestinal Clinic at Groote Schuur Hospital, University of Cape Town, South Africa, and Associate Professor of Internal Medicine/Gastroenterology, at the Mayo Clinic, Rochester, Minnesota. His nutritional gastroenterology research focuses on evaluating the physiological and pathophysiological responses to dietary intake and interventional feeding. Current research includes an NIH-supported investigation into the role of diet, colonic microbiota and the metabolome to determine colon cancer in diverse populations, a project inspired by his work in South Africa in which he observed the rarity of colonic adenomatous polyps and cancer in rural Africans compared to high rates in African-Americans. His clinical activities relate to the management of home parental feeding and the nutritional support of hospitalized patients.

Michael Robidoux, Ph.D.

Dr. Robidoux is a Full Professor in Health Sciences, School of Human Kinetics, University of Ottawa. He also is part of the Indigenous Health Research Group, a multidisciplinary research team representing fields from Ethnology, Physiology, Biology, Toxicology, Immunology and Nutrition Sciences, where he leads research programs investigating the risks and benefits of land-based food strategies. An award-winning Social Sciences and Humanities Research Council researcher, his primary research focuses on indigenous cultural practices as they relate to physical activity and local dietary practices. Currently, he and colleagues are studying the overall viability, sustainability, benefits and risks of wild food consumption in four First Nations communities in northwestern Ontario, Northwest Territories and British Columbia. This model of research is expanding to other rural remote indigenous communities throughout Canada.

Devanjan "Dev" Sikder, D.V.M., M.S., Ph.D.

Dr. Sikder is Founder and President of Science Entertainment and Design (SED), a collaborative science program for grades K-12, and a faculty member at several medical schools and research facilities (UT Southwestern Medical Center, Dallas; Sanford Burnham Medical Research Institute, Orlando; College of Medicine, University of Florida, Gainesville), where he has directed investigations in narcolepsy, obesity, diabetes, and cancer cure, culminating in research papers, patents, and clinical trials. His research interests include metabolic target discovery in obesity and type II diabetes; genomic research; bioinformatics; appetite regulation; neurobiology

of addiction and depression; and K-12 science education. An Associate Editor of the American Journal of Digestive Diseases, he serves on editorial boards for numerous medical journals, and has delivered lectures at prestigious national and international conferences, including TED.

Keynote Speakers

Kalidas Shetty, Ph.D.

Dr. Shetty is a Professor of Plant Science & Founding Director of Global Institute for Food Security & International Agriculture at North Dakota State University in Fargo and former Professor of Food Biotechnology at the University of Massachusetts Amherst. His research is focused on complex and integrative metabolic systems to improve food technologies and combat global diet- and environment-linked chronic disease and metabolic systems for sustainable community development. He is involved in community development projects working for sustainable food systems for better health in indigenous communities in America, sustainable fruit and vegetable production in urban communities to improve diet and lead to better health and enhancing traditional food systems and food diversity to combat chronic diet-related disease in Asia, Africa, and the Americas. His academic and outreach efforts have been recognized with awards from the University of Massachusetts and the Asia-Pacific Clinical Nutrition Society. In addition to his research, he has served as a Jefferson Science Fellow as the Science Advisor to the Bureau of Economic and Business Affairs, United States Department of State.

Donald Warne, M.D., M.P.H.

Dr. Warne is Chair of the Department of Public Health at North Dakota State University, and Senior Policy Advisor to the Great Plains Tribal Chairmen's Health Board. An adjunct clinical professor at the Arizona State University Sandra Day O'Connor College of Law, he teaches American Indian Health Policy. Formerly, Dr. Warne was a primary care and integrative medicine physician with the Gila River Health Care Corporation in Sacaton, Arizona, and a Staff Clinician with the National Institutes of Health in Phoenix, Arizona, where he conducted diabetes research and developed diabetes education and prevention programs in partnership with tribes. A member of the Oglala Lakota tribe from Pine Ridge, South Dakota, he comes from a long line of traditional healers and medicine men. Dr. Warne is a Certified Diabetes Educator (CDE), and a Diplomate of both the American Board of Family Practice and the American Board of Medical Acupuncture.

Biographical information of ISGP Board of Directors

Dr. George Atkinson, Chairman

Dr. Atkinson founded the Institute on Science for Global Policy (ISGP) and is an Emeritus Professor of Chemistry, Biochemistry, and Optical Science at the University of Arizona. He is former head of the Department of Chemistry at the University of Arizona, the founder of a laser sensor company serving the semiconductor industry, and Science and Technology Adviser (STAS) to U.S. Secretaries of State Colin Powell and Condoleezza Rice. He launched the ISGP in 2008 as a new type of international forum in which credible experts provide governmental and societal leaders with understanding of the science and technology that can be reasonably anticipated to help shape the increasingly global societies of the 21st century. Dr. Atkinson has received National Science Foundation and National Institutes of Health graduate fellowships, a National Academy of Sciences Post Doctoral Fellowship, a Senior Fulbright Award, the SERC Award (U.K.), the Senior Alexander von Humboldt Award (Germany), a Lady Davis Professorship (Israel), the first American Institute of Physics' Scientist Diplomat Award, a Titular Director of the International Union of Pure and Applied Chemistry, the Distinguished Service Award (Indiana University), an Honorary Doctorate (Eckerd College), the Distinguished Achievement Award (University of California, Irvine), and was selected by students as the Outstanding Teacher at the University of Arizona. He received his B.S. (high honors, Phi Beta Kappa) from Eckerd College and his Ph.D. in physical chemistry from Indiana University.

Dr. Ben Tuchi, Secretary/Treasurer

Dr. Tuchi is chairman of the board of directors of the Arizona Research Park Authority. He received his B.S. and M.S. degrees in Business Administration from the Pennsylvania State University and his Ph.D. in Finance from St Louis University. His full time teaching career began in 1961 at St. Francis College and continued until 1976 at West Virginia University. From 1976 through 1996 he served in cabinet levels at West Virginia University, The University of Arizona, The University of North Carolina at Chapel Hill, and finally as Senior Vice Chancellor for Business and Finance of the University of Pittsburgh. During those assignments he was simultaneously a tenured professor of finance. He retired from the last executive post in 1996 and returned to a full-time teaching position as Professor of Finance at the University of Pittsburgh, until his retirement in 1999. For the two years prior

to his retirement he was the Director of Graduate Programs in Business in Central Europe, at Comenius University, making his home in Bratislava, The Slovak Republic.

Dr. Janet Bingham, Member

Dr. Bingham is President of the George Mason University (GMU) Foundation and Vice President of Advancement and Alumni Relations. GMU is the largest university in Virginia. Previously, she was President and CEO of the Huntsman Cancer Foundation (HCF) in Salt Lake City, Utah. The foundation is a charitable organization that provides financial support to the Huntsman Cancer Institute, the only cancer specialty research center and hospital in the Intermountain West. Dr. Bingham also managed Huntsman Cancer Biotechnology Inc. In addition, she served as Executive Vice President and Chief Operating Officer with the Huntsman Foundation, the private charitable foundation established by Jon M. Huntsman Sr. to support education, cancer interests, programs for abused women and children, and programs for the homeless. Before joining the Huntsman philanthropic organizations, Dr. Bingham was the Vice President for External Relations and Advancement at the University of Arizona. Prior to her seven years in that capacity, she served as Assistant Vice President for Health Sciences at the University of Arizona Health Sciences Center. Dr. Bingham was recognized as one of the Ten Most Powerful Women in Arizona.

Dr. Henry Koffler, Member

Dr. Koffler is President Emeritus of the University of Arizona (UA). He served as President of the UA from 1982-1991. From 1982 he also held professorships in the Departments of Biochemistry, Molecular and Cellular Biology, and Microbiology and Immunology, positions from which he retired in 1997 as Professor Emeritus of Biochemistry. His personal research during these years concentrated on the physiology and molecular biology of microorganisms. He was Vice President for Academic Affairs, University of Minnesota, and Chancellor, University of Massachusetts/Amherst, before coming to the UA. He taught at Purdue University, where he was a Hovde Distinguished Professor, and the School of Medicine at Western Reserve University (now Case Western Reserve University). Dr. Koffler served as a founding Governor and founding Vice-Chairman of the American Academy of Microbiology, and as a member of the governing boards of Fermi National Accelerator Laboratory, the Argonne National Laboratory, and the Superconducting Super Collider Laboratory. He was also a board member of the Association of American Colleges and Universities, a member and Chairman of the Council of Presidents and a member of the executive committee of the National Association of Land Grant Colleges and Universities. He was also Founder, President and board

member of the Arizona Senior Academy, the driving force in the development of the Academy Village, an innovative living and learning community. Among the honors that Dr. Koffler has received are a Guggenheim Fellowship and the Eli Lilly Award in Bacteriology and Immunology.

Mr. Jim Kolbe, Member

For 22 years, Mr. Kolbe served in the United States House of Representatives, elected in Arizona for 11 consecutive terms, from 1985 to 2007. Mr. Kolbe is currently serving as a Senior Transatlantic Fellow at the German Marshall Fund of the United States, and as a Senior Adviser to McLarty Associates, a strategic consulting firm. He advises on trade matters as well as issues of effectiveness of U.S. assistance to foreign countries, on U.S.-European Union relationships, and on migration and its relationship to development. He is also Co-Chair of the Transatlantic Taskforce on Development with Gunilla Carlsson, the Swedish Minister for International Development Cooperation. He also is an adjunct Professor in the College of Business at the University of Arizona. While in Congress, he served for 20 years on the Appropriations Committee of the House of Representatives, was chairman of the Treasury, Post Office and Related Agencies subcommittee for four years, and for his final six years in Congress, he chaired the Foreign Operations, Export Financing and Related Agencies subcommittee. He graduated from Northwestern University with a B.A. degree in Political Science and then from Stanford University with an M.B.A. and a concentration in economics.

Dr. Charles Parmenter, Member

Dr. Parmenter is a Distinguished Professor Emeritus of Chemistry at Indiana University. He also served as Professor and Assistant and Associate Professor at Indiana University in a career there that spanned nearly half a century (1964-2010). He earned his bachelor's degree from the University of Pennsylvania and served as a Lieutenant in the U.S. Air Force from 1955-57. He worked at DuPont after serving in the military and received his Ph.D. from the University of Rochester and was a Postdoctoral Fellow at Harvard University. He has been elected a Member of the National Academy of Sciences and the American Academy of Arts and Sciences, and a Fellow of the American Physical Society and the American Association for the Advancement of Science. He was a Guggenheim Fellow, a Fulbright Senior Scholar, and received the Senior Alexander von Humboldt Award in 1984. He has received the Earle K. Plyler Prize, was a Spiers Medalist and Lecturer at the Faraday Society, and served as Chair of the Division of Physical Chemistry of the American Chemical Society, Co-Chair of the First Gordon Conference on Molecular Energy Transfer, Co-organizer of the Telluride Workshop on Large Amplitude Motion and

Molecular Dynamics, and Councilor of Division of Chemical Physics, American Physical Society.

Mr. Thomas Pickering, Member

Mr. Pickering is Vice Chairman of Hills & Co, international consultants, and Strategic Adviser to NGP Energy Capital Management. He co-chaired a State-Department-sponsored panel investigating the September 2012 attack on the U.S. diplomatic mission in Benghazi. He served as U.S. ambassador to the United Nations in New York, the Russian Federation, India, Israel, El Salvador, Nigeria, and the Hashemite Kingdom of Jordan. Mr. Pickering also served on assignments in Zanzibar and Dar es Salaam, Tanzania. He was U.S. Under Secretary of State for Political Affairs, president of the Eurasia Foundation, Assistant Secretary of State for Oceans and International Environmental and Scientific Affairs, and Boeing Senior Vice President for International Relations. He also co-chaired an international task force on Afghanistan, organized by the Century Foundation. He received the Distinguished Presidential Award in 1983 and again in 1986 and was awarded the Department of State's highest award, the Distinguished Service Award in 1996. He holds the personal rank of Career Ambassador, the highest in the U.S. Foreign Service. He graduated from Bowdoin College and received a master's degree from the Fletcher School of Law and Diplomacy at Tufts University.

Dr. Eugene Sander, Member

Dr. Sander served as the 20th president of the University of Arizona (UA), stepping down in 2012. He formerly was vice provost and dean of the UA's College of Agriculture and Life Sciences, overseeing 11 academic departments and two schools, with research stations and offices throughout Arizona. He also served as UA Executive Vice President and Provost, Vice President for University Outreach and Director of the Agricultural Experiment Station and Acting Director of Cooperative Extension Service. Prior to his move to Arizona, Dr. Sander served as the Deputy Chancellor for biotechnology development, Director of the Institute of Biosciences and Technology, and head of the Department of Biochemistry and Biophysics for the Texas A&M University system. He was Chairman of the Department of Biochemistry at West Virginia University Medical Center and Associate Chairman of the Department of Biochemistry and Molecular Biology at the College of Medicine, University of Florida. As an officer in the United States Air Force, he was the assistant chief of the biospecialties section at the Aerospace Medical Research Laboratory. He graduated with a bachelor's degree from the University of Minnesota, received his master's degree and Ph.D. from Cornell University and completed postdoctoral study at

Brandeis University. As a biochemist, Dr. Sander worked in the field of mechanisms by which enzymes catalyze reactions.

Mr. Richard Armitage, Special Adviser

Mr. Armitage is the President at Armitage International, where he assists companies in developing strategic business opportunities. He served as Deputy Secretary of State from March 2001 to February 2005. Mr. Armitage, with the personal rank of Ambassador, directed U.S. assistance to the new independent states (NIS) of the former Soviet Union. He filled key diplomatic positions as Presidential Special Negotiator for the Philippines Military Bases Agreement and Special Mediator for Water in the Middle East. President Bush sent him as a Special Emissary to Jordan's King Hussein during the 1991 Gulf War. Mr. Armitage also was Deputy Assistant Secretary of Defense for East Asia and Pacific Affairs in the Office of the Secretary of Defense. He graduated from the U.S. Naval Academy. He has received numerous U.S. military decorations as well as decorations from the governments of Thailand, Republic of Korea, Bahrain, and Pakistan. Most recently, he was appointed an Honorary Companion of The New Zealand Order of Merit. He serves on the Board of Directors of ConocoPhillips, ManTech International Corporation, and Transcu Ltd., is a member of The American Academy of Diplomacy as well as a member of the Board of Trustees of the Center for Strategic and International Studies.

Biographical Information of ISGP Staff, Interns and Volunteers

George Atkinson, Ph.D.

Dr. Atkinson is the Founder and Executive Director of the Institute on Science for Global Policy (ISGP) and is an Emeritus Professor of Chemistry, Biochemistry, and Optical Science at the University of Arizona. His professional career has involved academic teaching, research, and administration, roles as a corporate founder and executive, and public service at the federal level. He is former Head of the Department of Chemistry at the University of Arizona, the founder of a laser sensor company serving the semiconductor industry, Science and Technology Adviser (STAS) to U.S. Secretaries of State Colin Powell and Condoleezza Rice, and past president of Sigma Xi, The Scientific Research Society. He launched the ISGP in 2008 as a new type of international forum in which credible experts provide governmental and societal leaders with the objective understanding of the science and technology that can be reasonably anticipated to help shape the increasingly global societies of the 21st century.

Jennifer Boice, M.B.A

Ms. Boice, the ISGP Program Coordinator, worked for 25 years in the newspaper industry at the Tucson Citizen and USA Today, and was the Editor of the Tucson Citizen when it was closed in 2009. Additional appointments at the Tucson Citizen included Business News Editor, Editor of the Online Department, and Senior Editor. She also was a business columnist. Ms. Boice received her M.B.A. from the University of Arizona and graduated from Pomona College in California with a degree in economics.

Sweta Chakraborty, Ph.D.

Dr. Chakraborty is Associate Director for the ISGP. Prior to joining the ISGP, Dr. Chakraborty served as the resident cognitive behavioral scientist at Lootok Ltd., a risk management consulting firm. She received her doctorate in Risk Management from King's College London, and has more than 20 published articles, has contributed to three books, and is author of the book "Pharmaceutical Safety: A Study in Public and Private Regulation." She is currently an adjunct assistant professor at Columbia University and a program associate at Oxford University's Centre for Socio-Legal Studies.

Barbara Del Castello, B.A.

Ms. Del Castello, ISGP Senior Fellow, is a graduate of Eckerd College, St. Petersburg, Florida, with a degree in Biology and a minor in Anthropology and currently is conducting post baccalaureate research on the genetic origins of the thymus at the University of Georgia, Athens.

Torsten Fiebig, Ph.D.

Dr. Fiebig, ISGP Fellow, is the Founder and Chief Executive of Advanced Optix Research, LLC. He holds two doctorate degrees in science, has been a professor and conducted research at various academic institutions, including the California Institute of Technology, Northwestern University and the Max Planck Institute for Biophysical Chemistry (Germany). His research interests include energy sciences, medical optics and biological physics.

Christina Medvescek, B.A.

Ms. Medvescek, ISGP Program Administrator, is an internationally published journalist and editor specializing in health, human development and conflict resolution. She also serves as an EEO mediator for the U.S. Postal Service, and as a mediator, facilitator and instructor for the Center for Community Dialogue, Tucson, AZ.

Joseph Roberts, Ph.D

Dr. Roberts, ISGP Senior Fellow, earned his doctorate in social psychology from The Ohio State University in 2011. His research has examined the influence of mindsets on self-control, planning, and decision-making in health and public policy domains. In addition to his work for ISGP, Dr. Roberts teaches courses in psychology, statistics, and research methods at The Ohio State University in Columbus, Ohio.

Sperry Van Langeveld, M.S., M.Ed, M.B.A.

Mr. Van Lengeveld is an ISGP Associate Fellow whose career has included positions in polymer research and senior management for large industrial suppliers. In 1984, he established a personal computer manufacturing business that he and his wife operated until their retirement in 1999. He holds diverse graduate degrees and studies and teaches at the University of Arizona.

Andrea Vazquez

Ms. Vazquez is an ISGP Fellow, is a senior at Arizona State University pursuing her bachelor's degree in social work. She is also a College Prep-Assistant at a high school in Tucson, Arizona. Her goal as a social worker is to challenge social injustice and advocate for people who are vulnerable and oppressed, especially youth.

ISGP Interns

Alissa Welker

Ms. Welker is a senior Environmental Science major, with Peace and Justice and Spanish minors, at Villanova University, Pennsylvania. She has done several agriculture-focused internships and is currently working on her senior thesis, "Cultivate a Conversation," which aims to pinpoint similarities among stakeholders in the food and agriculture industry, and ultimately start a conversation.

Katie Wheeler

Ms. Wheeler is majoring in Biology and Communication at Eckerd College, Florida. Her academic and personal interests led her to a passion for food systems. She has worked in several diverse food-related settings and aims to deepen her understanding of how different disciplines and perspectives play a role in and contribute to the state of food systems.

Volunteers from North Dakota State University

Uthra Jayakumar, B.S.

Ms. Jayakumar holds a Bachelor's degree in Liberal Studies with an emphasis on Mass Communication, from the Management Development Institute of Singapore. She is currently a free-lance journalist in the area of cyber security risk analysis and assurance. She is also pursuing a Master's degree in Journalism at the University of Technology Sydney, Australia.

Ramnarain Ramakrishna, M.S.

Mr. Ramakrishna has a Master's degree in Food Science and Nutrition from the University of Leeds, U.K., and is a doctoral candidate in the Cereal Science program at North Dakota State University. His research intersects the domains of plant physiology and food science, and seeks to study protective antioxidant mechanisms in plants, and their relevance in addressing oxidative stress-linked chronic diseases in humans such as early stage Type 2 diabetes

Ashish Cristopher, M.S.

Mr. Cristopher is pursuing his doctoral studies in food safety at the North Dakota State University. His research focuses on bioactive functionalities of cereal crops and other food ingredients in relevance to food safety and human health improvement, especially targeting early stages Type 2 diabetes. He holds Master's in Biotechnology from the Bangalore University, India.