Institute on Science for Global Policy (ISGP)

Food Security:
Production and Sustainability

Conference organized and convened by the ISGP
in partnership with Eckerd College in St. Petersburg, Florida, U.S.
April 24—25, 2015

ISGP Academic Partnership (IAP) with Eckerd College

Institute on Science for Global Policy (ISGP)

Food Security:
Production and Sustainability

Conference organized and convened by the ISGP
in partnership with Eckerd College, in St. Petersburg, Florida, U.S.
with financial support from Sigma Xi, The Scientific Research Society
April 24–25, 2015

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

Institute on Science for Global Policy (ISGP)

Tucson, AZ Office
3320 N. Campbell Ave.
Suite 200
Tucson, AZ 85719

Washington, DC Office
818 Connecticut Ave. NW
Suite 800
Washington, DC 20006

www.scienceforglobalpolicy.org

ISBN: 978-0-9861007-2-7

Table of contents

Introduction

Dr. George H. Atkinson
Founder and Executive Director, Institute on Science for Global Policy
and
Professor Emeritus, Department of Chemistry and Biochemistry
and College of Optical Sciences, University of Arizona

Preface

The contents of this book were taken from material presented at a conference organized and convened by the Institute on Science for Global Policy (ISGP) on April 24–25, 2015, in partnership with Eckerd College, in St. Petersburg, Florida and with financial support from Sigma Xi, The Scientific Research Society. This specific ISGP conference, *Food Security: Production and Sustainability,* was part of the ISGP Academic Partnerships (IAP) program, which is based on collaborations with distinguished academic institutions. These IAP conferences reflect a common commitment to significantly improve the communication of credible scientific and technological (S&T) understanding to both policy makers and to the public *writ large.*

The process used to organize ISGP conferences begins with the recognition that Food Safety, Security, and Defense (FSSD) has become a focal point on the international stage for numerous critical issues affecting public health spanning the diverse cultural, ethical, and economic characteristic that define all societies. Societal decisions concerning how to appropriately incorporate the often transformational scientific advances associated with FSSD into public and private sector policies rely on debates that highlight the credible options developed worldwide. Given the global impact of FSSD, such debates deserve attention from both domestic and international policy makers from a wide range of disciplines. ISGP conferences offer a rarely encountered environment in which such critical debates can occur among internationally distinguished scientists, influential policy makers, societal stakeholders, and the public.

Based on extensive interviews conducted by the ISGP staff with an international group of subject-matter experts, the ISGP invited three highly distinguished individuals with expertise in FSSD to prepare the three-page, policy position papers (designed for the nonspecialist) that were debated at the Eckerd College IAP conference. These three 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 IAP conference participants in the caucuses that followed the debates are also presented.

The debate summaries and caucus results, derived from the contributions of IAP conference participants, were prepared by the ISGP staff in collaboration with the students enrolled in the ISGP conference-inspired course taught by Eckerd College faculty.

This one-semester course, which included planning and convening an ISGP-style conference, focused the current food supply and production systems domestically and internationally with emphasis on the environmental implications and sustainability of agriculture, including:

- the identification and discussions of the challenges of increasing crop production.
- the exploration of avenues for potential improvement in agricultural productivity.

ISGP Academic Partnerships (IAP)

Recent history suggests that many societies would benefit from improving how scientifically credible information is used to inform policy decisions on a wide range of pressing issues (e.g., food safety, climate change, infectious diseases). Those engaged in the IAP programs recognize that communication between those with S&T expertise and those policy makers responsible for ensuring safe, secure, and prosperous societies must be effective and timely. Venues that promote the concise and accurate presentations of viable S&T options to policy makers, while encouraging critical assessments, are essential in identifying effective policy decisions that can be publicly supported and therefore, effectively implemented. No less important is the organization of venues in which the public can both witness and participate in such debates concerning the advantages and potential risks of these S&T options. IAP events provide opportunities for both college- and university-level students and the public to debate those important societal issues of our time that depend on an accurate understanding of credible S&T options.

Such public events are derived from the invitation-only debates and caucuses pioneered by the ISGP in which candid exchanges of ideas and criticism among internationally-recognized S&T professionals, policy makers in government and the private sector, and societal leaders are the norm. These critical debates and caucuses are the centerpieces for the pedagogical approach underlying IAP programs, and therefore, are emulated in the structure of the IAP that are convened at participating

colleges and universities. The participating students help organize and lead each IAP conference at their respective institutions with audiences comprised of their fellow students, faculty, and members of the public.

The academic preparation of the students begins with classroom studies under the supervision of faculty from their respective institutions. In addition to the classroom studies, participating students are offered the opportunity to (i) assist the ISGP staff in interviewing S&T experts worldwide, (ii) read the extensive background material and reports available to the ISGP (including advance copies of the policy position papers used in formal ISGP conferences), (iii) participate in the formal debates of the policy position papers alongside leading experts in the field, (iv) moderate the caucus groups to ensure Areas of Consensus and Actionable Next Steps are democratically reached and consolidated, and (v) help to craft conference publications.

The overall educational experience can be viewed as a "practical S&T-policy laboratory" designed to (i) prepare the students for active roles in informing and guiding policy makers at the local, regional, national, and global levels and (ii) expose the public to informed debates provided by distinguished S&T experts and led by students who have participated in the IAP. Taken together, both experiences are important steps toward ensuring that appropriate respect for rational thinking is given to the future formulation and implementation of public and private sector polices.

Current realities

As the second decade of the 21st century opens, most societies are facing difficult decisions concerning how to appropriately use, or reject, the dramatic new opportunities offered by modern scientific advances and the technologies that emanate from them. Advanced scientific research programs, as well as commercially viable technologies, are now developed globally. As a consequence, many societal issues related to S&T necessarily involve domestic and international policy decisions, both in the public and private sectors.

The daunting challenges to simultaneously recognize immediate technological opportunities while identifying those emerging S&T achievements that foreshadow transformational advantages and risks within specific societies are now fundamental governmental responsibilities. These responsibilities are especially complex because policy makers must consider the demands of different segments of society, which often have conflicting goals. For example, decisions must balance critical commercial interests that promote economic prosperity with the cultural sensitivities that often determine if, and how, S&T can be successfully integrated into any society.

Since 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, it is increasingly important that the S&T and policy communities (public and private) communicate effectively. With a seemingly unlimited number of urgent S&T challenges, both more- and less-affluent societies need their most accomplished members to focus on effective, real-world solutions relevant to their specific circumstances.

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. There is a critical need to have the relevant S&T information concisely presented to policy communities in an environment that promotes open questions and debates led by those nonexperts directly engaged in decisions. The IAP model of debate aims to simultaneously convey to the public this same degree of understanding, confidence, and acknowledgment of risk necessary to obtain the broad societal support needed to effectively implement any decision.

ISGP conference structure

At each ISGP conference, internationally recognized, subject-matter experts are invited to prepare concise (three pages) policy position papers. For the April 24–25, 2015, IAP conference at Eckerd College, these papers described the authors' diverse views and perspectives on the current realities, scientifically credible opportunities and associated risks, and policy issues concerning Food Security: Production and Sustainability. Students from the class taught at Eckerd College were invited to assist in the editing of the policy position papers prior to their public dissemination several weeks before the conference convened. Conference participants were from Eckerd College and the communities it serves, including faculty and students from colleges and universities across the country, local high schools, government and public health representatives, private-sector and industry leaders, and leading researchers in related fields.

The conference agenda was comprised of three 90-minute sessions, each of which was devoted to a debate of a given policy position paper. In each session, the author was given 5 minutes to summarize his views while the remaining 85 minutes were opened to all participants, including other policy paper authors, for questions, comments, and debate. The debates focused on clarifying the understanding among the nonspecialists and identifying areas of consensus and actionable policy decisions supported by scientifically credible information.

While the Chatham House Rule (no attribution of remarks to any participant outside the conference setting) is routinely used in many ISGP conferences to

encourage frank discussions and critical debates, all IAP conference are conducted without any restrictions on attribution. This procedure recognizes the importance of engaging the public and press in debates that facilitate professional and respectful communication while accurately articulating well founded scientific and policy options.

The not-for-attribution summaries of each debate, prepared by the ISGP staff in collaboration with Eckerd College students in the class, are based on the collective notes and recordings from each debate and are presented here immediately following each policy position paper. These summaries represent the best effort by staff and students 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 views expressed in these summaries do not necessarily represent the views of a specific author, as evidenced by his or her respective policy position paper. Rather, 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 three debates, small caucus groups co-moderated by ISGP staff and Eckerd College students and representing a cross section of all participants worked to identify areas of consensus and the actionable next steps to be considered within governments and civil societies in general. 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 conclusions that could have policy relevance both domestically and internationally.

A summary of the overall areas of consensus and actionable next steps emerging from these caucuses is presented here immediately following this introduction under the title of **Conference conclusions.**

Concluding remarks

IAP conferences are designed to provide environments that facilitate publicly accessible debates of the credible S&T options available to successfully address many of the most significant challenges facing 21st century societies. IAP debates test the views of subject-matter experts through critical questions and comments from citizens and nonspecialists committed to finding effective, real-world solutions. Obviously, IAP 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, IAP programs focus on fostering environments that can significantly improve the communication of ideas and recommendations, many of which are in reports developed by other organizations and institutes, to the policy communities responsible for serving their constituents in the public.

While IAP conferences begin with concise descriptions of scientifically credible options provided by those experienced in the S&T subject, they rely heavily on the willingness of nonspecialists and citizens to critically question these S&T concepts and proposals. With the introduction of the IAP conference model, now students and the general public can voice their opinions and learn how decisions that undoubtedly will impact their lives are made. Overall, IAP conferences seek to provide a new type of venue in which S&T expertise not only informs the citizen, but also in which realistic policy options can be identified for serious consideration by governments and societal leaders. Most importantly, IAP programs 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

To effectively reduce food waste, increase sustainable agricultural productivity, and improve food safety throughout the food chain, multidisciplinary stakeholder collaborations are clearly necessary. New collaborations need to be developed and existing collaboration need to be strengthened if the advice provided to policymakers at the local, regional, national, and international levels is to be effective.

Actionable Next Steps

- Establish a forum for open dialogue and communication across a variety of stakeholders to foster creative partnerships and develop solutions for food security and sustainability issues. Solutions need to focus on specific guidelines for stakeholders (e.g., industry, government, consumers) on which to build consensus, and which reflect specific regional and socio-economic priorities.
- Implement integrated education initiatives on the topic of food waste through collaborative efforts between the nonprofit and for profit sectors to assist major stakeholders (e.g., educators, school boards, municipalities) in identifying the best strategies for policy implementation.

Area of Consensus 2

The development and gradual introduction of novel crops (e.g., perennial crops) that promise to improve overall agricultural stability are necessary for long-term food security, not only with respect to human consumption and general wellbeing, but also to improve ecosystem health and soil integrity.

Actionable Next Steps

- Identify and convene a consortium of funding entities to review promising research results and assess the potential benefits of novel crops as part of their grants-in-aid programs focused on the integrated support for research, development, and commercialization.
- Establish a universal method of calculating nutritional and ecological

benefits and risks in order to compare and contrast crops and cropping systems as part of the decision-making process for resource allocations.

- Implement initiatives (e.g., public education campaigns, extension services) focused on key community members (e.g., farmers, students) to better inform them about novel crops and agricultural practices appropriate to their particular regions and communities.
- Increase accessibility of educational resources on novel crops (e.g., perennials), and ensure that these resources are translated appropriately across various groups by taking into account demographic influences (e.g., culture, religion, age).

Area of Consensus 3

A multitiered, transparent, and accessible governance system streamlining both new and existing regulations concerning genetically engineered (GE) animal and crop products is essential to shift the current process-based evaluations toward product-based, risk/benefit assessments.

Actionable Next Steps

- Establish an egalitarian process using a panel of independent experts to assess the benefits (e.g., sustainability, increased nutritional value) and risks (e.g., allergens, loss of biodiversity) of GE animal and crop products.
- Launch an unbiased, educational campaign to explain animal and crop products produced by various processes (e.g., conventional, genetically-modified) to aid demographically diverse consumers make informed food decisions based on scientifically credible information.

ISGP conference program

Friday, April 24th

09:30 – 10:45 **Registration**

09:45 – 11:00 *Brunch*

11:15 – 11:30 ***Welcoming Remarks***
Dr. George Atkinson, Institute on Science for Global Policy (ISGP), Founder and Executive Director,
and
Dr. Donald R. Eastman III, Eckerd College President

Presentations and Debates

11:30 – 13:00 **"Value Chain Efficiency and Sustainable Production: The Role of Uncommon Collaboration"**
Ms. Rachel Goldstein, Global Sustainability Manager, Scientific and Regulatory Affairs, Mars, Inc.
Moderated by George Atkinson

13:00 – 13:30 *Break*

13:30 – 15:00 **"Perennial Crops are a Key to Sustainably Productive Agriculture"**
Dr. Lee R. DeHaan, Plant Geneticist, The Land Institute
Moderated by Aubrey Paris

15:00 – 15:30 *Break*

15:30 – 17:00 **"Regulatory Oversight of New Plant and Animal Varieties in the United States"**
Dr. Alison Van Eenennaam, Biotechnology Specialist, University of California, Davis
Moderated by Sweta Chakraborty

Saturday, April 25th

08:00 *Breakfast*

Caucuses

08:30 – 12:00 **Focused group sessions**

12:00 – 14:00 *Lunch and Campus Tours*

14:00 – 17:00	**Plenary Caucus Session** Dr. George Atkinson, *moderator*
17:00	**Closing Remarks** Dr. George Atkinson

Value Chain Efficiency and Sustainable Production: The Role of Uncommon Collaboration**

Rachel Goldstein, M.B.A.
Global Sustainability Manager, Scientific and Regulatory Affairs, Mars, Inc.
McLean, Virginia, U.S.

Summary

The Food and Agricultural Organization of the United Nations (FAO) estimates that by the year 2050, agricultural productivity will need to double to support a population projected to reach 9 billion. FAO defines food security as "*exist[ing] when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life*." Food-related risks facing business and society worldwide are complex. Addressing these global issues requires that business, government, academia, and civil society work together to develop strategies to (i) increase agricultural productivity, (ii) reduce food waste throughout the range of activities that bring products to customers and (iii) improve food safety practices throughout the food value chain.

In 2013, the Institute of the Environment at the University of Minnesota found that the current yields of maize, rice, wheat, and soybean are increasing at rates that are less than the rate needed to double global production by 2050. Although production shortfalls could be met by expanding croplands, that option comes with a high environmental cost to biodiversity and carbon emissions. Decreasing food waste and increasing food safety are critical actions to maximize availability of food within our existing system, while reducing the environmental impacts on the resources and infrastructure.

Current realities

Agricultural productivity will need to be more efficient before it becomes capable of feeding a growing global population. Demand for food is increasing as populations grow and wealth increases, creating an appetite for more varied and resource-intensive diets. There is increased competition for land and water as well as for the energy, labor, and capital required for growing, manufacturing, packaging, storing, transporting, and preparing an estimated 4 billion tons of food

for the world's 7 billion people. Climate change adds to the agricultural challenges, particularly in developing countries where many current farming practices damage the environment and are a major source of greenhouse gases (GHG).

Given the current situation, many stakeholders have issued a call to increase food production from existing farmland in ways that place far less pressure on the environment and that do not undermine our capacity to continue producing food in the future. This "sustainable intensification" (SI) approach is a policy goal for a number of national and international institutions. SI should be seen as part of a multipronged strategy to achieve sustainable food security rather than an all-encompassing solution.

A major untapped opportunity to increase food availability is the reduction of food waste. The FAO estimated that in 2011 roughly 33% of all food produced ended up as waste, although some estimates put that figure as high as 50% or up to 2 billion tons per year. This represents a massive set of inefficiencies for all stakeholders along the value chain in terms of water, energy, land use, and wasted calories, as noted by the World Economic Forum.

In the developing world, losses are mainly attributable to the absence of food-chain infrastructure and lack of knowledge or investment in storage technologies on farms, although data are scarce. For example, in India it is estimated that 35% to 40% of fresh produce is lost because neither wholesale nor retail outlets have cold storage. Even with rice grain, which can be stored more readily, as much as one-third of the harvest in Southeast Asia can be lost to pests and spoilage. By contrast, in more-affluent countries, most food-chain losses are seen at the retail, food service, and consumer stages. In-store food losses in the U.S. totaled an estimated 43 billion pounds in 2008, according to the Natural Resources Defense Council, equivalent to 10% of the total food supply at the retail level and thus represent an area to improve efficiency.

Food waste in the supply chain is also a result of unsafe food. There is overwhelming evidence that food safety is linked to food security and nutrition and there are food safety challenges in both developed and developing markets. For example, it is estimated that 25% of all staple food crops are contaminated by fungal toxins. Unsafe food cannot be deemed consumable and cannot be disseminated into supply chains. Food safety is one of the most significant and pervasive issues in sustainable development efforts. Current methods are proving insufficient to manage increasingly complex risks. The food industry must develop better mechanisms to understand, identify and manage these risks. Food safety and waste are interconnected issues that, if addressed concurrently and in an integrated fashion, will allow us to secure more food from our existing system.

Scientific opportunities and challenges

The private sector has the opportunity to play a pivotal role in raising standards in food security, food safety, and sustainability globally. To fully realize this role, business needs to view the value chain as a whole, not just focus on what is inside the four walls of its factories. Businesses need to fully understand their supply chains, work with suppliers and farmers to help recognize the issues, mitigate risk, and develop solutions collectively. Business needs to create transparency mechanisms and incentives that help it control risks and optimize food production.

Stakeholder collaboration is needed to leverage investment in areas such as food safety and plant science, generating knowledge in the precompetitive space that is open to all. No one entity can achieve these goals on its own. This research will help farmers plant crops that are healthier, more productive, and more resistant to threats, thus improving food security. While there have been increasing opportunities for multiple stakeholders to collaborate, there are still challenges to be overcome. For example, there is a lack of global, harmonized standards and regulations, making it difficult to realize the efficiencies that can increase the availability of food from the existing agricultural system. Additionally, many farmers do not have the resources (e.g. irrigation, fertilizer, machinery, crop protection, and soil conservation measures) to invest in improving their farm operations and infrastructure, creating a barrier to economic growth and development.

Policy issues

The World Resources Institute reports an amazing 24% of all food calories grown today are lost or wasted between the farm and the fork. Current efforts must not focus solely on sustainable production, but also include reducing food waste and improving food safety throughout the value chain to close the gap between food available today and food needed in 2050. The food industry uses millions of tons of raw agricultural materials and has a vested interest, as well as a responsibility, in being part of the solution. Often businesses have tools, capabilities and industry experience that can help mitigate and manage many of these issues. The following actions are needed to enable the private sector to fully realize its role in developing strategies to increase agricultural productivity, reduce food waste and improve food safety:

- Stakeholders must align on the risks food insecurity poses to global economies if left unattended. Industry must align on risks as threats to business that can only be addressed through uncommon collaborations that bring together wide-ranging expertise. Policymakers must create incentives and mechanisms to translate science into economic assessments

of risk and potential loss to business. Stakeholders must determine how to harmonize and leverage this economic data across supply chains, and business must mitigate risks and develop a balance between best practices, self-regulation and regulation to address these critical global issues.

- Industry can — and must — play a critical role in helping to test, understand, and mitigate global food safety risks. Industry has a huge opportunity to advance global food safety knowledge through technology and active collaboration to better understand microorganisms and how they behave in all parts of the value chain. With a bigger focus on processing large data sets sourced from different points of the value chain, industry can enable critical progress in global food safety and security by being transparent, sharing data, and sharing lessons learned about successful and unsuccessful practices.
- Investment into both research and technology-transfer platforms is a critical activity in service of increasing production. All crops need to be supported by research in the laboratory and practical, on-the-ground application so they can benefit from plant resilience, pest and disease control, and better agricultural practices The most effective ways to raise productivity on farms is to show best practices in action, creating an iterative feedback loop throughout the various agricultural systems, and giving farmers the skills and tools they need to apply it on their own farms by utilizing extension services where they exist, and developing them where they don't.
- Innovation in packaging design is a critical strategy to reduce food waste without creating new sources of waste through discarded or non-recycled packaging. While there are legitimate concerns regarding over-packaging food, appropriate amounts of packaging can act to significantly reduce food waste and the associated environmental impacts by protecting food from damage, extending shelf life, etc. Innovation has been seen in frozen and ambient categories in the form of more effective, re-closable packaging.

References

Garnett, T. et al., (2013). Sustainable Intensification in Agriculture: Premises and Policies. *Science,* VOL 341; 33-34.

Godfray, Charles J. et al., (2010). Food Security: The Challenge of Feeding 9 Billion People. *Science.* VOL 327; 812-818.

WRAP, 2015, Banbury, Strategies to achieve economic and environmental gains by reducing food waste

*** A policy position paper prepared for presentation at the conference on Food Security: Focus on Production and Sustainability, convened by the Institute on Science for Global Policy (ISGP), April 24–25, 2015, at Eckerd College in St. Petersburg, Florida, U.S.*

Debate Summary

The following summary is based on notes recorded by the ISGP staff during the 90-minute not-for-attribution debate of the policy position paper prepared by Ms. Goldstein (see above). Ms. Goldstein 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 Ms. Goldstein. Given the not-for-attribution format of the debate, the views comprising this summary do not necessarily represent the views of Ms. Goldstein, as evidenced by her policy position paper. 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

- Food waste, which occurs during production, processing, packaging, and in the home, needs to be effectively managed and significantly reduced to achieve global food security. Waste in more-affluent societies is often influenced by consumer opinion (e.g., rejection of blemished produce) and not by the quality or nutritional value of the food.
- The development of sustainable growing practices needs to be a priority for food companies as they endeavor to become economically sustainable, net-zero-waste entities. Current research in sustainable food production includes (but is not limited to) growing practices, packaging, and waste diversion tactics.
- Because food safety, quality, and sustainability regulations are not standardized globally and their enforcement is variable, regulations and enforcement both need to be more uniform to facilitate the creation of

partnerships between large companies and growers in less affluent regions that underpin streamlined, efficient trade.

- With the need for more food to feed a growing population and an increasing global demand for diversified food options, the nutritional quality of food sources needs to become a primary criterion in food production, marketing, and consumption. The nutritional value of the processed food products identified as major components of the food supply chain used to address anticipated food instability in the 21st century.

Current realities

Global population growth increases the demand for not only food, but also more varied food sources, including resource-intensive foods such as meat and dairy. Certain types of protein and calories require more energy and resources during production and distribution than others and food sources differ in the level of nourishment provided to the consumer. Individuals in more-affluent nations create a demand for more resource-intensive foods, which causes individuals in less-affluent nations to emulate their more-affluent counterparts.

The demand for more diverse food supplies requires that food be imported, as geographic regions only support the growth of certain crops varieties. Large companies import these products from growers (often small-scale), causing many producers in less-affluent nations to grow food for export rather than the food required for their own consumption. Climate change is affecting the ability of large companies to outsource many commodity products, because alterations in temperature and precipitation patterns change the ability of growers to produce foods that demand a specific climate.

Due to the globalized nature of the food system, regulatory standards for food imports, exports, and quality are designated by a variety of organizations (e.g., FAO and the World Health Organization [WHO] collaborate on the Codex Alimentarius), and some private companies also maintain their own standards. The processing and transport period in the food supply chain provides an opportunity for food to be exposed to contaminants and if one purchaser rejects a shipment it likely will be accepted by another, because of regulatory inconsistencies. Current data fails to indicate whether the majority of contaminated foods come from within a country or from imports. Regardless, it was emphasized that food safety cannot be considered a competitive advantage because all related companies experience a negative impact if a food safety mishap stigmatizes the entire industry.

Intercompany or corporate-academia partnerships are facilitating research into environmental sustainability, which is one of the greatest challenges faced by

modern food companies. Research is ongoing regarding increasing crop yields on existing land, which decreases deforestation threats and improves the livelihoods of suppliers. Other research areas include developing ways to decrease water usage and generate less methane or nitrogen dioxide during food production. It was mentioned that growing practices such as monocultures impact environmental sustainability, so perhaps alternative methods such as intercropping needs to be more widely explored.

The adoption of sustainable business practices can be influenced by consumers, since food security and sustainability impact the quality, type, and cost of food to which consumers have access. Social (e.g., human rights) and environmental issues may impact the purchaser's decisions, also. For example after a particular grocery store in England labeled products that were received by ship versus airplane, the data suggested that consumers changed their purchasing habits to more frequently select ship-transported foods, which have a smaller environmental impact than airplane-transported counterparts.

The sources of food waste vary, but misinterpretations of "use by," "sell by," and "best by" dates are a leading cause of waste in the consumer sphere. In addition, because food is relatively inexpensive to produce, it is economically advantageous for food producers and processors to dismiss products as waste if consumers are unlikely to accept them. For instance, consumers rarely select produce that is blemished, oddly shaped, or small in size. Thus, even though these products are nutritious and safe to eat, they end up being discarded in cull piles. Corporate entities are partially responsible for the extreme selectivity exhibited by consumers, as advertisements and marketing campaigns give consumers a "perfect product" model that is based on appearance.

Within the industrial sector, companies that primarily create shelf-stable products generate most of their waste when perishable items require refrigeration. Companies seeking to meet zero-waste standards divert their waste to other uses (e.g., compost, animal feed). The pet food industry currently uses many food products that are not deemed suitable for human consumption due to blemishes or other minor faults. Currently, inefficiencies within the food system are being examined by organizations such as the Food Waste Reduction Alliance, a consortium comprising the Grocers Manufacturers Association, Food Marketing Institute, and American Restaurant Association. These groups also examine how dates printed on packages affect purchasing and decides how wasted food can be repurposed.

Scientific opportunities and challenges

Current crop research has the potential to improve food security and provide options

for enhanced sustainability in food production. For example, commodity crops such as cocoa and peanuts can be designed to exhibit resilience to climate change, pests, and contamination by disease-causing agents (e.g., aflatoxins from fungi). It was argued, however, that if growing techniques are modified to improve the health of plants and soils (e.g., limiting the use of monoculture, using fewer chemicals) there will be less need to alter plants genetically because healthy plants are better able to resist pests. It was agreed that suppliers will be more likely to grow crops using sustainable techniques if companies come together and demand a change in practice.

A critical challenge in food safety and security is ensuring that food is nutritious. Processed foods may offer a potential solution to the food security challenge due to high availability and minimal storage requirements, but more nutritionally complete varieties would have to be developed. Initial steps in addressing this challenge might involve food companies limiting serving sizes, reducing sodium content, and eliminating trans fats from their products. Packaging improvements also have the opportunity to help maintain the nutritional content and safety of processed foods.

Regarding improvements in product packaging, it is challenging to strike a balance between saving food from becoming waste and wasting other resources for more effective packaging. As a result, it is necessary to develop practices that minimize packing waste but allow for recyclability and minimal use of resources. Reducing food waste upstream in the system might also provide one of the most significant opportunities for reductions in greenhouse gas emissions. It was suggested that the Food Safety Modernization Act (FSMA) might be able to impact food waste and sustainability in general, but it was recognized that FSMA primarily pertains to U.S. food sources and not the wide variety of imported products that Americans consume. In fact, increases in regulation mandated by FSMA might temporarily increase food waste because of improved detection practices, a possibility that would be beneficial for food safety but detrimental for sustainability.

An opportunity exists to address food waste at the consumer level, especially if food sellers create a market for blemished products. This would require that the public accept food products that may look different than what they are accustomed to buying. Sellers could also decrease waste in their facilities by educating their customers about the true meanings of "sell by," "use by," and "best by" dates.

While it is difficult to maintain compliance with the regulations of all nations involved in the growth and distribution of a particular product, this challenge needs to be overcome to outsource commodity foods. In addition, it is important that production information and technologies be explained in culturally appropriate ways that respect traditional growing practices and priority differences. Partnerships between client companies and local individuals and can result in net benefits, such

as improvements in the techniques, yields, and livelihoods of remote growers. Information regarding food sourcing and certifications (e.g., sustainability or human rights) could be conveyed to consumers by individual companies using digital media (e.g., QR codes).

As regulations are developed and certifications established, enforcement of these standards is challenging, especially when considering commitments on a company-by-company basis. An opportunity has therefore arisen for third-party groups (e.g., Greenpeace, Rainforest Alliance) to monitor and report whether companies are honoring personal and regulatory commitments. These groups might improve trust in the food system by facilitating information sharing between companies and the public.

The accountability of food producers could be enhanced through popular media that distributes information regarding company sustainability, or lack thereof For example, Global Forest Watch allows the public to witness deforestation in real-time while overlaying the identity of the company that owns the land. If based on credible information, popular and social media reports hold potential for improving public awareness and allowing consumers to make educated decisions.

Policy issues

Individual food products and dietary guidelines need to encourage consumers to voluntarily adopt a more environmentally sustainable diet. Consumer-based reductions in food waste could be incentivized by a variety of strategies with the goal of inducing a change in perspective. For example, the absence of trays in cafeterias discourages individuals from taking food that they might not eat; restaurants charging customers for not finishing their food could have a similar effect.

Governments need to offer support for infrastructural developments on farms to reduce the amount of waste occurring during production. Concurrently, food production and processing companies have a responsibility to examine their product portfolio and develop ways to decrease the environmental impact of generating those products. Companies need to be penalized for creating large quantities of food waste, including cases in which unsafe foods result in the widespread product recalls. Use of more effective food safety testing metrics can be incentivized to prevent food-related disease outbreaks resulting in food waste. It was noted, however, that development of more stringent and thorough tests is challenging because it is not always possible to predict future causes of contamination.

It was suggested that environmental sustainability labels be implemented on products in an attempt to indicate how much water, energy, and transport distance is required to bring a product to market. Displaying positive sustainability labels

could become a marketing strategy for companies. It was recognized, however, that the current labeling system for products is complex and confusing, as both corporate and third-party (e.g., Rainforest Alliance, Fair Trade) labels exist to indicate different measures of sustainability. This would reduce the efficacy of adding centrally regulated sustainability labels to products.

Taxation (e.g., value-added or carbon-usage taxes) may be more effective than caps or limits in reducing the amount of carbon used or generated by companies, including the food industry. Establishment of such taxes would require careful planning, however, to ensure that they do not become regressive. It was suggested that companies can develop collaborations to address sustainability concerns, though competition between like-minded companies might prevent the efficacy of this approach. It was argued, however, that competition would not be a significant barrier to improving sustainable practices because component products are often the same across companies. It is not until a component product is altered or processed by a company that it becomes unique (e.g., imported cocoa is nearly the same for Mars, Nestlé, and Hershey's, and it does not truly reflect its trademark until it is manipulated in-house).

Local sustainability priorities often need to be addressed before global concerns. Important priorities for local consideration include impacts on water and land. Prioritizing how to address issues of sustainability requires that a hierarchy of environmental concerns be delineated because different products impact the environment in different ways. Soybeans, for instance, are a greenhouse gas-intensive crop, whereas other crops are water-intensive. Greenhouse gas generation is a global issue and might therefore be deemed a high priority, but if lessening greenhouse gas emissions comes at a cost to water in a production areas where water is scarce, then local water concerns must be prioritized.

Overall, diverse enforcement and regulatory standards result in varying levels of control for food safety and sustainability in different markets. Though global regulatory standards for food trade exist, they need to be re-assessed on a regular basis to continue reflecting changes in the international food system. Partnerships between large corporations and growers in remote regions offer many potential benefits but require the establishment of strict import quality control standards. Governments need to establish these regulatory standards transparently, providing opportunity for industry and public comment.

Perennial Crops Are a Key to Sustainably Productive Agriculture**

Lee R. DeHaan, Ph.D.
Plant Geneticist, The Land Institute, Salina, Kansas, U.S.

Summary

Agricultural production of grain is central to the global food supply, and grain fields dominate vast regions of the landscape. Despite improvements, grain production still results in soil erosion and loss of nutrients into ground and surface water where they become pollutants. Replacing annual grain crops with perennial plants (which live for several years without replanting) has potential to remedy most of the limitations to sustainability seen in grain cropping systems, while expanding productivity. Currently, policy supports the development of perennial crops, such as switchgrass, that would be dedicated to biofuel production. Such perennial biofuels could protect soil and water, but may have unintended consequences as they compete for land on which to grow food. A better solution is to develop perennial crops that produce food for human consumption, with residues available for biofuel. To enable widespread success of perennial crops and insure their sustainability benefits, agricultural policy should begin by moving away from support of particular commodities (e.g., corn, soybeans, wheat) and instead pay producers for providing ecosystem services, including clean water, carbon sequestration, and wildlife habitat. Government mandates for biofuels should be phased out. Instead, resources should be dedicated to sustained efforts to develop new perennial crops that can primarily produce human-edible food, and secondarily provide residue that is usable as biofuel or livestock feed.

Current realities

More than 75% of human food calories come from grains, and increases in grain production have enabled a population explosion over the past century. However, the grain systems that now dominate vast regions of the globe generate serious sustainability concerns both on and off the farm. Soil erosion is moderate to severe on 80% of the world's agricultural lands, causing an estimated 10 million hectares to be abandoned every year. As soil quality declines, wild lands are brought into cultivation to maintain an adequate food supply. Fertilizers such as nitrogen and

phosphorus run off agricultural lands into ground or surface waters where they become contaminants. Lost fertilizers have an economic cost to farmers, and once in waters they damage wildlife populations and can render water unfit for drinking without expensive treatment. Due to rising population and increasing affluence, global demand for grain in 2050 is expected to be more than double that of 2005. To meet this demand without increased environmental costs, ecological intensification has been proposed. In ecological intensification, ecological principles are invoked to enable greater productivity while protecting soil and preventing off-site impacts. Perennial crops that live for several years will be central to achieving ecological intensification worldwide, since they use more of available sunlight and water to produce greater potential yield, while simultaneously building and protecting soil.

Biofuels have been developed to improve sustainability of energy production, but all of the current technologies and approaches have associated sustainability concerns. Current projects to develop agricultural biofuels fall into three main categories. 1. Grain from annual crops can be made into liquid biofuels. This system has been supported by policy, which has resulted in production of biofuels with poor energy return, no benefit to climate change mitigation, increased soil degradation, higher food cost as food is turned to fuel, and expanded use of nonrenewable resources, such as water stored in nonrecharging aquifers. 2. Crop residues left after harvesting grain could be used as fuels. Residue systems have sustainability concerns similar to or worse than conventional annual grain systems. Residue fuels avoid using human-edible food as fuel, but if a substantial portion of the residue is removed, severe soil degradation can occur. 3. Dedicated perennial biofuels such as grasses or trees could improve soil quality, sequester carbon, and provide ecosystem services such as clean water and wildlife habitat. However, dedicating land to perennial biofuels will compete for land to grow food. As additional lands are tilled for food crops, the result is predicted to be a counterintuitive increase in greenhouse gas emissions.

Crop breeding, historically a mostly public enterprise, is a mature methodology that has primarily moved into the private sector. For existing grain crops, private-sector breeding has provided consistently improved varieties for agriculture in industrialized countries. However, private plant breeding companies are unable to tackle long-term, higher-risk projects of developing completely new crops. Some governments, both state and federal, as well as foundations, are beginning to realize the potential in funding plant breeding to develop new crops with the ability to enhance sustainability for farmers, communities, and ecosystems. Among these new crops are nut trees and shrubs (e.g., hazelnuts), winter-annual grain crops to plant when soil is normally bare (e.g., pennycress), and new perennial grain crops that would yield grain while covering the land year-around (e.g., perennial wheat).

Scientific opportunities and challenges

Recent advances in genetics and plant breeding have made possible the development of new crops, largely herbaceous perennials (e.g., perennial rice, perennial wheat, perennial sorghum), which are capable of providing direct food for humans in the form of grain. These new crops, the first of which is just entering commercial production, are expected to enhance ecosystem services such as carbon sequestration, clean water, soil quality improvement, and wildlife habitat. By using resources more fully and providing a source of sustainable biofuel by-products, these systems are projected to increase productivity of agroecosystems. Although dedicated biofuel crops may compete with food crops for arable land, the residue from perennial grains would be harvestable for sustainable co-production of food and fuel. Furthermore, the aboveground growth can be annually removed from many perennial crops without risking erosion.

One approach used to develop perennial grain crops is *de novo* domestication. Using modern breeding and genetic techniques, we now anticipate the transformation of crops from wild species to useful crops in decades, rather than the centuries it previously took. Domestication projects face the challenges of wild traits such as seed shedding, seed toxicity, small seed size, dormant seed, and difficulty in threshing. These are traits that were overcome in ancient domestication. Now, we can use comparative genomic techniques to assist in the domestication of perennial species that are related, even distantly, to our current annual crops. For instance, new techniques such as TILLING (i.e., induced mutations followed by genomic testing for desired genetic changes) and genome editing can be used to identify or create the gene forms required to accomplish domestication.

Wide hybridization is another major approach that can be used to create perennial grains. In this case, current grain crops are crossed to their wild relatives that are perennials, with the goal of combining perenniality with the domesticated growth form of the crop. In wide hybridization, overcoming sterility can be a major challenge. Combining the desirable traits from the crop and the perennial parent while eliminating the undesirable traits can also be difficult. Basic research is now studying the genetics of perenniality, which is expected to have substantial benefit to perennial grain breeding.

Sustaining seed yield of herbaceous perennials for several years is a challenge for perennial grain production. Although perennials that require rotating to a new crop every three to five years can still have substantial sustainability benefits, extending the productive lifespan of perennials can provide economic benefits and enhanced sustainability. In the short term, low-input management techniques to sustain yield are needed. Planting density, grazing, biomass removal, nutrient

management, intercropping, and thinning techniques are being studied to determine their potential to sustain yield. In the longer term, plant breeding should be effective in developing crop varieties with sustained yield that do not require special management.

Policy issues

- Agricultural policy must move away from support for particular commodities (e.g. corn, soybeans, wheat), and toward payment for ecosystem services from working agricultural lands. The strong correlation between perennial cover and reduced nutrient runoff or leaching, improved wildlife habitat, and reduced erosion could be used to structure support for agricultural lands providing increased ecosystem services.
- Government mandates and research support for biofuel crops must move toward perennial species capable of producing human food plus biofuel residues. New and current biofuels should be evaluated on their potential to produce a positive energy balance without depleting natural resources, increasing net greenhouse gas emissions, or reducing global production of human-edible food.
- Funders of agricultural research at all levels (international, federal, and state) need to commit to the development of new crops that can provide enhanced ecosystem services and sustainable yields of human-edible foods. These new crops may come in the form of short-season grains that can be grown when land is usually left bare or perennial grains and woody crops that live for several years or more. Breeding and agroecology programs to develop these new crops will require sustained funding for more than a decade.
- In Florida, agricultural policy needs to support the expansion of rotations that include perennials, such as the sod-based crop rotations that David Wright at the University of Florida has found to be more profitable than continuous annual crop rotations. Subsidies could be redirected from specific cash crops toward payments for sustainable practices, loans or grants to support the purchase of grazing livestock infrastructure, and support for demonstration projects that will help producers to learn about perennial rotations.

References

Glover, J. D., et al. (2010). Increased food and ecosystem security via perennial grains. *Science*, *328*(5986), 1638-1639.

Minnesota Pollution Control Agency. (2013). Nitrogen in Minnesota surface waters: Conditions, trends, sources, and reductions. Available online at: www.pca.state.mn.us/6fwc9hw.

Searchinger, T. & Heimlich, R. (2015). Avoiding bioenergy competition for food crops and land. Working Paper, Installment 9 of Creating a Sustainable Food Future. Washington, DC: World Resources Institute. Available online at http://www.worldresourcesreport.org.

*. ** A policy position paper prepared for presentation at the conference on Food Security: Focus on Production and Sustainability, convened by the Institute on Science for Global Policy (ISGP), April 24–25, 2015, at Eckerd College in St. Petersburg, Florida, U.S.*

Debate Summary

The following summary is based on notes recorded by the ISGP staff during the 90-minute not-for-attribution debate of the policy position paper prepared by Dr. Lee DeHaan (see above). Dr. DeHaan 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. DeHaan. Given the not-for-attribution format of the debate, the views comprising this summary do not necessarily represent the views of Dr. DeHaan, as evidenced by his policy position paper. 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 improve food security and ecological sustainability, the production and consumption of perennial crops, including fruits and nuts but especially grains, needs to be expanded. Perennial crops have many advantageous agricultural characteristics compared with annual crops, such as multiple harvests per year, decreased soil degradation and erosion, fewer required resource inputs, and improved resilience to extreme weather conditions.

- While they have shown much promise and have gained support from some large private companies and early adopter farmers, perennial crops require further development to improve yields, optimize harvesting practices, and incorporate them more effectively into the agricultural system. Public sector support for perennial crop development and seed distribution is critical to such expansion.
- Rather than subsidizing particular commodities, or related industries, in an attempt to foster environmental stewardship, policymakers and regulatory agencies need to create a system that prioritizes and incentivizes crops that efficiently produce food while measurably enhancing a sustainable environment (e.g., improving soil health).

Current realities

In the United States, people derive more than 70% of calories from annual grain crops, and nearly 75% of U.S. land is devoted to annual grain crops. There was agreement that heavy agricultural reliance on annual crops is resulting in widespread soil degradation and erosion due to the repeated planting and harvesting. In addition, reliance on annual crops threatens food security: Often, annuals are not viable in drought conditions, which are becoming more prevalent in the U.S. It was noted that a combination of drought and poor soil conservation were conditions that lead to the "Dust Bowl" of the 1930s. Sole reliance on annual crops can create significant issues for U.S. and global agricultural practices.

Perennials provide a viable crop choice for combating climate change effects on future food production. It was argued that perennial fruits, nuts and grasses offer some advantages over traditional annual crops. Newly developed perennial grasses like intermediate wheat grow faster and do not require complicated harvesting techniques beyond what's already required for annual wheat production. The entire above-ground portion of intermediate wheat is harvested, but the roots (the majority of the biomass) are retained and enhance soil quality. The fact that harvesting keeps their root systems intact means that perennial crops can help mitigate soil erosion and nutrient loss, especially during droughts and extreme weather conditions. Perennial crops are often adept at withstanding climate stresses, allowing them to better survive harsh weather fluctuations. For example, perennial rice, currently being developed in China, produces higher yields in drier regions and under drier temperature conditions than annual rice varieties.

A significant percentage of annual grain crops in the U.S are currently produced for biofuels. This practice was described as cost ineffective because it requires as much energy input to produce as the energy output of the final product, and as

ecologically detrimental. For example, most of the corn grown in Western Kansas is used for ethanol rather than food. It was suggested that this is not a productive use of either the corn or the water because the groundwater pumped in that region comes from non-renewing aquifers. Once this water supply is exhausted, agriculture in that region no longer will be possible.

Most perennials currently used in agriculture are nuts and fruits, and it was suggested that production of these commodities needs to expand in the food system. However, it was noted that tree-based crops are typically underutilized because it takes several years before trees can be harvested, and the harvesting process itself can be difficult.

Many perennial crops are still in development, and therefore there is a general lack of information available for farmers and the public on the topic. Novel perennial crops such as intermediate wheat require further testing and are not yet commercially available, although some early-adopter farmers have partnered with the developers and the company, Patagonia Provisions, to accelerate perennial optimization.

Several downsides to perennial crops were highlighted. Perennial crops yields decrease each time they reproduce and reproduction tends to stop when stressed by conditions such as drought. Perennial seeds are anticipated to cost more than annuals and the economic costs of perennial production are not yet clear. However, developers anticipate that net costs will be lower than those for annual wheat production.

Although many annual crops have perennial relatives, the breeding of perennial traits into annual legumes is very difficult, and in some cases not feasible. Furthermore, annual vegetable production does not cause the same wide-scale landscape and soil degradation as annual grain production. For these reasons, there is not a high demand to create perennial vegetable crops.

Scientific opportunities and challenges

Perennial grain crops have several hurdles to cross before becoming a widespread viable choice. Encouraging food producers and consumers to embrace perennial varieties is a potentially significant hurdle, but it was argued that these market shifts could be achievable.

Shifting to perennial grain crops has challenges. Certain perennial crops cannot be grown in climates and regions where annuals are currently being grown. For example, the relatively constant temperature of Florida, and the lack of a cold winter, does not provide the seasonal cues required for perennial flowering. Further research would be needed to develop varieties of perennials that use different cues than temperature fluctuations. Perennial sorghum was proposed as a solution to

this problem because it originates from the perpetually warm regions of Africa. Another challenge is the possibility that perennial crops will yield less with each subsequent harvest.

Learning to grow new crops is an inherent challenge for farmers, but that shift could be relatively easy and ultimately yield positive returns. Perennial crops are anticipated to require fewer resource inputs. They can be left in the field for several years and still produce seeds and fruit, translating to potentially reduced costs and fewer repeated cultivations. Their strong root structure prevents other plants from growing in the surrounding soil, acting as a form of natural weed control and easing the harvesting process. It was noted that best practices for perennial harvesting are still being established, and opportunities exist for the development of educational outreach systems and programs for novel perennial crops.

Shifting to perennial grains could present minimal disruption to consumers because crops such as wheat, rice, and sorghum already exist in annual form. Although consumers would be introduced to more crop varieties, there would be nothing that had not been seen before in their food markets. Furthermore, it was generally agreed that while perennial crops would be integrated into the current food system, annual crops would not be fully replaced.

While opportunities exist to expand fruit and nut production, significant potential also exists in the development of perennial grasses for seed production. The economic cost/benefits of intermediate wheat grass and switch grass compared to corn is currently under study. One key challenge is increasing the yields of intermediate wheat grass. The major developmental milestone that needs to be achieved before there can be an economic incentive for farmers is breeding a perennial crop that can yield 1,000 pounds of harvest per acre.

Although the debate mostly focused on the U.S., it was mentioned that perennial crops are also currently being developed internationally. Perennial sorghum is being developed in Africa, with a new trial initiated in 2014. Work on a perennial rice strain is being performed in China, where the perennial rice crops typically produce two to three harvests per year and the perennial version outproduces the annual crop in dry seasons.

Researchers have gained considerable knowledge of the nutrient and allergen contents of perennial wheat grass, but little is known about other perennial varieties such as rice and sorghum. While the amino acid content of perennial wheat is almost identical to annual wheat, the vitamin and mineral profiles are distinct. Further research and development needs to be conducted on the fortification of perennial crops, as an incorporation of perennial crops into the U.S. population diet would

likely cause a decrease in consumption of dietary nutrients from fortified annual grain crops.

Although perennials are more adept than annuals at surviving temporary environmental stressors, they often do so with a reduction in seed production, unlike annuals that can produce a higher number of seeds before succumbing to the stressor. This means that in drought years, food production is likely to decrease for perennial crops. Researchers are meeting this challenge by utilizing breeding approaches to establish perennial crops strains that continue to produce seeds under stress.

Both challenges and opportunities exist in developing perennial crops through genetic modification. It was generally agreed that genetically engineering a perennial crop would be a fast, safe, and effective way to create plants that traditionally take years to cultivate. However, there are currently no validated ways to efficiently incorporate perennial genes into a crop. The breeding of new traits in perennials is difficult to ascertain. Tracking the incorporation of specific perennial genes with molecular markers is not yet practical, as the desired genes are often involved in many different functions within the plant. Furthermore, the concern was raised that farmers utilizing genetically engineered perennial crops run the risk of being economically beholden to the companies that engineered the plants.

Policy issues

It was generally agreed that current policies regarding annual crops need to be restructured to include perennial crops.

Additionally, regulatory incentives and subsidy focus should shift towards crops that offer both human food and better environmental protection.

It was generally agreed the public sector needs to support perennial food crop development, particularly perennial grain crops, and initiate their production. The Forever Green Initiative in Minnesota could serve as an exemplar model for such public policy support. With a concerted effort to advance their development, perennial grain crop yields could match that of annuals, making their adoption an important response to future food supply needs and changing climate.

Private-sector groups that research carbon sequestration, soil health, etc. (e.g., Applied Ecological Services), need to be consulted in creating a new governmental subsidy system which measures and promotes environmental benefits of various agricultural practices. In some cases, the development of qualitative proxies for ecosystem benefit, rather than quantitative measurements, might be needed. Instead of subsidizing specific commodities such as biofuels, subsidies need be shifted to promote crops that have a positive environmental impact. Crops that yield food and support clean water, healthy soil, wildlife preservation, etc., need to be given priority.

Rather than encouraging farmers to create uncultivated land "buffers" around waterways that prevent soil erosion and water contamination, states need to encourage farmers to plant perennial crop barriers that protect both waterways and produce food.

At the state level, agronomy departments (which are responsible for developing new crops) and pollution control agencies need to seek to enhance communications and pursue opportunities for joint efforts. Such mutually beneficial collaborations could form the basis of a strong coalition to persuade the public and policymakers to embrace the utilization of perennial crops.

Also, each state's Crop Improvement Association, which is a system currently in place to distribute seeds to farmers, could act as the means of perennial seed production and distribution. This system links intellectual property rights to the university where seeds are developed, therefore a portion of the sales are re-invested into the R&D system.

Regulatory Oversight of New Plant and Animal Varieties in the United States**

Alison Van Eenennaam, Ph.D.
Biotechnology Specialist, University of California, Davis,
Davis, California, U.S.

Summary

Genetically modified, or, more correctly, genetically engineered (GE) plants and animals have and will continue to contribute to food production and sustainability in the future. The current regulatory system for the products of this breeding method is lengthy and prohibitively expensive for all but large, multinational corporations. This level of regulatory scrutiny is often not supported by the risk posed by these products, and is prohibiting the commercialization of many public sector applications of this technology. No unique risks have been associated with the use of GE over the past 20 years. Regulatory effort must be proportional to risk posed by the product being evaluated. Currently, identical products produced using different breeding methods are subject to vastly different levels of regulatory scrutiny. The current process-based trigger for regulatory evaluation of GE plants and animals is disincentivizing the development of beneficial GE applications to the detriment of global food security and agricultural sustainability. It is time to refocus regulatory evaluations on the risks and benefits posed by novel traits in new varieties of crops and animals, irrespective of the breeding method that was used to introduce those traits.

Current realities

Regulatory systems provide one way for society to find a balance among the potential benefits, risks, and concerns associated with new technologies. The United States "Coordinated Framework for the Regulation of Biotechnology," promulgated in the 1980s, is technically agnostic towards the technology or process under review. According to the Office of Science and Technology Policy (OSTP), "Exercise of oversight in the scope of discretion afforded by statute should be based on the risk posed by the introduction and should not turn on the fact that an organism has been modified by a particular process or technique … (O)versight will be exercised only where the risk posed by the introduction is unreasonable, that is, when the value of the reduction in risk obtained by additional oversight is greater than the cost thereby

imposed (1992)." This suggests that the U.S. only exercises regulatory authority over organisms — plant or animal — based on the risks they pose. This is irrespective of the breeding technique used to produce them, and used only when the risk posed is unreasonable, which is clarified to mean the cost of regulatory oversight is not greater than the reduction in risk obtained by that oversight.

In practice, this is not what happens. The United States Department of Agriculture (USDA) regulatory process for GE plants is triggered by the dependence of any genetic modification upon a plant pest or potential to become a plant pest. The dependence of older GE techniques on pest- and virus-derived genetic components resulted in a *de facto* process-based regulatory regime of GE plants by the USDA's Animal and Plant Health Inspection Service. Likewise, the trigger for the U.S. Food and Drug Administration (FDA) regulation of GE animals is those animals modified by recombinant DNA (rDNA) techniques, including the entire lineage of animals that contain the modification. All GE animals are captured under these provisions, regardless of their intended use. Thus, although the regulatory evaluation is based on the product (the GE animal), the method used to produce the genetic change (i.e. rDNA versus other breeding methods) that results in the product is the trigger for regulatory oversight.

The cost of discovery, development, and authorization of a new trait introduced into a crop using GE between 2008 and 2012 was USD$136 million and took approximately 13 years from product concept to launch. On average, about 26% of those costs, USD$35.1 million, were incurred as part of the regulatory testing and global registration process (McDougall, 2011). The longest phase of product development is regulatory science and registration activities, approximately 5.5 years for traits introduced in 2011. Over the past 20 years, the FDA found all of the transgenic crop events (i.e., crop/unique gene-insertions) evaluated to be substantially equivalent to their conventional counterparts, as have regulators from other countries (Herman and Price, 2013).

No GE animals have yet been approved for food consumption anywhere in the world. The fast-growing AquAdvantage GE salmon, first developed in 1989, has been mired in regulatory limbo for years and the development and regulatory costs have exceeded $77 million. In contrast, there is no regulatory oversight of traits introduced using conventional breeding techniques, including fast-growing Atlantic salmon, produced using conventional breeding approaches. The *prohibitive cost* of achieving *regulatory* approval has limited the development of improved GE plant and animal varieties by public sector scientists and small companies. To date, only 5 of the 167 events (3%) that have been commercialized in the U.S. originate from research developed within the public sector. Breeders have instead chosen to

improve the majority of crops using unregulated techniques, which are often less precise and more time consuming. As a result, social and environmentally valuable technologies, as well as specialty (i.e.,non-commodity) crop projects, are noticeably absent from the market, with the exception of disease-resistant papaya.

The most profound implications of the high cost of regulation triggered by the use of GE in the development of new varieties include delays in the global diffusion of proven technologies, which has resulted in a lower rate of growth in the global food supply and higher food prices, and disincentives for investing in further research and development using GE as a breeding method. This has resulted in a slowdown in the development of new plant and animal varieties, some of which were anticipated to introduce broad consumer and environmental benefits such as nutritionally fortified crops, and disease-resistant plants and animals.

Scientific opportunities and challenges

There are a large number of publicly developed GE crops in the development pipeline, including disease-resistant and nutrient-fortified crops (Ricroch and Hénard-Damave, 2015). Examples include oranges resistant to citrus greening disease, blight-resistant chestnut trees, and a host of vitamin-fortified crops for the developing world. There are also many GE specialty crops (e.g. fungus-resistant strawberries), developed by public sector scientists who do not have the financial resources to go through the current process-based regulatory system. Additionally, a number of GE crops in development will likely fall outside of the scope of current regulations either by deliberate design (e.g., water-use efficient switchgrass produced using no plant pest-derived genetic components), or because of the development of new technologies for genetic manipulation, which involve precision editing of the genome (e.g., corn with reduced phytate expression developed using a nuclease to produce a targeted DNA deletion). These new breeding methods enable the creation of targeted base pair changes, and importantly there will often be no analytical way to differentiate genetic changes intentionally made using these new methods from those resulting from naturally occurring mutations.

If regulatory oversight should be exercised only when the risk posed by the introduction of a new variety is unreasonable as stated by the OSTP, there is no rationale for regulating varieties exhibiting a genetic trait produced using classical breeding techniques differently from those exhibiting the same trait produced using molecular techniques, if the risks are the same. Process-based regulatory oversight would seem to be justified if there is something inherently risky about the process (e.g., radiation mutagenesis) that results in unreasonable risks in

the resulting product. For example, if a technology were used to make a polled (hornless) Holstein dairy cow by editing the horned gene to exactly the same sequence as exists naturally in other breeds of cattle (e.g., polled Herefords), it is unclear why that polled animal should be subjected to a multimillion dollar regulatory review when an animal with exactly the same genotype and phenotype produced using crossbreeding and gene introgression would be subject to none. Likewise, it is difficult to envision how the food safety and environmental risks posed by the polled trait in the Holstein breed are different to those posed by the polled trait in the Hereford breed.

Policy issues

The current regulatory oversight of new varieties of plants and animals in the U.S. is neither science-based nor product-driven. It overregulates crops and technologies that have proven track records of safety, which precludes public sector breeders from access to traditional GE technology, and is likely to provide little regulatory oversight over varieties that have been developed using newer breeding methods. Nor does it consider the potential benefits associated with the new varieties. Consideration of risk and benefit tradeoffs would represent a shift away from a risk-assessment process that focuses only on risks, to one that addresses the probability of whether a balance of potential benefits associated with the new variety outweigh potential risks. It is time to refocus regulatory oversight of new varieties of plants and animals around their risk/benefit profiles as posed by novel trait(s), irrespective of the breeding technique used to produce them. According to existing policy, regulatory oversight should be triggered only when the risk posed by the novel attributes of the variety are unreasonable and the value of the reduction in risk obtained by such oversight is greater than the costs associated with regulation. Further, regulatory evaluations must consider not only risks, but also explicitly consider the potential benefits resulting from the novel trait(s).

Regulatory evaluation of new plant and animal varieties (USDA)

- Regulatory oversight of new plant and animal varieties must be triggered by unreasonable unique risks associated with the novel trait(s) in that species in relation to known risks associated with existing varieties
- Required regulatory studies must be hypothesis-driven based upon the novel attributes of the variety, and not the breeding method used to develop the new variety.

- Potential benefits resulting from the novel trait(s) must be explicitly identified to enable an evaluation of the risk-to-benefit ratio posed by the introduction of the new variety.

Safety evaluation of food produced from new plant and animal varieties (FDA)

- Novel foods made with any technology must be evaluated using a scientific, risk-based approach.
- Specific novel attributes of the food such as the presence of a completely new substance in the food supply, changes in a macronutrient, an increase in a natural toxicant, or the presence of novel allergens must be the trigger for comprehensive food safety evaluation.

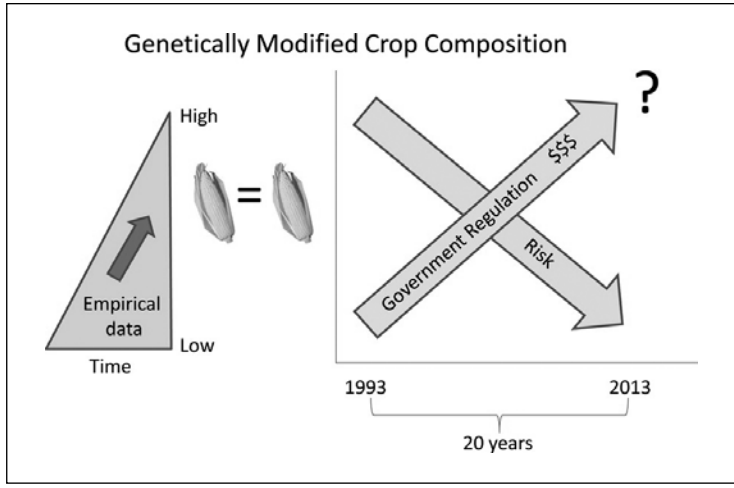
References

McDougall P. (2011). The cost and time involved in the discovery, development and authorisation of a new plant biotechnology derived trait. Consultancy Study for Crop Life International by P McDougall, Midlothian, UK

Herman RA, Price WD. (2013). Unintended compositional changes in genetically modified (GM) crops: 20 years of research. *J Agric Food Chem*. 4;61(48):11695-701.

Ricroch AE, Hénard-Damave MC. (2015). Next biotech plants: new traits, crops, developers and technologies for addressing global challenges. *Crit Rev Biotechnol*. 2:1-16.

. ** A policy position paper prepared for presentation at the conference on Food Security: Focus on Production and Sustainability, convened by the Institute on Science for Global Policy (ISGP), April 24–25, 2015, at Eckerd College in St. Petersburg, Florida, U.S.



Source: *Journal of Agricultural and Food Chemistry.* http://pubs.acs.org/doi/abs/10.1021/jf400135r

Debate Summary

The following summary is based on notes recorded by the ISGP staff during the 90-minute not-for-attribution debate of the policy position paper prepared by Dr. Van Eenennaam (see above). Dr. Van Eenennaam 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. Van Eenennaam. Given the not-for-attribution format of the debate, the views comprising this summary do not necessarily represent the views of Dr. Van Eenennaam, as evidenced by her policy position paper. 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, GE food products have the potential to positively impact food security and environmental sustainability by addressing nutrient deficiencies, drought tolerability, and chemical overuse, the current regulatory process surrounding the production and implementation of genetically engineered (GE) food sources is costly and time-consuming, indirectly discouraging scientific research on novel products with useful applications. All foods, regardless of how they were derived, would benefit from being subjected to the same regulatory standards.
- While controversial and likely to create consumer pushback, a product-based, rather than process-based regulatory system, whereby products would be analyzed according to the risks they might pose rather than the means used to produce them, is a more effective regulatory process. Food regulation systems are currently process-based and fail to recognize that the end product of more traditional breeding methods could be the same as a GE variety (e.g., polled cows).
- Because consumers currently tend to distrust GE food products for a variety of reasons, including fear of the unknown future impacts of new technology, these perceptions need to be addressed prior to the implementation of risk-benefit analysis as the preferred tool for

determining product safety. Health and environmental risks are considered as part of risk-benefit analysis, but consumers need to be able to understand that zero-risk is impossible to achieve.

Current realities

Traditionally bred crops are not subjected to specific regulatory evaluations, and breeders are responsible for self-regulating their production processes. Breeders are trusted not to breed varieties that are more harmful to consumers than preceding varieties, which is not equivalent to the regulatory requirements for genetically engineered (GE) crops. The regulatory environment for GE agricultural products involves evaluations by multiple organizations (e.g., FDA, USDA, Environmental Protection Agency [EPA]), requiring hundreds of millions of dollars over several years to bring a product to market. Furthermore, the labeling of food safety reviews for these products as "voluntary" is misleading because every item that has made it to market has completed the review process. The regulatory environment for GE products is similar in other countries, especially because many countries model their policies according to those of U.S. agencies.

GE technologies are currently used on a regular basis in a variety of applications. For instance, insulin injections for diabetics and therapeutics for cancer patients utilize GE and are publicly accepted. Additionally, of the estimated 18 million farmers currently growing GE crops, more than 16 million of them operate in less-affluent nations. While this holds economic promise for less-affluent nations, the development of new GE food products has been hindered by the high cost of regulatory approval. Even large food companies have suspended research on novel GE crops because the regulatory pipeline costs are not recovered by profit once the product goes to market. This is especially true for specialty crops.

In general, consumers tend to be distrustful of GE plants and animals although this problem is not unique to genetic engineering in food production (i.e., views regarding politicized topics such as vaccinations are also polarized). Distrust can be perpetuated through unreliable sources of information, such as celebrities or popular media outlets. Distrust is further perpetuated through the prevailing perception that regulatory agencies are influenced by large food producers and manufacturers that use financial incentives to accelerate regulatory approval. It was generally agreed, however, that it would be impossible to influence all of the many regulatory agencies involved in GE technology regulation.

Another concern of the public entails the health and environmental safety of GE food products. Technologies thought to be safe in the past were discovered to be dangerous far after their use became commonplace (e.g., DDT, organophosphates).

Accordingly, implementation of GE plants and animals might have negative effects that proliferate biologically in nature. Human health impacts were questioned as well, as some participants wondered if modern technologies are reducing the nutritional value or safety of our food (e.g., residual antibiotics in milk). It was recognized, however, that products such as milk are tested for unwanted contaminants.

There currently exists no risk-benefit analysis when determining the potential utility of GE foods. Only risks are weighed at present, but this is problematic because zero-risk is an impossible standard to reach, whether the breeding method is traditional or GE. For example, regulatory proceedings on fast-growing salmon currently focus on the risk of GE salmon escaping confinements and outcompeting wild species. Benefits, such as tactics allowing for breeding in land tanks or the fact that a fast-growing phenotype necessitates the consumption of fewer resources, are ignored when determining whether the GE technology can be brought to market.

Scientific opportunities and challenges

A prominent challenge associated with the implementation of GE food products is the widespread distrust of the technology, an uneasiness that has been supported by popular media (e.g., *Jurassic Park*). If GE crops and traditional crops were evaluated using the same regulatory checklist, consumers might panic regarding all food sources, since traditionally bred products would be compared to supposedly risky GE varieties. It was noted, however, that this panic would be less likely to occur if both benefits and risks were considered in the regulatory process. A suggestion was also made regarding the usefulness of identifying shared values between GE crop and traditional crop production, such as climate change and environmental footprint, as well as changing the GE conversation to address how new technologies can help achieve these shared values.

Evaluating and overcoming health and environmental risks associated with GE products must be accomplished for these products to be useful at the market level. However, it was stressed that unique risks (i.e., insertion of a gene from organism A into organism B, not deactivation of a naturally occurring gene in organism A) associated with a new product should be treated with greater regulatory scrutiny. These unique health risks might include expression of allergens in food products that normally would not contain allergens. Environmental risks must also be considered, particularly of the possibility of biological pollution to the exposed environment.

Despite the necessity to overcome the risks, there are a variety of opportunities for the use of GE technologies in food. Genetic breeding techniques offer a great deal of precision in the food production process, potentially allowing for better control and fewer risks compared to traditional methods. GE crops could also improve

environmental wellbeing and sustainability, since certain genetic improvements in the past have been shown to decrease environmental footprints (e.g., GE technologies have decreased the number of required dairy cows by tens of millions). Introducing disease resistance would lessen the need to spray chemicals or treat crops in the field, protecting the environment while maintaining productivity.

GE technologies also have applications for food security in more- and less-affluent regions. About 20% of animal products are lost to disease globally each year. The introduction of disease resistance traits could ensure that food quantities improve. In areas where nutrients are lacking in the diet, biofortification of crops could be used to improve the nutritional quality of produce. Food security challenges associated with water scarcity and droughts could be ameliorated by introducing drought resistance into plant species.

For these opportunities to be realized, the challenge of redeveloping the regulatory system must be overcome, since the financial burdens associated with the current system are preventing scientists and breeders from developing beneficial GE products. The current regulatory processes are antiquated and much scientific progress has been made since their establishment. A new regulatory process would have to be developed and accepted by policy makers and government regulatory organizations alike, a task which would take a great deal of time and effort.

Disagreement arose regarding whether benefits could be used to outweigh risks in regulatory practice, since an identified risk will be present whether benefits arise from the technology. Because zero-risk is unattainable, however, it would be impossible to utilize GE or traditional breeding strategies to create novel food products. In regards to the correct balance of analyzing risks and benefits, it was suggested that the successful implementation and acceptance of GE Hawaiian papaya could be an example of how to structure the acceptance of alternative GE products in the future. Emphasis was placed on the fact that the incorporation of GE papaya into the marketplace was based on three main characteristics: (i) development by public sector scientists (e.g., University of Hawaii); (ii) disappearance of papaya from the market if the technology was not adopted; and (iii) perceived safety of a disease-resistance trait.

Policy issues

While it was suggested that the current regulatory process for food be modified, the recommended adjustments were met with mixed opinions. A product-based, rather than process-based, system was proposed by which products would be analyzed according to the risks they might pose rather than the means used to produce them. Specifically, this style of regulatory system would include identifying what trait has

been expressed in the organism, deciding whether a risk is associated with that trait's expression, and performing a government organization-driven evaluation (e.g., FDA) if a risk is recognized. This plan was met with controversy, as some individuals expressed concern regarding unknown consequences of novel processes used in food production (e.g., genetic engineering).

It was emphasized that all foods should be subjected to the same regulatory standards, unlike the current practice by which only GE foods are regulated. If two products are produced in different ways (i.e., traditional breeding versus GE) but introduce the same risks, they need to be monitored equally. Moreover, unique risks need to be used in product evaluation, and the regulations imposed should be proportional to the amount of risk introduced.

Whether the current regulatory process is modified or remains the same, it was generally agreed that certain risks need to be considered when regulating food production. This would be especially true if a risk-benefit analysis is implemented for new production sources and technologies. Human health and safety is a major concern, as well as environmental implications. It was mentioned that regulatory procedures should be tailored to end-goal applications (e.g., aids to medical drug versus glycosylate delivery).

Lastly, product-labeling rules should be based on product attributes, much like the suggested changes to the regulatory process. For example, if an allergen is introduced into a product, such as a peanut trait expressed in a tomato, then the product should be labeled with appropriate risk information. However, it is not necessary to require a product to be labeled simply because its breeding process is different from traditional breeding.

Acknowledgment

Numerous individuals and organizations have made important contributions to the Institute on Science for Global Policy (ISGP) program on Food Safety, Security, and Defense. Some of these contributions directly supported the efforts needed to organize the ISGP conference, *Food Security: Production and Sustainability,* convened in partnership with Eckerd College on its campus St. Petersburg, Florida, April 24–25, 2015. Other contributions aided the ISGP in preparing the material presented in this book, which includes the three invited policy position papers and the not-for-attribution summaries of the views presented in the discussions, critical debates, and caucuses that ensued at Eckerd College.

The willingness of those in the scientific and policy communities to be interviewed in the preparation for the conference is appreciated, as are the efforts of the three subject-matter experts invited to present their views concerning food production and sustainability in their policy position papers. The willingness of these authors to engage all conference participants in the vigorous debates and caucuses that compose all ISGP conferences was especially noteworthy. The biographies of these three authors are provided here.

The success of every ISGP conference critically depends on the active engagement of all 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, even unique, environment focused on clarifying understanding for the nonspecialist. Since these debates and caucuses address specific questions related to formulating and implementing effective public and private-sector policies, ISGP and Eckerd College are greatly indebted to all those who participated in the conference.

The efforts made by the faculty, students, and administration of Eckerd College in collaboration with the ISGP to organize and convene the second conference within the ISGP Academic Partnership (IAP) program were uniformly recognized as outstanding and are appreciated. The results of their efforts served the interests not only of the academic community, but of the communities engaged with Eckerd College. The brief biographies of the faculty and students from Eckerd College involved are presented here.

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 that is addressing many of the most important societal questions of our time. The ISGP remains a not-for-profit organization that does not lobby on any issue except rational thinking. The brief biographical backgrounds for the ISGP Board members are presented here.

The energetic, highly professional work of the ISGP staff merits special acknowledgment and appreciation. The staff's outstanding interviewing, organizing, and writing skills remain essential to not only organizing the conference itself, but also to recording the often-diverse views and perspectives expressed in the critical debates, 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. Biographical information on all the ISGP staff involved is presented here.

ISGP programs are financially supported by government agencies and departments and through gifts from private-sector entities and philanthropic individuals. Specifically, the IAP conference on *Food Security: Production and Sustainability* received funding from Eckerd College. The ISGP benefited greatly from generous gifts provided by the MARS Corp., Monsanto Corp., and Edward and Jill Bessey.

It is also important to note that the ISGP has benefitted from a major contribution from Sigma Xi, The Scientific Research Society, that has helped facilitate the organizing and convening of the conference on food production and sustainability.

Dr. George H. Atkinson
Founder and Executive Director
Institute on Science for Global Policy
July 30, 2015

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: Food Security and Diet-linked Public Health Challenges*, to be 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

- *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, 2014, 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 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

Rachel Goldstein, M.B.A.

Ms. Goldstein is the Global Sustainability Manager for Scientific and Regulatory Affairs at Mars, Inc. She started with Mars in November of 2011. Her roles include leading an internal sustainability advisory group on packaging, advising and implementing programs on sustainability related claims, and representing Mars as the Co-Chair of the Food Beverage and Agriculture working group of the Sustainability Consortium. Prior to Mars, Rachel was the Team Leader of the U.S. Environmental Protection Agency's Landfill Methane Outreach Program (LMOP), a voluntary program that encourages methane emissions reductions through the capture and beneficial use of landfill gas. She was also the lead for this work in India, China and Southeast Asia under the Global Methane Initiative. Rachel spent eleven years in the environmental safety and health field before joining EPA. She is an active member of the Women's Council on Energy and Environment and has an M.B.A. with an Environmental Management Concentration from The George Washington University, and a B.S. in Human Factors Engineering from Tufts University.

Lee Dehaan, Ph.D.

Dr. Dehaan is a staff member at the Land Institute. Raised on a farm in Minnesota, he has a strong background in the everyday challenges of agriculture. His focus is development of Kernza (wheatgrass) as a perennial grain. He earned a B.A. in Plant Science and Biology at Dordt College, and M.S and Ph.D. degrees in Agronomy, specializing in Agro-ecology, at the University of Minnesota. He received two awards there: an outstanding graduate student award from his department and a scholarship for meritorious graduate students from Crop Science Society of America. His graduate research focused on development of new leguminous perennial crops. From 2001 to 2010 he led the perennial-wheat breeding program at The Land Institute. Prior to that, he served on a two-year Land Institute Graduate Research Fellowship .

Alison Van Eenennaam, Ph.D.

Dr. Van Eenennaam is a Cooperative Extension Specialist in Animal Genomics and Biotechnology at University of California, Davis. Her internationally recognized research and extension program focuses on the use of DNA-based biotechnologies to address applied problems of animal agriculture. She received a Bachelor of Agricultural Science from the University of Melbourne in Australia, and both an MS

in Animal Science, and a Ph.D. in Genetics from UC Davis. Her research interests include the use of whole genome selection approaches for the genetic improvement of livestock with a special emphasis on beef cattle. She currently serves as the Extension representative on the U.S. National Beef Cattle Evaluation Consortium Industry Council where she has been involved in validation of DNA-marker tests for beef cattle since 2005. She is also involved in public education and uses a variety of media to inform general public audiences about science and technology, and provides a credentialed voice on some controversial topics including cloning and genetically engineered animals. Dr. Van Eenennaam was the recipient of the 2010 National Award for Excellence in Extension from the U.S. Association of Public and Land-Grant Universities (APLU), and the 2014 Borlaug Council for Agricultural Science and Technology (CAST) Communication Award.

Biographical information of Eckerd College faculty and student participants

Faculty

Liza Conrad, Ph.D.

Dr. Conrad is an assistant professor at Eckerd College. She received her Ph.D. in Plant Breeding and Genetics from Cornell University in 2007. Prior to that, she received her Bachelor of Science in Biology from the State University of New York College at Cortland in 2000. Her research interests are in plant molecular biology, with her focus being primarily on the genetic control of flower development in cereal crops, such as rice and maize.

Joel Thompson, Ph.D.

Dr. Thompson is a professor at Eckerd College. He received his PhD in Marine Geochemistry at Syracuse University in 1989. His research areas include geomicrobiology, biogeochemistry, biogenic mineralization, sediment diagenesis, microbialites, and chemical and geological oceanography.

Stephen Weppner, Ph.D.

Dr. Weppner is an associate professor of physics at Eckerd College. He received a Bachelor of Arts in Physics and Mathematics from State University or New York Geneseo and a Ph.D. in physics from Ohio University. He joined the faculty of Eckerd College in 1997. His theoretical research is in the computations of the scattering cross-sections for collisions of nucleons (protons or neutrons) with nuclei.

Student participants

Daniela Baeza

Daniela Baeza grew up outside of Washington D.C. and graduated from Eckerd College 2015. She received her degree in the fields of Political Science and international Relations/Global Affairs. She is a member of the Ford Foundation Scholars Program, and was funded a grant to conduct behavioral science research in Singapore. She is also a member of the Political Science Honors Society, and the National Collegiate Hispanic Honor Society at Eckerd College. She is currently an Intern with ISGP.

Anna Barboza

Anna Barboza, from Silver Spring, Maryland, graduated with a degree in Marine Biology from Eckerd College. As a student in Liza Conrad's Food Security class, Anna closes her last chapter at Eckerd College with an avid enthusiasm for food security issues and agriculture. Her plans for after college include an internship through the International Rescue Committee with their New Roots Campaign, which establishes community gardens for refugees in the greater Baltimore, Maryland area. Proceeding the summer, she plans on moving to Big Coppit Key, Florida.

Barbara Del Castello

Barbara Del Castello, from Pacifica, CA, graduated from Eckerd College in 2015. She received her B.A. in Biology with a minor in Anthropology. Her interests include human genetics and evolution, human disease, food security issues, as well as scientific communication. Before her work with ISGP, Barbara worked on research regarding Alzheimer's disease in transgenic C. elegans. She has participated in archaeological digs in Thailand as well as a paleontological dig in Florida. She is currently a Senior Fellow with ISGP.

Sally Florio

Sally Florio is a graduating senior from Eckerd College in Saint Petersburg, Florida. As an undergraduate student, she gained a Bachelor of the Arts in Environmental Studies with two minors, one in Biology and the other in Coastal Management. Sally hopes to focus on an environmental education career while also improving policy in the US Public Schools regarding outdoor education and environmental learning. She plans to attend graduate school for environmental science and policy in the near future.

Derek Godshall

Derek Godshall is from Souderton, PA and is an International Relations and French major at Eckerd College, class of 2016. His research interests concentrate on food as a human right, what the international community to help realize this goal, and how to better integrate disadvantaged populations into development gains.

Ginny Hamilton

Ginny Hamilton, originally from Gladwyne Pennsylvania, graduated Eckerd College in May 2015. She completed her studies with a B.S. in Marine Science and a B.A. in Psychology. She hopes to use her dual degree to find a way to better communicate information from scientists to the general public.

Roxanne Hoorn

Roxanne Hoorn, is a sophomore at Eckerd College in St. Petersburg, Florida, working toward a degree in Biology with a focus on Ecology. Roxanne is also a Fellow in the Ecological Society of America's Strategies for Ecology Education, Diversity and Sustainability (SEEDS) program. As part of her fellowship she will be working as an intern at Harvard Forest this summer, investigating the impact of climate change on ant foraging behavior. Her future research interests are focused around ecology and conservation.

Andréa Martin

Andréa Martin is a senior at Eckerd College studying Environmental Studies and minoring in Human Development. Andréa was born and raised in Vermont, where she drew inspiration from to study the environment. Andréa is the co-president of Eckerd College Garden Club and the co-founder of the Eckerd College Beekeeping Club. She is an Innovator for the Office of Service Learning and a Resident Advisor. Off campus, Andréa has held internships with the Peace and Justice Center, Vermont Center for Integrative Therapy, and Common Roots. This summer, she looks forward to mangrove field conservation work in Indonesia and she hopes to pursue a career that allows her to continue traveling and serving the environment.

Emma Sheffield

Emma Sheffield is from Groton, Massachusetts and graduated from Eckerd College in 2015 with a B.S. in Biology and minors in Japanese, Chemistry, and Mathematics. She is currently working in the field of plant ecology.

Julia Sparks

Julia Sparks, from Atlanta, GA, is an Environmental Studies and Economics major at Eckerd College, where she will graduate in 2016. She is a member of Eckerd College's Ford Foundation Scholars Program, and was funded a grant to conduct research in South America.

Cleo Warner

Cleo Warner is a graduate from Eckerd College class of 2015. She has a B.A. in Literature and Environmental Studies, and was a residential advisor for the last two years of her time at Eckerd. Throughout her studies and various internships and jobs, Cleo has focused on science communication with a particular interest in food systems.

Katie Wheeler
Katie Wheeler, a New Mexico native, is a first year Biology and Communications major at Eckerd College. Katie's passion lies in the field of food security as it relates to environmentalism, nutrition and human rights. She is currently an Intern with ISGP.

Sarah Wiemert
Sarah Wiemert is a junior at Eckerd College. She is working toward an Environmental Studies major with two minors in Biology and Anthropology. Currently, she hopes to become involved in the urban agriculture movement that surrounds St. Petersburg, FL, where she currently lives.

Sarah White
Sarah White, born and raised in Nashville Tennessee, is currently a sophomore at Eckerd college. She intends to major in Biology with a Psychology minor.

Rachel Yorston
Rachel Yorston is a current sophomore at Eckerd College, where she is majoring in Environmental Studies with a minor in Anthropology. In the past, she has served as a research associate at Eckerd College studying ecovillages around the world and the various sustainable initiatives that such communities can encourage. Her plans for future study include sustainability, permaculture, and environmental education.

Nicole Zavala
Nicole Zavala is a current Eckerd College student studying Environmental Studies. She plans to graduate in 2016.

Conference debaters

Daniela Baeza
Eckerd College
Food Security student

Anna Barboza
Eckerd College
Food Security student

Bill Bilodeau
Board of Directors, Sustainable Urban Agriculture Coalition
Co-manager, Faith House Garden

Jason Cavatorta
Johnny's Selected Seeds

Claudine Cooper
St. Petersburg College

Barbara Del Castello
Eckerd College
Food Security Student
ISGP Fellow

Roy E. Crabtree
Administrator, Southeast Region
National Marine Fisheries Service

Gail Eggeman
Market manager/founder The
Saturday Morning Market;
Director, Florida Association of
Community Farmers Markets

Sally Florio
Eckerd College
Food Security student

Sandra Gadsden
Executive Director,
The Edible Peace Patch Project

Maisie Ganzler
Vice President, Bon Appétit

Derek Godshall
Eckerd College
Food Security student

Jordan H. Maeson
Founder & President, Safer Dining

Ginny Hamilton
Eckerd College
Food Security student

Cathy Harrelson
Director, Co-Founder,
Emergent Strategic Consulting

Roxanne Hoorn
Eckerd College
Food Security student

Janet Keeler
Department of Journalism
University of South Florida-
St. Petersburg

Patrizia La Trecchia
Professor of Food & Sustainability
University of South Florida-Batel

Andrea Martin
Eckerd College
Food Security student

Rick Martinez
Sweetwater Organic Community Farm

Ronald Millard
Board of Directors, Sigma Xi

Francesca Nelson
International Institute for Tropical Agriculture
(CGIAR), Tanzania

Alison Ormsby
Professor of Environmental Studies
Eckerd College

Joe Parker
Immokalee Farm Workers Coalition

Dick Pierce
Academy of Senior Professionals
Eckerd College

Sandra Reyes
College student
North Port, FL

Darden Rice
St. Petersburg City Council

Emmanuel Roux
Founder & Executive Director, Urban Food Park

Rita Sewell
StPete.LocallyGrown.net

Emma Sheffield
Eckerd College
Food Security student

Julia Sparks
Eckerd College
Food Security student

Max St. Brown
Assistant Professor of Economics
Eckerd College

Paul Stein
Board of Directors, Sigma Xi

Cleo Warner
Eckerd College
Food Security student

John Weaver
The FoodCrafters, Rhode Island

Katie Wheeler
Eckerd College
Food Security student

Sarah White
Eckerd College
Food Security student

Sarah Wiemert
Eckerd College
Food Security student

Rachel Yorston
Eckerd College
Food Security student

Nicole Zavala
Eckerd College
Food Security student

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 PhD 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 Sr. 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 former President and CEO of the George Mason University (GMU) Foundation and GMU's Vice President for Advancement. 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 and volunteers

ISGP staff

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, and Science and Technology Adviser (STAS) to U.S. Secretaries of State Colin Powell and Condoleezza Rice. In 2014, Dr. Atkinson was elected President of Sigma Xi, The Scientific Research Society. Based on principles derived from his personal experiences, 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 is the Program Coordinator for ISGP. She worked for 25 years in the newspaper industry at the Tucson Citizen before joining the ISGP. She was the Editor of the Tucson Citizen when it was closed in 2009. She received her M.B.A. from the University of Arizona and graduated from Pomona College in California with a degree in economics.

Samantha Cermignano, B.S.

Ms. Cermignano is a Senior Fellow with oversight over the ISGP Academic Partnership (IAP) program. She received her Bachelor of Science in Biology with a concentration in Pre-Health from Ursinus College, Pennsylvania. She previously held a position at the University of Pennsylvania as a visiting undergraduate researcher in hematology, and has been published in the journal *Blood*. She will be entering medical school in fall 2015.

Sweta Chakraborty, Ph.D.
Dr. Chakraborty is Associate Director of ISGP. 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 forthcoming 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.

Cathy Green, Ph.D.
Dr. Green is an Adjunct Fellow with the ISGP. She is an underwater archaeologist specializing in outreach and education programs with the National Oceanic and Atmospheric Administration's (NOAA) Thunder Bay National Marine Sanctuary. Green combines her background in nautical archaeology with her experience teaching on shipboard education programs to bring the maritime heritage resources of the sanctuary program to a wide audience.

Christina Medvescek, B.A.
Ms. Medvescek is Program Administrator for the ISGP. She 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 volunteer mediator, facilitator and instructor at the Center for Community Dialogue in Tucson, Arizona.

Aubrey Paris, B.S.
Ms. Paris is a Senior Fellow with the ISGP. She earned her Bachelor of Science degree in Chemistry and Biology from Ursinus College, where she was also a French minor and Fellow of the Center for Science and the Common Good. Her honors chemistry research involved the development of novel transition metal complexes in the electro- and photochemical reduction of carbon dioxide, and she is continuing this work at Princeton University in pursuit of her Ph.D. in Chemistry. She was a 2014 AMGEN Scholar at the University of California, Berkeley, and is a co-founder of Globalized Ethics for Medical Science (GEMS), a not-for-profit and publicly accessible infectious-disease reporting database.

Ramiro Soto, B.S.
Mr. Soto is a Fellow with the ISGP. He graduated in May 2015 from University of Arizona College of Science with a degree in General Applied Mathematics and a minor in Hebrew Studies. He plans to enter a doctoral program to further his studies in mathematics.

Andrea Vazquez, ISGP Fellow

Ms. Vazquez is a Fellow with the ISGP. She currently is a student at Arizona State University pursuing her bachelor's degree in social work. She also serves as a college prep assistant at a Tucson, Arizona, high school. Her goal as a social worker is to advocate for people who are vulnerable and oppressed, especially youth.

ISGP volunteers

Margaret Butchy

Ms. Butchy has an interest in urban public health. She graduated from Villanova University with a dual degree in Biochemistry and Philosophy. This spring, she completed a special master's program in Interdisciplinary Medical Science at Drexel University College of Medicine. She currently attends Drexel's medical school and plans on becoming a primary care physician. She hopes to practice medicine in the Philadelphia area and participate in changes to the region's health care policy and system.

Shantelle Crawford

Ms. Crawford is a junior at Ursinus College. She is working toward her Bachelor of Science degree in Biology with an Art and Art History minor. During the 2014-15 academic year, Ms. Crawford has served as the senate liaison for Ursinus' black student union organization Sankofa Umoja Nia (SUN). In addition, she works in an undergraduate lab doing research using mice as a model for research on Fetal Alcohol Spectrum Disorder (FASD).

Marilyn Day

Ms. Day is a member of the Ursinus College class of 2016. She is a Biology major with a Neuroscience minor and conducts research at the intersection of these disciplines. Ms. Day is a member of the Center for Science and the Common Good and will be interning for the ISGP in summer 2015. She is also Vice President of her sorority, Tri Sigma, and Vice President of Tri Beta, the Biology honors society. This coming summer, Ms. Day will be participating in the Amgen Scholars Program at UCLA. After graduation, she plans to attend graduate school to earn her Ph.D. in neurobiology.

Erin Klazas

Ms. Klazas is a member of the Ursinus College Class of 2016. She is a Biology and Media and Communication Studies double major. Ms. Klazas is a Bonner Leader, and a member of Phi Alpha Psi sorority. She also teaches an After-School Science

Exploration recreational course at Eisenhower Leadership academy in Norristown, PA, where she brings the fun in science to fifth and sixth graders in underprivileged environments.

Samantha White

Ms. White is a member of the Class of 2017 at Ursinus College. Ms. White is majoring in Biology and minoring in Neuroscience. During the summer of 2013, she was involved in the Howard Hughes Medical Institute-funded FUTURE program, studying the effects of prenatal ethanol exposure on the corticothalamic system. Currently, Ms. White continues her research in the Biology department and works as a teaching assistant for the Biology labs. Outside of her studies, she is an Ursinus College Ambassador and the Vice President of Campus Activities Board.