AUTHENTICATED
U.S. GOVERNMENT
INFORMATION
GPO

HEARING TO CONSIDER THE SOCIETAL BENEFITS OF BIOTECHNOLOGY

HEARING

BEFORE THE

SUBCOMMITTEE ON HORTICULTURE, RESEARCH, BIOTECHNOLOGY, AND FOREIGN AGRICULTURE

OF THE

COMMITTEE ON AGRICULTURE HOUSE OF REPRESENTATIVES

ONE HUNDRED THIRTEENTH CONGRESS

SECOND SESSION

JULY 9, 2014

Serial No. 113–16



Printed for the use of the Committee on Agriculture
agriculture.house.gov

U.S. GOVERNMENT PRINTING OFFICE

88–678 PDF WASHINGTON : 2014

For sale by the Superintendent of Documents, U.S. Government Printing Office
Internet: bookstore.gpo.gov Phone: toll free (866) 512–1800; DC area (202) 512–1800
Fax: (202) 512–2104 Mail: Stop IDCC, Washington, DC 20402–0001

COMMITTEE ON AGRICULTURE

FRANK D. LUCAS, Oklahoma, *Chairman*

BOB GOODLATTE, Virginia, *Vice Chairman*
STEVE KING, Iowa
RANDY NEUGEBAUER, Texas
MIKE ROGERS, Alabama
K. MICHAEL CONAWAY, Texas
GLENN THOMPSON, Pennsylvania
BOB GIBBS, Ohio
AUSTIN SCOTT, Georgia
SCOTT R. TIPTON, Colorado
ERIC A. "RICK" CRAWFORD, Arkansas
SCOTT DESJARLAIS, Tennessee
CHRISTOPHER P. GIBSON, New York
VICKY HARTZLER, Missouri
REID J. RIBBLE, Wisconsin
KRISTI L. NOEM, South Dakota
DAN BENISHEK, Michigan
JEFF DENHAM, California
STEPHEN LEE FINCHER, Tennessee
DOUG LAMALFA, California
RICHARD HUDSON, North Carolina
RODNEY DAVIS, Illinois
CHRIS COLLINS, New York
TED S. YOHO, Florida
VANCE M. MCALLISTER, Louisiana

COLLIN C. PETERSON, Minnesota, *Ranking Minority Member*
MIKE MCINTYRE, North Carolina
DAVID SCOTT, Georgia
JIM COSTA, California
TIMOTHY J. WALZ, Minnesota
KURT SCHRADER, Oregon
MARCIA L. FUDGE, Ohio
JAMES P. MCGOVERN, Massachusetts
SUZAN K. DELBENE, Washington
GLORIA NEGRETE MCLEOD, California
FILEMON VELA, Texas
MICHELLE LUJAN GRISHAM, New Mexico
ANN M. KUSTER, New Hampshire
RICHARD M. NOLAN, Minnesota
PETE P. GALLEGO, Texas
WILLIAM L. ENYART, Illinois
JUAN VARGAS, California
CHERI BUSTOS, Illinois
SEAN PATRICK MALONEY, New York
JOE COURTNEY, Connecticut
JOHN GARAMENDI, California

NICOLE SCOTT, *Staff Director*
KEVIN J. KRAMP, *Chief Counsel*
TAMARA HINTON, *Communications Director*
ROBERT L. LAREW, *Minority Staff Director*

SUBCOMMITTEE ON HORTICULTURE, RESEARCH, BIOTECHNOLOGY, AND FOREIGN AGRICULTURE

AUSTIN SCOTT, Georgia, *Chairman*

VICKY HARTZLER, Missouri
JEFF DENHAM, California
STEPHEN LEE FINCHER, Tennessee
DOUG LAMALFA, California
RODNEY DAVIS, Illinois
CHRIS COLLINS, New York
TED S. YOHO, Florida

KURT SCHRADER, Oregon, *Ranking Minority Member*
SUZAN K. DELBENE, Washington
JIM COSTA, California
MARCIA L. FUDGE, Ohio
ANN M. KUSTER, New Hampshire
JUAN VARGAS, California
SEAN PATRICK MALONEY, New York

CONTENTS

	Page
Davis, Hon. Rodney, a Representative in Congress from Illinois, opening statement	1
Schrader, Hon. Kurt, a Representative in Congress from Oregon, opening statement	4
Scott, Hon. Austin, a Representative in Congress from Georgia, prepared statement	3
Submitted material	51
Submitted statement on behalf of Alvin Jones, Principal, Jones Laffin Company, Inc.	72
WITNESSES	
Just, Ph.D., David R., Professor, Co-Director, Cornell Center for Behavioral Economics in Child Nutrition Programs, Charles H. Dyson School of Applied Economics and Management, Cornell University, Ithaca, NY	6
Prepared statement	7
Juma, Ph.D., Calestous, Professor, Practice of International Development, and Director, Science, Technology, and Globalization Project, John F. Kennedy School of Government, Belfer Center for Science and International Affairs, Harvard University, Cambridge, MA	9
Prepared statement	11
Bolden-Tiller, Ph.D., Olga, Associate Professor, Tuskegee University, Tuskegee, AL	25
Prepared statement	27
Lidback, Joanna S., Owner, The Farm at Wheeler Mountain, Westmore, VT; on behalf of Agri-Mark, Inc.; National Council of Farmer Cooperatives	28
Prepared statement	29

HEARING TO CONSIDER THE SOCIETAL BENEFITS OF BIOTECHNOLOGY

WEDNESDAY, JULY 9, 2014

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON HORTICULTURE, RESEARCH,
BIOTECHNOLOGY, AND FOREIGN AGRICULTURE,
COMMITTEE ON AGRICULTURE,
Washington, D.C.

The Subcommittee met, pursuant to call, at 10:10 a.m., in Room 1300, Longworth House Office Building, Hon. Rodney Davis presiding.

Members present: Representatives Scott, Davis, LaMalfa, Yoho, Schrader, DelBene, and Kuster.

Staff present: DaNita Murray, John Goldberg, Mary Nowak, Nicole Scott, Skylar Sowder, Tamara Hinton, John Konya, Keith Jones, Liz Friedlander, and Riley Pagett.

OPENING STATEMENT OF HON. RODNEY DAVIS, A REPRESENTATIVE IN CONGRESS FROM ILLINOIS

Mr. DAVIS. This hearing of the Subcommittee on Horticulture, Research, Biotechnology, and Foreign Agriculture to consider the societal benefits of biotechnology, will come to order.

I would like to first welcome everyone, good morning, and I am going to give an opening statement on behalf of Chairman Scott who has lost his voice. Being from Georgia, I always thought we needed a translator anyway, so I didn't know what the problem was, but Austin has lost his voice, and therefore, has relinquished the gavel to me today, so on behalf of him, I apologize.

I am pleased to offer the opening statement on behalf of Chairman Scott. Thank you all for being here today to discuss an issue that has become increasingly important over the last 2 decades. The purpose of today's hearing of the Subcommittee on Horticulture, Research, Biotechnology, and Foreign Agriculture is to consider the many benefits we as a society have realized through technological advances.

In the field of agriculture, we cope with the challenge of feeding an ever expanding world population while maintaining the safety, quality, diversity, and affordability in our food supply that we as Americans have come to expect. Biotechnology has played a critical role in meeting a number of consumer and societal needs. From the earliest experiments with agriculture to present time, we have been growing, cross-breeding, and fundamentally altering the crops and livestock we raise in order to meet the societal needs. As our needs have evolved, so has the use of technology. With each step

in our technological development, we are able to produce more with less while simultaneously continuing to improve the safety, quality, diversity, and affordability of the food that we consume.

Biotechnology is the application of biological science that makes use of living organisms to provide new products for agricultural, industrial, and medical uses. Consumers have long benefitted from biotechnology. For example, biotech includes the use of microorganisms in bread making, or the production of drug products such as insulin. As our capabilities have expanded, our potential for developing products that enhance benefits to consumers and producers has grown.

Unfortunately, a combination of factors has intervened to challenge consumer acceptance of biological technologies and potentially threaten further enhancements in this field. Secretary of State John Kerry recently stated, "The challenge is that by 2050, the world's population is going to grow to 9 billion people. That is going to demand at least a 60 percent increase over our current agricultural production." He went on to say: "It is simply true that biotechnology has dramatically increased crop yields. It has dramatically decreased loss due to pests and disease, and it allows us to feed more people without converting tropical forests or fragile lands in order to do so. So we save money and we save the environment and we save lives. It is a virtuous circle."

It is particularly troubling that a small minority has so confused the vocabulary of biotechnology as to threaten the development of this science and its role in feeding and nourishing our people, fighting disease, resolving the conflict between production agriculture and conservation, and doing all these things with fewer farmers on less land.

Today, we will hear from witnesses who will further outline how society has benefitted from these scientific achievements and the challenges that biotechnology faces in the future. We will hear about many specific advances, but I would like to highlight just a couple here.

One great example of the consumer benefit to biotechnology is with the dietary Vitamin A. It is estimated that Vitamin A deficiency kills 670,000 children under the age of 5 each year. With the genetically engineered Golden Rice, which contains beta-carotene, a precursor of Vitamin A, we can significantly reduce the amount of Vitamin A deficiency and deficient-related deaths in children around the world.

Another example is with Celiac Disorder. This disorder affects 1 in every 133 individuals with symptoms ranging from deterioration of the small intestines lining to osteoporosis. With advances in biotech wheat, both adolescents and adults can live a more fulfilling life with this genetically predisposed autoimmune disorder. Additionally, ¾ of all Americans are deficient in Vitamin D. Large deficiencies of Vitamin D have been linked to cancer, heart disease, diabetes, soft bones in children, and osteoporosis. Many Americans receive Vitamin D from orange juice, yet the disease of citrus greening threatens to leave a large portion of the orange industry unusable. Without this vital industry, the number of Americans at risk of a Vitamin D deficiency will rise indefinitely.

New biotechnology can help the citrus industry fight the greening disease and potentially increase the amount of Vitamin D in each glass of orange juice. Utilization of these biotechnologies improves our environment as the crops we are developing require a smaller carbon footprint by reducing the acres, water, and other resources needed to grow them. Biotechnology provides numerous benefits to not only the American consumer but also to consumers worldwide. With the use of this technology, we can fight diseases, increase available food sources, and reduce overall environmental impact.

In addition to the witnesses before us today, we have received submitted testimony and extraneous material that is relevant to today's hearing, and without objection, these materials will be included in the record.

[The documents referred to are located at p. 51.]

Mr. DAVIS. Before us today is a panel of five witnesses that will speak to these benefits. We are joined by Dr. David Just, Professor of Applied Economics and Management at Cornell University; Dr. Olga Bolden-Tiller, Associate Professor at Tuskegee University; Dr. Calestous Juma, Professor of the Practice of International Development at Harvard University; and Ms. Joanna Lidback, Owner and Operator of The Farm at Wheeler Mountain, a small family dairy operation.

We appreciate the time each of you have given to prepare for this hearing. Your testimony will be important to show the effect new agricultural technology has on the consumer. Thank you.

[The prepared statement of Mr. Scott follows:]

PREPARED STATEMENT OF HON. AUSTIN SCOTT, A REPRESENTATIVE IN CONGRESS FROM GEORGIA

Good morning.

Thank you all for being here today to discuss an issue that has become increasingly important over the last 2 decades.

The purpose of today's hearing of the Subcommittee on Horticulture, Research, Biotechnology, and Foreign Agriculture is to consider the many benefits we as a society have realized through technological achievements.

In the field of agriculture, we cope with the challenge of feeding an ever expanding world population while maintaining the safety, quality, diversity and affordability in our food supply that we have come to expect. Biotechnology has played a critical role in meeting a number of consumer and societal needs. From the earliest experiments with agriculture to present time, we have been growing, cross-breeding, and fundamentally altering the crops and livestock we raise in order to meet the societal needs. As our needs have evolved, so has the use of technology. With each step in our technological development, we are able to produce more with less, while simultaneously continuing to improve the safety, quality, diversity and affordability of the food we consume.

Biotechnology is the application of biological science that makes use of living organisms to provide new products for agricultural, industrial, or medical uses. Consumers have long benefited from biotechnology. For example, biotechnology includes the use of microorganisms in bread making or production of drug products such as insulin.

As our capabilities have expanded, our potential for developing products that enhance benefits to consumers and producers has grown. Unfortunately, a combination of factors has intervened to challenge consumer acceptance of biological technologies and potentially threaten further enhancements in this field.

Secretary Kerry recently stated "the challenge is that by 2050, the world's population is going to grow to 9 billion people. That is going to demand at least a 60 percent increase over our current agricultural production."

He went on to say: "It is simply true that biotechnology has dramatically increased crop yields. It has dramatically decreased loss due to pests and disease, and

it allows us to feed more people without converting tropical forests or fragile lands in order to do so. So we save money and we save the environment and we save lives. It is a virtuous circle."

It is particularly troubling that a small minority has so confused the vocabulary of biotechnology as to threaten the development of this science and its role in feeding and nourishing our people; fighting disease; resolving the conflict between production agriculture and conservation; and doing all these things with fewer farmers on less land.

Today we will hear from witnesses who will further outline how society has benefitted from these scientific achievements and the challenges biotechnology faces in its future.

We will hear about many specific advances but I would like to highlight just a couple here. One great example of the consumer benefit to biotechnology is with the dietary Vitamin A. It is estimated that Vitamin A deficiency kills 670,000 children under the age of 5 each year. With the genetically engineered Golden Rice, which contains beta-carotene, a precursor of Vitamin A, we can significantly reduce the amount of Vitamin A deficient related deaths in children around the world.

Another example is with Celiac Disorder. This disorder affects 1 in 133 individuals, with symptoms ranging from deterioration of the small intestines' lining to osteoporosis. With advances in biotech wheat, both adolescents and adults can live a more fulfilling life with this genetically predisposed autoimmune disorder.

Additionally, ¾ of all Americans are deficient in Vitamin D. Large deficiencies of Vitamin D have been linked to cancer, heart disease, diabetes, soft bones in children, and osteoporosis. Many Americans receive Vitamin D from orange juice. Yet, the disease of citrus greening threatens to leave a large portion of the orange industry unusable. Without this vital industry, the number of Americans at risk of a Vitamin D deficiency will rise, indefinitely. New biotechnology can help the citrus industry fight the greening disease and potentially increase the amount of Vitamin D in each glass of orange juice.

Utilization of these biological technologies improves our environment, as the crops we are developing require a smaller carbon footprint by reducing the acres, water, and other resources needed to grow.

Biotechnology provides numerous benefits to not only the American consumer but also to consumers worldwide. With the use of this technology, we can fight diseases, increase available food sources, and reduce overall environmental impact.

In addition to the witnesses before us today, we have received submitted testimony and extraneous material that is relevant to today's hearing. Without objection these materials will be included in the record.

Before us today is a panel of five witnesses that will speak to these benefits. We are joined by Dr. David Just, Professor of Applied Economics and Management at Cornell University; Dr. Olga Bolden-Tiller, Assistant Professor at Tuskegee University; Dr. Calestous Juma, Professor of the Practice of International Development at Harvard University; and Ms. Joanna Lidback, Owner and Operator of The Farm at Wheeler Mountain, a small, family dairy operation.

We appreciate the time each of you have given to prepare for this hearing. Your testimony will be important to show the effect new agricultural technology has on the consumer. Thank you. I would like to recognize my colleague from Oregon, Ranking Member Schrader, for any opening remarks he may have.

Mr. DAVIS. I would like to recognize now my colleague from Oregon, Ranking Member Schrader for any opening remarks that he may have.

OPENING STATEMENT OF HON. KURT SCHRADER, A REPRESENTATIVE IN CONGRESS FROM OREGON

Mr. SCHRADER. Thank you very much, Mr. Chairman. Frankly, I think you covered it pretty darn well.

I really appreciate the opportunity to have this hearing because I think it is time to put some good information out there. There has been an attempt to demonize hybrid and genetic engineering without fully understanding the benefits that we have had for thousands of years, and more recently, with the condensed timeframe, with the biotechnology advances we have, to be able to do some of

the things in a shorter timeframe, which some would say is a bad thing or implies is a bad thing.

I am on organic farmer myself, I practiced organic farming for 20 some years, and you can grow things organically. There is no need to get into a whole other labeling conflict or concern about something that for all accounts has been deemed just as safe as any other hybrid technology we have used, again, over the last century or 2.

So, this is an opportunity for us to clear the air a little bit, no pun intended. I find it somewhat ironic that those very people that seem to be most concerned about climate change seem to be against one of the major tools we can use to actually combat some of the deleterious effects of current farming practices. There is less tillage needed with some of the biotechnology crops we have going on here. There is pesticide resistance that we can inculcate here. There are opportunities to increase the nutritional value of these crops that you alluded to, Mr. Chairman. These are all good things that those very same people would be lauding in any other situation.

And to be honest, some of the panel will talk about this today, what we have here is a failure to communicate. We have a situation where a lot of folks from the social aspect of things have not caught up, once again, with the technological advances we have made. We see this in telecommunications all the time where we are way behind the curve trying to figure out how to regulate or not regulate the Internet and make sure that communication is done in a way where we are not using Ma Bell type of technologies to deal with modern advances. I think we are seeing the same thing here. You know, there is nothing that—and I am a scientist—that I have seen, that would implicate food altered in laboratory or altered in the field done with the testing we have with FDA, USDA is unhealthy or unsafe.

And I am very, very worried. Here is my biggest worry, Mr. Chairman. I would be interested in what the panel says. My biggest worry is that under the guise of trying to inform the consumer, we actually misinform the consumer, we imply there is some problem where there is not a problem. Now, if we had a better education system and consumers were more savvy, but we run the risk at one point of making, frankly, labeling almost irrelevant and a moot point, and that would be a shame because people do need to be informed about health hazards, environmental hazards that are—that they really would be worried about that could affect themselves or their children.

So, anyway, I look forward to the hearing. I think it is going to be a good one and hopefully help clear the air a little bit.

Thank you very much, Mr. Chairman.

Mr. DAVIS. Thank you, Ranking Member Schrader.

Obviously we have already introduced the witness panel. I would like to go ahead and begin with your testimony, and we will start with Dr. Just. Please begin when you are ready.

STATEMENT OF DAVID R. JUST, PH.D., PROFESSOR, CO-DIRECTOR, CORNELL CENTER FOR BEHAVIORAL ECONOMICS IN CHILD NUTRITION PROGRAMS, CHARLES H. DYSON SCHOOL OF APPLIED ECONOMICS AND MANAGEMENT, CORNELL UNIVERSITY, ITHACA, NY

Dr. JUST. Thank you.

And I thank the Subcommittee for the invitation to testify regarding consumer perceptions and benefits of biotechnology. I commend you for giving the attention to this important topic.

I am David Just, a Professor of Applied Economics and Management at Cornell University. For the past 16 years, I have conducted research in the field of agricultural and food economics. I published dozens of studies examining how consumers respond to the presentation of food, including several studies that directly examine issues regarding genetically modified organisms or GMOs, both the attitudes of consumers and also those of farmers responding to GMOs.

There is a large and growing number of consumers that now stigmatize GMOs in the U.S. Consumers tend to lump foods that are labeled as having been genetically engineered together with foods that are highly processed, infused with chemical preservatives, and in fact, reproduced foods. Consumers associate GMOs primarily with some unquantifiable health risk similar to that posed by untested or poorly tested medicines or drugs.

Consumers consider GMOs as a single technology with a single set of characteristics rather than the thousands of differentiated modifications that now appear in the market. This misperception allows the consumers to regard the GMOs in caricature, each equally risky and none possessing any particular benefits to them.

Generally, when consumers consider GMOs, they tend to regard them in comparison to some hypothetical alternative food that is pristine and presents no perceived health risk. In reality, the alternatives generally present a greater health risk and something that is quantifiable. More often, GMOs have been introduced specifically to eliminate the use of pesticides or other chemical preservatives or other treatments that do present a health risk.

This is the case, for example, with *Bt* corn, a product that consumers are most likely to encounter in the marketplace today. The industry is partly if not wholly to blame for the consumer misperception. Industry is focused understandably on marketing the benefits to farmers to get them to adopt. Consumers often have only a latent understanding of why genetic modifications are introduced into the food supply in the first place. Because consumers are not actively considering why these modifications have been introduced, they tend to ignore the health, nutrition, or other benefits that they have to offer.

When given the choice between conventional foods and GMOs, consumers express a strong preference for conventional foods; however, when the same choice is presented in a way that the consumers can understand the reasons for the genetic modification, they overwhelmingly choose the GMOs.

Thus, consumers would rather buy poultry that has been genetically modified to resist diseases than buying chicken, for example, that has been fed antibiotics in order to accomplish the same pur-

pose. In fact, almost 85 percent prefer genetic modification in this case.

Supporting studies find that consumers are enthusiastic about GMOs that have been introduced in order to enhance nutrition, safety, or health, but a little more skeptical of those introduced primarily to address agricultural productivity. When consumers are presented with direct explanations of the direct benefits to consumers, they are much more willing to accept the technology. Consumers have also failed to grasp the benefits to society as a whole. GMOs have been instrumental in increasing agricultural productivity. This technology has reduced the price of commodities by between four and ten percent. Given our era of historically high crop prices, this technology is essential to providing low cost food, particularly to developing countries.

In developing countries, GMOs hold the promise to overcome generations of relatively low yields and high levels of disease. For example, genetically modified corn in Africa has been used to reduce the incidents of esophogeal cancer and birth defects. These developing countries have paid a very high price for consumer rejection of biotechnology in the European Union. These poor nations will face a further dwindling of fortunes if we fail to convince U.S. consumers of the benefits.

Unfortunately, consumers often look on developing country adoption of GMOs as evidence of large U.S. corporations exploiting the poor. These corporations, despite wonderful cooperative efforts in developing countries, have failed to use their own good will efforts to connect with concerned constituencies in the U.S. and also Europe.

If we are to turn the tide of irrational consumer fears regarding biotechnology, these firms must make a concerted effort to communicate the direct health benefits to consumers from reduced use of chemicals in food production and the indirect benefits to developing country consumers of more abundant and lower cost food. It is easy to stigmatize genetic modification as a benefit only to large agribusinesses. It is much more difficult to stigmatize a variety of corn, for example, that is reducing the incidents of blindness in sub-Saharan Africa.

Again, I would like to thank the Subcommittee for inviting me to testify, and I will be happy to answer any questions you may have.

[The prepared statement of Dr. Just follows:]

PREPARED STATEMENT OF DAVID R. JUST, PH.D., PROFESSOR, CO-DIRECTOR, CORNELL CENTER FOR BEHAVIORAL ECONOMICS IN CHILD NUTRITION PROGRAMS, CHARLES H. DYSON SCHOOL OF APPLIED ECONOMICS AND MANAGEMENT, CORNELL UNIVERSITY, ITHACA, NY

I thank the Subcommittee for the invitation to testify regarding consumer perceptions and benefits of biotechnology, and commend you for giving your attention to this topic. I am David Just, Professor of Applied Economics and Management the Charles H. Dyson School of Applied Economics and Management at Cornell University and Co-Director of the Cornell Center for Behavioral Economics in Child Nutrition. For the past 16 years I have conducted research in the field of agricultural and food economics. I have published dozens of studies examining how consumers respond to the presentation of food including health claims. My work consists of direct studies of consumer responses to various food choices and the impact of food and agricultural policy on production and trade practices. I have conducted dozens

of field experiments examining consumer choice and response to product descriptions. I have published a half dozen studies directly examining issues related to genetically modified organisms (GMOs), looking at both consumer attitudes toward GMOs and farmer responses to GMOs.

In general, we find a large and growing number of consumers who stigmatize GMOs. This stigma has long been a factor in Europe, and we see the same pattern emerging in the U.S. In consumer studies, we find that people tend to lump food that is labeled as having been genetically engineered together with categories of foods such as those that contain chemical preservatives or other ingredients with long names that sound overly technical, or foods that are highly processed and factory produced.[1] For example, one prominent study finds that consumers are generally willing to pay about 14% less for GMOs than similar products that are not GMOs.[2] Consumers tend to associate GMOs primarily with some unquantifiable health risk, similar to that posed by untested or poorly tested drugs or medication, though they also express some more minor concerns about environmental impacts. Moreover, consumers tend to consider GMOs as a monolithic technology with a single set of characteristics, rather than the thousands of differentiated modifications that now appear in the market. This misperception allows consumers to perceive GMOs in caricature, with each being equally risky and none possessing any particular benefits. Generally, when consumers consider GMOs, they tend to regard them in comparison to some hypothetical alternative food that is pristine and presents no perceived health risk. In essence, they consider it a question of GMO *versus* an ideal food.[3] In reality, the non-GMO alternative generally presents a greater and quantifiable health risk. GMOs are often introduced specifically to eliminate the use of pesticides or other chemical treatments that can present a health risk. This is the case with *Bt* corn, one of the products consumers are most likely to encounter.

Consumers have developed misperceptions regarding the benefits of biotechnology in part because the industry does not explain those benefits to them. Industry has focused understandably on marketing the benefits of growing these crops to farmers, leaving consumers with a latent understanding of why genetic modifications are introduced into the food supply to begin with. Because consumers do not actively consider why these modifications have been introduced, they tend to ignore the health, cost, nutrition or other benefits of these foods. When given the choice between conventional foods and GMOs, consumers express a strong preference for conventional foods.[4] However, my research has shown that when the same choice is presented in such a way that consumers can understand the reasons for genetic modification, they overwhelmingly choose GMOs. For example, consumers would rather buy poultry that has been genetically modified to resist diseases than chicken that has been fed antibiotics to accomplish the same purpose. In fact, almost 85% prefer genetic modification in this case. This preference is even stronger for those with a college education, in which case more than 90% would select the genetic modification.[5] Supporting studies by other researchers find that consumers are enthusiastic about GMOs that have been introduced in order to enhance nutrition, safety or health, but a little more skeptical of those introduced primarily to address agricultural productivity.[6] When consumers are presented with direct explanations of the direct benefits to consumers, they are much more willing to accept the technology.[7]

Consumers have also failed to grasp the benefits of biotechnology to society as a whole. GMOs have been instrumental in increasing agricultural productivity. This technology has reduced the price of commodities by 4% to 10%—a fact that is not

---

[1] Wansink, B.A. Tal and A. Brumberg. "Ingredient Based Food Fears and Avoidance: Antecedents and Antidotes." *Food Quality and Preference* 38(2014):40–48.

[2] Huffman, W.E., J.F. Shogren, M. Rousu and A. Tegene. "Consumer Willingness to Pay for Genetically Modified Food Labels in a Market with Diverse Information: Evidence from Experimental Auctions." *Journal of Agricultural and Resource Economics* 28(2003): 481–502.

[3] Heiman, A., D.R. Just and D. Zilberman. "The Role of Socioeconomic Factors and Lifestyle Variables in Attitudes and the Demand for Genetically Modified Foods." *Journal of Agribusiness* 18(2000): 249–260.

[4] Lusk, J.L., M. Jamal, L. Kurlander, M. Roucan and L. Taulman. "A Meta-Analysis of Genetically Modified Food Valuation Studies." *Journal of Agricultural and Resource Economics* 30(2005): 28–44.

[5] Heiman, A., D.R. Just and D. Zilberman. "The Role of Socioeconomic Factors and Lifestyle Variables in Attitudes and the Demand for Genetically Modified Foods." *Journal of Agribusiness* 18(2000): 249–260.

[6] Hossain, F. and B. Onyango. "Product Attributes and Consumer Acceptance of Nutritionally Enhanced Genetically Modified Foods." *International Journal of Consumer Studies* 28(2004): 255–267.

[7] Wansink, B.A. Tal and A. Brumberg. "Ingredient Based Food Fears and Avoidance: Antecedents and Antidotes." *Food Quality and Preference* 38(2014): 40–48.

understood by the typical consumer.[8] Due to the labor, transportation and regulatory costs of food production in the U.S., the impact of this basic commodity price effect is much smaller at the highly processed retail level of most American food. However, this has had an important direct impact on consumers in the developing world. Given our era of historically high crop prices, this technology is essential to providing low cost food, particularly in developing countries. Additionally, some of the most successful introductions of GMOs have occurred in developing countries, as these new technologies hold the promise to overcome generations of relatively low agricultural yields and high levels of disease. For example, genetically modified eggplant in India is helping to reduce pesticide use and to increase the yields of relatively poor farmers. Pesticide use has a known and measurable impact on the health and longevity of farmers. Genetically modified corn in Africa has helped reduce the prevalence of Mycotoxin Fumonisin in maize,[9] which has been linked to esophageal cancer and birth defects. This new technology promises to make developing country agriculture competitive with the west, and to help reduce poverty worldwide. Developing countries have paid a very high price for consumer rejection of biotechnology in the European Union, forcing them to choose between sustainable productivity and access to markets.[10] Poor nations will face a further dwindling of fortunes if we fail to convince U.S. consumers of the benefits.

Many of the consumers in the U.S. who are most sensitive to GMO consumption are also those who list concern for developing countries among their highest priorities. Unfortunately, these consumers often look on developing country adoption of GMOs as evidence of large U.S. corporations exploiting the poor. These corporations—despite wonderful cooperative efforts in developing countries—have failed to use their own good-will efforts to connect with concerned constituencies in the U.S. or Europe. If we are to turn the tide of irrational consumer fears regarding biotechnology, firms that produce GMOs must make a concerted effort to communicate both the direct health benefits to U.S. consumers from reduced use of chemicals in food production, and the indirect benefits to developing country consumers of more abundant and lower-cost food. This effort will necessarily differentiate the various reasons for modification and should focus on branding the individual modifications rather than the entire technology. It is easy to stigmatize genetic modification as a benefit only to large agribusinesses, but it is difficult to stigmatize corn that is reducing the incidence of blindness in sub-Saharan Africa.

Again, I would like to thank the Subcommittee for inviting me to testify. I would be pleased to answer any questions you may have.

Mr. DAVIS. Thank you, Dr. Just.

We will go in order where you are seated, Dr. Juma.

STATEMENT OF CALESTOUS JUMA, PH.D., PROFESSOR, PRACTICE OF INTERNATIONAL DEVELOPMENT, AND DIRECTOR, SCIENCE, TECHNOLOGY, AND GLOBALIZATION PROJECT, JOHN F. KENNEDY SCHOOL OF GOVERNMENT, BELFER CENTER FOR SCIENCE AND INTERNATIONAL AFFAIRS, HARVARD UNIVERSITY, CAMBRIDGE, MA

Dr. JUMA. Thank you very much, Mr. Chairman. I am very grateful to the Committee for giving me the opportunity to come and testify here this morning.

I had the opportunity in the past to serve as the Executive Secretary of the UN Convention on Biological Diversity that was drafting laws that were intended specifically to govern and regulate genetically modified products and at the time, it was argued that these products were unlikely to have any benefits to consumers,

[8] Brookes, G., T-H. Yu, S. Tokgoz, A. Elobeid. "The Production and Price Impact of Biotech Crops." Center for Agricultural and Rural Development Working Paper, Iowa State University, January 2010.

[9] Pray, C., J. Rheeder, M. Gouse, Y. Volkwyn, L. v.d. Westhuizen and G.S. Shephard. "Can *Bt* Maize Reduce Exposure to the Mycotoxin Fumonisin in South Africa?" Presented at the International Association of Agricultural Economists', Beijing China, 2009.

[10] Evenson, R.E., "Status of Agricultural Biotechnology: An International Perspective." In Just, R.E., J.M. Alston and D. Zilberman (eds.), *Regulating Agricultural Biotechnology: Economics and Policy.* Springer: New York, 2006, pp. 103–123.

they are likely to harm the environment, and they are only likely to benefit the industrialized countries.

I have spent the last 15 years or so since leaving that job, basically building up a body of evidence of what has happened since then, and the evidence does not support those claims. Unfortunately, those are the claims that led to the introduction of a wide range of laws and restrictions around the world that have made it difficult, in fact, for consumers to benefit from the dramatic advances of agricultural biotechnology.

This country has been a champion in leading the creation of the industry. It was because of a decision in this country to allow the patenting of living organisms that the industry, the biotechnology industry was actually born. The lifespan of a patent is roughly 20 years. If it takes about 20 years to approve a product and get it to the market, that is really a major obstacle and a disincentive to anybody who wants to invest in biotechnology.

A good example of that is the case of transgenic salmon in this country which has taken 20 years of regulatory effort. A patent lasts almost as long. So we do have really very significant barriers to the ability of the global community to benefit from biotechnology, but the evidence is very clear. We have seen it in the case of India, for example, and parts of Africa where biotechnology cotton has been adopted. Farm incomes have gone up by 50 percent. These farmers have, therefore, been able to have additional revenue with which they have been able to afford food, so we see a direct impact of increases in biotechnology, adoption in biotechnology, increases in farm income and food security.

And so it is evidence that sovereign leadership is really essential in ensuring that the global community can benefit from these advances.

And there are really two areas that I think are very important. The first is public awareness, education of the public so the public is fully informed about the benefits of biotechnology. At the moment, that space for public education, as has already been mentioned, is already occupied by people who spend most of their time denigrating biotechnology. I think a lot more work needs to be done in that area.

Second, the area of making it possible for biotechnology products to be approved in a timely manner is a very important aspect of ensuring that consumers can benefit from the product, so I would like to make a case that in fact sovereign leadership in this country, particularly, which championed the creation of the industry, is critical to enabling the global community to benefit from biotechnology.

Thank you very much for giving me the time, and I will be happy to answer questions.

[The prepared statement of Dr. Juma follows:]

PREPARED STATEMENT OF CALESTOUS JUMA, PH.D., PROFESSOR, PRACTICE OF INTERNATIONAL DEVELOPMENT, AND DIRECTOR, SCIENCE, TECHNOLOGY, AND GLOBALIZATION PROJECT, JOHN F. KENNEDY SCHOOL OF GOVERNMENT, BELFER CENTER FOR SCIENCE AND INTERNATIONAL AFFAIRS, HARVARD UNIVERSITY, CAMBRIDGE, MA

Societal Benefits of Agricultural Biotechnology

Global Status and Outlook

Executive Summary [1]

The rise of the U.S. biotechnology industry is largely a result of reforms in intellectual property rights that allowed for the patenting of living forms. However, global regulatory hurdles have made it difficult for society to fully reap the benefits of biotechnology. Society's innovative and entrepreneurial potentialities will be hobbled if the regulatory process for new biotechnology products takes as long as the duration of patent protection, which is at most 20 years. It has taken as long for the United States to complete the approval process for transgenic salmon. Worldwide, even more onerous and discriminatory hurdles stand in the way of societal benefits of biotechnology. Biotechnology product pipelines are being choked by discriminatory regulations, labeling threats, and a rising tide of product disparagement and misinformation.

This submission argues that although many transgenic crops are still in their early states of adoption and even more are still being tested and developed, emerging trends show significant societal benefits through positive economic impact (especially by raising farm incomes), fostering food security, and promoting environment sustainability. The crops show the potential to increase agricultural production on existing arable land; reduce losses related to pests, disease, and drought; increase access to food through higher farm incomes; raise nutrition levels; and promote sustainable agriculture. The pipeline of crops with potential benefits include a wide range of applications such as enhanced photosynthesis, stress tolerance, aluminum tolerance, salinity tolerance, pest and disease resistance, nitrogen use efficiency, phosphate use efficiency, and nitrogen fixation. However, restrictive regulations are undermining the ability of society to reap these benefits.

The largest benefits of transgenic crops are economic and derive from increased income from higher yields and resistance to loss. The best example of this is in India, where transgenic cotton production per hectare is demonstrably higher than that of non-transgenic cotton. Indian smallholder farmers who planted *Bt* cotton earned 50% more from higher production due to reduced pest damage. With the extra income, farmers' food consumption levels increased. Likewise, farmers from countries as diverse as South Africa, the Philippines, and the United States who planted *Bt* maize saw significantly higher yields. In the United States, transgenic papaya helped save the industry in Hawaii, and it is predicted that agricultural biotechnology is the most promising option for combating the citrus greening that is severely impacting those industries in Florida, Texas, and California. Finally, crops are currently in the pipeline that address loss related to local pests and disease in developing countries. Examples include transgenic bananas that combat *Xanthomonas* wilt (Uganda, Kenya), pest-resistant eggplant (Bangladesh, India, Philippines), and pest-resistant cowpea (Nigeria).

Second, transgenic crops offer the ability to biofortify key crops, which is especially helpful in numerous countries where Vitamin A deficiency is a concern (*e.g.,* Golden Bananas in Uganda and Golden Rice in the Philippines). Furthermore, other developing countries are seeking to promote increased agricultural production of key staple crops that offer nutritional benefits such as transgenic cassava and sorghum in Sub-Saharan Africa. Other crops in the pipeline with nutritional benefits include high-oleic oil soybean, which aims to eliminate trans fats, and the "Arctic Apple," designed to resist browning and therefore encourage healthier lunch choices among schoolchildren.

Finally, transgenic crops offer environmental benefits by requiring less spraying of pesticides, reducing the amount of arable land needed for increased agricultural production, and combating the effects of climate change through the development of drought-resistant crops such as Water Efficient Maize for Africa (WEMA). Re-

[1] The submission uses the term "transgenic crops" to refer only to those crops that have been developed through the use of genes derived from unrelated species. All crops that are in use today have in one way or another been genetically modified through methods that do not involve the transfer of genes across species. This paper is therefore concerned only with transgenic crops and not all genetically modified (GM) crops, which include plants derived from conventional plant breeding.

duced spraying of insecticides results in improved human and ecological health (NAS 2010b).

To realize the potential of transgenic crops, it is important to view them as one of the many sources of food security and to assess the benefits and risks on a case-by-case basis. Given rising agricultural challenges including the impact of climate change, it would be a mistake to adopt agricultural policies that expressly exclude transgenic crops as one of the options.

The early days of the introduction of transgenic crops were marked by divergent views over the long-term benefits and risks. It has been 18 years since the large-scale commercial release of the products and there is now sufficient evidence upon which to base historical assessments. For example, many of the policies adopted by emerging countries to regulate transgenic crops assumed that their risks were likely to be catastrophic, thereby requiring a high degree of caution. While careful monitoring of the crops continues to be warranted, the evidence so far available does not support the adoption of restrictive and costly regulatory policies.

Transgenic crops have recorded the fastest adoption rate of any crop technology in the last century. This is mainly because of the benefits that they confer to farmers, most of whom reside in developing countries. Between 1996 and 2013, transgenic crops added US$116.9 billion to global agriculture, more than ½ of which accrued to farmers in developing countries. If the crops had not been introduced, the world would have needed another 123 million hectares of land to meet the same levels of production. These benefits are inconsistent with earlier concerns that transgenic crops would not benefit small-scale farmers.

Evidence from large-scale studies supports the view that the crops on the market do not carry unique risks. For example, the European Commission funded more than 50 research projects involving 400 researchers at the cost of €200 million to evaluate this issue. The studies found that "the use of biotechnology and of GE plants *per se* does not imply higher risks than classical breeding methods or production technologies" (European Commission 2010, p. 16). The journal *Critical Reviews of Biotechnology* recently published a comprehensive literature review covering the last 10 years of transgenic crop safety and effects on biodiversity and human health. It concluded that "the scientific research conducted thus far has not detected any significant hazard directly connected with the use of GM crops" (Nicolia, *et al.,* 2013, p. 2).

Transgenic crops have been shown to carry the same risk profile as their conventional counterparts. In the long-run, the risks of excluding transgenic crops from global agricultural options would outweigh the risks of including them. Moreover, preventing the commercialization of transgenic crops undermines countries' abilities to leverage the power of biotechnology whose benefits extend to other fields such as health, environmental management, and informatics.

The way forward is clear. As mentioned, transgenic crops not only offer increased incomes for farmers, biofortification, and environmental benefits. But the impact of transgenic crops on the overall price of food is just as important, especially in a world where there is a need to feed a growing population of approximately nine billion by 2050 and address a surge in consumption, including a 70% increase in the demand for food. Transgenic technology leads to more efficient production methods as well as a reduction in loss, which in turn leads to lower food prices both in the United States and abroad.

The balance of evidence suggests that transgenic crops offer no greater risks than their conventional counterparts, and their economic, nutritional, and environmental benefits are extensive. Yet whether or not the crops described above reach the farmers and consumers who need them most depends on the regulatory agencies and the lengthy and costly approval processes of each country, as well as on public resistance to transgenic crops in general.

The United States has historically played a critical role as a champion of biotechnology innovation worldwide. Its leadership is urgently needed at a time when global agricultural challenges are mounting. More specifically, there is a need to bring the regulatory processes governing the approval of agricultural biotechnology in line with the state of scientific knowledge pertaining to the crops and scientific advances. There is no alternative to the evidence-based regulatory processes that have enabled the United States to emerge as the world's biotechnology innovation powerhouse. To cede this responsibility to opponents of innovation will undermine U.S. competitiveness, erode its scientific leadership, and put the global community at risk from the rising economic and ecological challenges. It will deprive global citizens of important societal benefits of agricultural biotechnology. Put more directly, a national whose regulatory processes take as long as the duration of a patent cannot continue to be a champion of innovation. This has to change and there is no better time than the present.

Contents

Executive summary
Introduction
1. Global societal challenges
Agriculture and the wider economy
Food security and nutrition
Sustainability and resilience
2. Societal benefits of agricultural biotechnology
Agricultural production
Agricultural and the economy
Food safety and nutrition
Sustainability and resilience
3. Policy implications and outlook
Conclusion
References
Acknowledgements
Biographical summary

Introduction

The rise of the U.S. biotechnology industry is largely a result of reforms in intellectual property rights that allowed for patenting of living forms. However, regulatory hurdles around the world have made it difficult for society to fully reap the benefits of biotechnology. Society's innovative and entrepreneurial potentialities will be hobbled if the regulatory process for new biotechnology products takes as long as the duration of patent protection, which is at most 20 years. It has taken as long for the United States to complete the approval process for transgenic salmon. Worldwide, even more onerous and discriminatory hurdles stand in the way of societal benefits of biotechnology. Biotechnology product pipelines are being choked by discriminatory regulations, labeling threats, and a rising ride of product slander and misinformation.

There is a need to feed a growing population of about nine billion by 2050 and address a surge in consumption, including a 70% increase in the demand for food. Climate change and rising food prices will negatively impact African countries the most. The challenge of feeding a growing population will include increasing production on existing arable land. One of the ways to combat climate change and higher food prices is to expand the agricultural innovation toolkit, which includes transgenic crops. The aim of this submission is to review the societal impacts of transgenic crops, which range from increased food security to economic, nutritional, and environmental benefits. In addition to these, both farmers and consumers benefit: the former from increased income and the latter from lower prices stemming from more efficient production, improved nutrition and environmental protection. Furthermore, small farmers in developing countries are shown to benefit just as much as their counterparts in industrialized countries. Finally, "adopters report improvements in health, education, debt repayment, maternal care services and food security" (Carpenter, 2013, p. 249).

This submission argues that although many transgenic crops are still in their early states of adoption and even more are still being tested and developed, emerging trends show significant societal benefits through positive economic impact (especially by raising farm incomes), fostering food security, and promoting environmental sustainability. The pipeline of crops with potential benefits include a wide range of applications such as enhanced photosynthesis, stress tolerance, aluminum tolerance, salinity tolerance, pest and disease resistance, nitrogen use efficiency, phosphate use efficiency, and nitrogen fixation (UK Council for Science and Technology, 2013).

The submission is divided into three sections. The first section outlines trends in food security and biotechnology. This is followed by a section that examines some of the examples of the role of transgenic crops in the wider economy, especially in raising farm incomes. The final section reviews some of the major regulatory challenges associated with the adoption of transgenic crops and animals, as well as outlining a way forward.

There are many claims that biotechnology cannot contribute to solving food insecurity or benefit smallholder farmers. Critics argue that biotechnology is a red herring—that food insecurity is simply the result of poor infrastructure, distribution,

and income level. Transgenic crops are also criticized for being part of the agro-industrial complex. Critics link transgenic crops with increased pesticide use, monoculture, and industrialized farming at the expense of smallholder farmers. They argue that large agricultural corporations perpetuate food insecurity by selling expensive, unnecessary technology to poor farmers; preventing farmers from saving seeds; destroying plant diversity; and displacing millions of farmers. Critics claim that transgenic crops were developed with industrialized countries in mind; that they would hardly be adopted or accepted in developing countries; and that the technology continues to ignore the plight of smallholders.

These claims are driven by a wide range of concerns that tend to assert what has not been denied and deny what has not been asserted. In fact, transgenic crops demonstrate numerous societal benefits. But realizing the potential needs to be viewed in a wider food security context.

1. Global Societal Challenges

Agricultural and the wider economy: There is a need to feed a growing population of approximately nine billion by 2050; address a surge in consumption and changing diets, including a 70% increase in the demand for food; and compensate for increasing biofuels production. Meanwhile, around 870 million people are undernourished (Searchinger, *et al.,* 2013, p. 1). This will require a doubling of current levels of food production. A recent study analyzed the current production and yield rates for four key crops (maize, rice, soybean, and wheat) and determined that annual yields are increasing at an average rate of 1.2%, or ½ the 2.4% rate that would double production and close the gap. At current rates, global production of each crop will only increase by approximately 67%, 42%, 38%, and 55%, respectively—well below what is needed to meet the expected demand (Ray, *et al.,* 2013). This is especially problematic in many developing countries where one or more of these crops are responsible for the majority of caloric consumption.

Transgenic crops can benefit smallholder farmers in several major ways. First, they help farmers avoid both production and income loss due to pests, disease, and environmental factors such as drought or flooding. This results in greater productivity. Insect-resistant (IR) traits are found to have the greatest impact in warm, tropical places where pests are more prevalent and where insecticides and inputs are not widely used—namely in emerging countries.

Essentially, food security is about expanding ecologically sustainable agricultural practices as well as increasing access to nutritious food. The rest of this submission seeks to address how biotechnology can play a role in increasing agricultural productivity, income levels, nutrition, and stability and resilience of the food system to various shocks, thereby helping to increase food security at the global level but especially in emerging countries.

Boosting agricultural production contributes directly to poverty alleviation by raising farm incomes, providing jobs, and reducing the cost of food. Agriculture is responsible for the majority of employment in many parts of the world. In fact, a World Bank report (2008) has shown that the growth of the agricultural sector is more effective at reducing poverty than is growth in any other sector. In Sub-Saharan Africa for example, agriculture "contributes to 34% of GDP and 64% of employment" across the continent (Juma, 2011a, p. 7). Because agriculture will continue to be an important source of employment in the future as well, increasing agricultural production will result in increased farm income and consumption.

Furthermore, in areas where farmers face a variety of problems and farm extension services are limited, biotechnology can be successful at filling the void, as it can make farming less complex, which suggests that "farmers with less human capital may benefit the most" (Sexton and Zilberman, 2010, p. 13).

Food security and nutrition: Advancements in science have demonstrated the important role that niche crops can play in improving human health. Achieving food security depends not only on increasing production but also on improving nutrition. Increasing the production of niche crops—also known as ancient grains, orphan crops, lost crops, famine crops, local crops, neglected crops, or wild foods—is one way to achieve this. Technological advancements in agricultural biotechnology and advances in fields such as plant genomics allow for the enhancement of existing crops and the ability to breed new ones that meet higher nutritional standards. Furthermore, many communities rely on niche crops, so increasing their production would also improve nutrition in food-insecure areas (Juma, 2014).

Sustainability and resilience: It is well established that the effects of climate change—from weather-related phenomena to rising food prices—will drastically affect agricultural productivity worldwide and developing countries the most. Measures will need to be taken to adapt crops to changing weather patterns. Changes in humidity are already affecting the world's primary cocoa-growing regions, while

drought has affected maize crops in both the United States and sub-Saharan Africa. In Southeast Asia, rice yields are affected by drought, salinity, and rising sea levels (Redfern, *et al.,* 2012).

Another dimension to the need for increased food production is related to agriculture's historically large environmental footprint—the industry "accounted for approximately 24 percent of global greenhouse gas emissions in 2010" (Searchinger, *et al.,* 2013, p. 2). It is also responsible for around 70% of global freshwater use, as well as contamination of water supplies and coastal areas from farm runoff. One of the biggest challenges of feeding a growing population is increasing production on existing arable land. Agricultural biotechnology not only has the potential to adapt crops to climate change, but it can also contribute to increasing yields on existing land and reducing emissions by encouraging fewer applications of pesticides and herbicides.

2. Societal Benefits of Agricultural Biotechnology

2.1 Agriculture and the wider economy

Technology played an important role in generating significant increases in agricultural productivity during Green Revolution. The combination of new, high-yielding crop varieties, agro-chemicals, and better irrigation techniques helped "raise food production to levels that no one would have dared predict . . . farmers in the developing and developed countries nearly doubled their per-hectare output of cereal production, increasing yields during this time by 3.16% annually" (Huang, *et al.,* 2002, p. 678). This led to a significant decline in poverty and hunger throughout much of Asia, because food levels rose, prices fell, as well as food trade and consumption increased.

However, the favorable conditions that led to the success of the Green Revolution have changed. Staple crops will be most affected by the "exhaustion of some past sources of growth [making] future yield expansion as great a challenge as in the past" (*Ibid.,* p. 678). Overuse of fertilizers and chemical pesticides has led to pest and weed resistance. It has also contributed to environmental degradation. Moreover, availability of arable land is declining, water resources are scarce and climate change is causing significant changes in weather patterns, making it necessary to find alternatives to current production methods.

Transgenic crops offer one alternative to addressing these challenges, as they are specifically designed to increase production while decreasing the use of pesticides and herbicides. A key point is that transgenic crops were not developed to increase yield directly but instead "to overcome barriers to efficient yield, that is, to control diseases, or yield-robbing weeds or insect pests" (McHughen, 2013, p. 7). Increased production is necessary to feed a growing population and meet an ever-increasing demand for food. The genetically modified soybean enabled double-cropping in Argentina, which specifically helped to meet the huge increase in soy demand-driven primarily by an increased desire for meat in Asia—with only a limited effect on prices (Zilberman, *et al.,* 2010).

Although studies that examine production increases of transgenic crops have produced varying estimates, recent cotton studies in India and China confirmed earlier results: transgenic cotton production per hectare are demonstrably higher than those of non-transgenic cotton, especially in India. Other benefits include decreased pesticide use especially in China, and health benefits in both countries (Pray, *et al.,* 2011). Cotton was the most-adopted genetically engineered crop globally and saw the highest production increase, and the global price effects of planting *Bt* cotton are estimated at 10% (Zilberman, *et al.,* 2010).

India had one of the lowest rates of cotton production in 2001–02 (at 308kg/ha). Aggregate levels of cotton increased substantially after the introduction of *Bt* cotton post-2002, reaching 560kg/ha (Pray, *et al.,* 2011, p. 98). *Bt* cotton was adopted at a rate of 90%, leading to "a 24% increase in cotton yield per acre through reduced pest damage and a 50% gain in cotton profit among smallholders. These benefits are stable; there are even indications that they have increased over time" (Kathage and Qaim, 2012). With the extra income, farmers' consumption levels increased 18% from 2006 to 2008 (Juma, Conceição, and Levine, 2014; Kathage and Qaim, 2012).

In China, where surveys were conducted from 1999 to 2007, mean production of *Bt* cotton was higher than conventional cotton. One concern is that *Bt* cotton production levels will decline over time due to the development of bollworm resistance or as a result of being "backcrossed into more varieties by public- and private-sector plant breeders" (Pray, *et al.,* 2011, p. 93). Yet evidence does not support these concerns as "aggregate cotton yields continue to rise in China suggesting that *Bt* cotton also continues to do well" (*Ibid.*).

A global impact study confirms the significant income gains among farmers in India and China who adopted transgenic IR cotton, transgenic *Bt* soybeans in South

America (including Argentina, Bolivia, Brazil, Paraguay, and Uruguay), and a variety of transgenic crops in the United States. South Africa, the Philippines, Mexico, and Colombia are also seeing the income benefits of adopting transgenic crops. These gains stem from greater productivity and efficiency. The largest income gains derive from the maize sector. In fact, "$6.7 billion additional income generated by GM insect resistant (GM IR) maize in 2012 has been equivalent to adding 6.6% to the value of the crop in the GM crop growing countries, or adding the equivalent of 3% to the $226 billion value of the global maize crop in 2012. Cumulatively since 1996, GM IR technology has added $32.3 billion to the income of global maize farmers" (Brookes and Barfoot, 2014, p. 9).

In Africa, where smallholder farmers use significantly fewer inputs than in developed countries, IR crops could have the greatest impact on production. By adapting the technology to local conditions, developing countries could also address the issue of yield drag, which occurs because companies typically modify generic seeds that are unspecific to a particular region. African countries could increase the production potential of transgenic crops by applying the technology to high-quality, local crop varieties.

Higher production is not the only positive impact of transgenic crops. They also help reduce loss due to pests, weeds, and diseases. The potential of this technology lies in how it is adapted to meet specific, local needs in developing countries, which can range from combating diseases to improving indigenous crops.

Researchers in Uganda, for example, are using biotechnology to reverse the trend of *Xanthomonas* wilt, a bacterial disease that causes discoloration and early ripening of bananas and costs the Great Lakes region approximately $500 million annually. There is currently no treatment for the disease, and given its status as a staple crop in this region, solving this problem would directly increase food security and income (Juma, Conceição, and Levine, 2014; Juma, 2011b). The most efficient method of containing the disease is by growing transgenic bananas instead of relying on more labor-intensive methods of removing and destroying affected bananas. By transferring two genes from green peppers, scientists were able to grow highly resistant bananas. Results from field trials in Uganda and Kenya are extremely promising, but the regulatory regimes do not yet allow for commercialization.

In Nigeria the insect *Maruca vitrata* destroys nearly US$300 million worth of blackeyed peas—a major staple crop—and forces farmers to import pesticides worth US$500 million annually. To solve the problem, scientists at the Institute for Agricultural Research at Nigeria's Ahmadu Bello University have developed a pest-resistant, transgenic blackeyed pea variety using insecticide genes from the *Bacillus thuringiensis* bacterium. The crop is also undergoing field trials in Burkina Faso and Ghana.

In Southeast Asian countries such as Bangladesh, India, and the Philippines, *Bt* brinjal is the region's first transgenic food crop and offers economic, nutritional, and environmental benefits. Researchers and scientists at the Bangladesh Agricultural Research Institute (BARI) developed *Bt* brinjal to resist the 'fruit and shoot borer' (FSB), with support from USAID and Cornell University. The result was significantly fewer pesticide sprays during the growing period and fewer dips in pesticide just before harvest. The transgenic eggplant has obvious farmer health and environmental benefits from reduced pesticide use. The crop was commercialized in Bangladesh, but its future remains in jeopardy as the government and opponents of transgenic crops seek to push or stall further crop sales. Furthermore, the Filipino government prohibited field trials of *Bt* brinjal, citing health and environmental concerns. As a result, commercialization of the crop remains stalled in India and the Philippines, and its future remains uncertain in Bangladesh (Hammadi, 2014).

Key industries in industrialized countries are also affected by loss from disease and pests. The most dramatic example is that of transgenic papaya, which helped save the industry in Hawaii. In the early 1990s, the papaya ringspot virus (PRSV) was transmitted rapidly by aphids and nearly decimated Hawaii's papaya industry, which saw yields plummet from 53 million pounds in 1992 to 26 million pounds in 1998. After the introduction of the "Rainbow" papaya in 1998, yields rose to 46 million pounds by 2001. At the time, farmers, producers, and consumers alike embraced it. Today it accounts for 77% of the papaya grown in Hawaii (Gonsalves, 2007). Other examples of transgenic food crops ready for commercialization in the U.S. include *Bt* sweet corn, virus-resistant summer squash, and pox-resistant plums. Finally, agricultural biotechnology offers a similar promise for combating the citrus greening disease (Huanglongbing) that is severely affecting those industries in Florida, Texas, and California. Citrus greening is caused by the bacterium *Candidatus Liberibacter asiaticus* (CLas), spread by the Asian citrus psyllid (ASP). Florida's citrus industry brings in an estimated $9.3 billion annually. Farmers stand to lose income, and a dramatic reduction in output would lead to higher prices of citrus fruits

and juices for consumers throughout the United States. Currently, increased use of insecticides and removal of infected fruit trees are the only known solutions. According to a recent report by the U.S. National Academy of Sciences, genetic engineering represents the best alternative to these costly and less-effective solutions (NAS, 2010a, p. 2).

It is also important to note what is not in the pipeline, namely smaller crops that are a staple in certain regions of the world but are unlikely to be developed in the foreseeable future because of prohibitive regulatory costs and risks. Regardless, promising transgenic vegetable crops such as insect-resistant bananas, blackeyed pea, eggplant, papaya, sweet corn, summer squash, plums, citrus fruits, and wheat must clear significant resistance and regulatory hurdles before their societal benefits can be realized.

As demonstrated, these techniques have the potential to address a wide range of agricultural, health, and environmental issues in emerging countries, resulting in societal benefits such as increased productivity and therefore contributing to increased food security.

Increasing production, reducing loss, and encouraging higher agricultural productivity among smallholder farmers has a significant effect on income and poverty. For one thing, growth in the agricultural sector is more effective at reducing poverty and increasing access to food than growth in any other sector. Since smallholder farmers comprise the majority of the workforce in sub-Saharan Africa, boosting their income levels through agricultural productivity would go a long way toward increasing food security.

The evidence from several long-term studies suggests that biotechnology is successful at helping smallholder farmers increase their income through costs savings. The last section showed how transgenic crops improve production and reduce loss. This translates into higher incomes at the farm level. A recent study explains how planting transgenic crops results in cost-savings up front, specifically with IR crops, which "require little capital and can substitute for chemical applications altogether" (Zilberman, *et al.,* 2010, p. 5). Not only were farmers able to reduce pesticide use, but they were also able to limit the related health risks.

Similarly, both IR and herbicide-tolerant (HT) crops can reduce input expenses associated with pesticide use, such as machinery costs, fuel costs, and water use. Although seed prices for transgenic cotton were higher than for conventional seeds in India, these costs were "offset by reductions in expenditures on pesticides and labor, due in large part to reductions in number of required sprays" (Pray, *et al.,* 2011, p. 94). Overall production costs decreased, and net revenue increased. In fact, revenue from *Bt* cotton exceeded that of conventional cotton in every household surveyed in China (*Ibid*). Results of *Bt* cotton studies in India also indicated that cost savings related to pesticide use, as well as higher production, offset the higher seed costs.[2]

When faced with fewer costs up-front, a reduction in crop loss, and more time available to pursue other income-generating activities, farmers have more income at their disposal, which also leads to greater consumption. So far, *Bt* cotton—which is the most widely adopted transgenic crop worldwide—has had the most significant impact on income. Approximately 15 million smallholder farmers in Burkina Faso, China, India, Pakistan, and a few other developing countries are growing *Bt* cotton. Several studies in India demonstrate the positive effects of *Bt* cotton on income, nutrition, and food security among poor farmers. Specifically, "*Bt* cotton adoption has raised consumption expenditures, a common measure of household living standard, by 18% during the 2006–2008 period" (Kathage and Qaim, 2012). In Burkina Faso, which grew 125,000 hectares of *Bt* cotton in 2009, rural households saw production increases of approximately 18.2% over those that grew conventional cotton; earning $39 per ha in profit. Although the seeds were more expensive, farmers saved money on inputs and labor (Vitale, 2010). The reduced insecticide spraying also contributed to human and environmental health.

Although *Bt* cotton does not directly contribute to better nutrition, it does indirectly contribute to food security by increasing household income levels and improving access to more nutritious food. This in turn increases the "purchasing power of farmers (and thus their exchange entitlements) and their access to food" (Juma, Conceição, and Levine, 2014). A recent study analyzes the impact of *Bt* cotton on caloric consumption and nutrition at the household level in four cotton-producing Indian states from 2003–09. The authors find that households growing *Bt* cotton leads them to consume significantly more calories—specifically, "each ha of *Bt* cotton has

[2] Different studies used different methods for calculating income gain from *Bt* cotton, but all indicated significantly higher profit margins for *Bt* cotton farmers (Pray, *et al.,* 2011, pp. 99–100).

increased total calorie consumption by 74 kcal per AE [adult equivalent] and day" (Qaim and Kouser, 2013, p. 6).

Furthermore, a smaller proportion of households are food insecure (7.93% of adopting *Bt* cotton households *vs.* 19.94% of non-adopting households) (*Ibid.,* table 2). The results also show that *Bt* adoption has led to consumption of more nutritious foods such as fruits, vegetables, and animal products. The authors estimate that if the households that do not currently grow *Bt* cotton switched, "the proportion of food insecure households would drop by 15–20%" (*Ibid.,* p. 6).

These findings indicate that increased income among smallholder farmer households that grow *Bt* cotton lead to greater food security and consumption of more nutritious food. But the results also demonstrate that farmers are the main beneficiaries of *Bt* cotton, rather than seed companies or biotechnology companies. This reinforces how plant biotechnology can be one important tool in addressing food insecurity.

Finally, farmers have seen their insurance costs decline as production risks stabilize. As a result, they will also gain access to better risk-management products. Given the increased production and income associated with *Bt* cotton, it can be extrapolated that further development of IR crops could "serve as an engine of rural economic growth that can contribute to the alleviation of poverty for the world's small and resource-poor farmers" (James, 2013).

2.2 Food safety and nutrition

The safety of transgenic foods has been a hotly debated issue. It gained international prominence following the publication of a paper that claimed that transgenic maize containing *Bt* genes caused cancer in rats (Séralini, *et al.,* 2012). The paper was used as a basis for regulatory action against transgenic foods in a number of countries. Upon closer scrutiny, however, several regulatory bodies including the European Food Safety Agency condemned the study as being methodologically defective (Arjó, *et al.,* 2013). The paper was later retracted by the journal that published it.

It is important to apply a case-by-case approach and focus on those foods that are on the market. Detailed reviews of the evidence so far available have come to the conclusion that the transgenic foods currently on the market carry the same risk profile as their conventional counterparts (Ricroch, Bergé and Kuntz, 2011). A comprehensive review of safety studies published over the last decade has examined the available evidence on the "safety of the inserted transgenic DNA and the transcribed RNA, safety of the protein(s) encoded by the transgene(s) and safety of the intended and unintended change of crop composition" (Nicolia, Manzo, Veronesi and Rosellini, 2013, p. 81). While acknowledging the need for further research, the review confirmed the general understanding that transgenic foods on the market today did not carry unique risks.

Interest in transgenic crops also includes their potential contribution to nutritional enhancement in staple crops, specifically targeting low-income families. There are several bio-fortified crops that are currently available or being tested in developing countries. These include "Golden Rice," which contains more beta carotene or Vitamin A, under evaluation in the Philippines and Bangladesh; and the "Golden Banana," bio-fortified with Vitamin A and iron and developed by Ugandan researchers (Wamboga, 2011). Nearly 15 million people either rely on bananas for their income or consumption, making it one of the most important crops in Uganda. It is estimated that the per capita consumption of bananas in Uganda is 0.7 kg per day. Scientists applied the pro-Vitamin A genes used in Golden Rice to a popular local crop to help solve a regional health issue. Addressing Vitamin deficiencies would lead to lower healthcare costs and higher economic performance.

In the UK, researchers at the John Innes Centre created a bio-fortified "purple tomato" by expressing genes from the snapdragon in the transgenic tomato. The dark color derives from the same antioxidant that is found in blueberries and cranberries—anthocyanin—and offers similar health benefits at a lower cost to consumers. By increasing the antioxidant levels in a common food such as the tomato, researchers hope to stimulate greater consumption of antioxidants. The purple tomato contains the "highest levels of anthocyanins yet reported in tomato fruit," and an early study of cancer-prone rats suggests that the tomato's high levels of anthocyanins increased the lifespan of these rats when eaten regularly. The purple tomato also has a longer shelf life than a nontransgenic tomato (Butelli, *et al.,* 2008; Shukman, 2014).

Other examples include the "Arctic apple" and J.R. Simplot's "Innate" potato, under development in Canada and the United States respectively. Both crops are designed to resist browning, making the apple an especially appealing choice for healthier school lunches. Browning is one of the most significant sources of food

quality loss worldwide. The techniques applied by such companies to address the challenge have the potential to be extended to fruits and vegetables in other regions of the world experiencing similar challenges. This would extend the shelf life of fruits and vegetables, thereby addressing the larger post-harvest loss problem.

Nutritional enhancements through genetic modification are still in their infancy. Examples such as Golden Rice and purple tomatoes are important because they represent proof of concept. When confirmed, they will open a wide range of opportunities for related modifications in other crops as well as the use of new techniques to improve human nutrition.

2.3 Sustainability and resilience

It is well established that climate change will adversely affect agricultural productivity primarily in developing countries. Many regions are expected to suffer production loss due to "drought, flood, storms, rising sea levels, and warmer temperatures" (Goering, 2012). In the past, these events were rare, and it was possible for farmers and regions to recover during the next growing season. Now it is imperative to determine ways of increasing the resilience and stability of food systems so that productivity is less affected by drought, flood, or both in the same season. Challenges include increasing productivity on existing land to conserve biodiversity and protect vulnerable land, as well as reducing agriculture's traditionally large environmental footprint.

Transgenic crops, for example, are one of the better land-saving technologies available, as they are designed to increase production on existing plots, avoiding slash and burn agriculture often practiced in developing countries. Indeed, "if the 377 million tons of additional food, feed and fiber produced by biotech crops during the period 1996 to 2012 had been grown conventionally, it is estimated that an additional 123 million hectares . . . of conventional crops would have been required to produce the same tonnage" (James, 2014a).

Transgenic crops have succeeded in reducing the environmental impact of agriculture by reducing pesticide use (by an estimated 8.5% in 2011 alone); and reducing fossil fuels and CO_2 emissions through less ploughing and less chemical spraying (saving approximately 1.9 billion kg of CO_2—the equivalent of removing 11.8 million cars from the road). The adoption of HT crops allows farmer to use a single broad-spectrum herbicide.

Limiting the practice of tilling, which is the use of mechanization for planting, weed control, and harvesting, is an important trend in sustainable agriculture. It refers to "direct planting into previous crop stubble without further soil disturbance" (Dill, *et al.,* 2008, p. 329). Farmers who practice conservation tillage aim to leave 30% residue on the surface of the soil, which can help reduce soil erosion by 70%.

Finally, several biotechnology tools, including tissue culture, diagnostics, genomics, and marker-assisted selection can be used collectively to isolate new traits such as drought or flood tolerance that can help mitigate the effects of climate change.

In 2012, drought wreaked havoc on maize production in the United States, highlighting what farmers in Africa already know: drought is, "by far, the single most important constraint to increased productivity for crops worldwide." The development of drought-tolerant crops is arguably the most important transgenic trait that will occur in the next decade of commercialization (Edmeades, 2013). The gene in question was isolated from a common soil bacterium known as *Bacillus subtilis.* It helps the plant cope better with stress caused by water shortages, allowing the plant to focus on filling the grains. In 2013, some 2,000 American farmers started to grow drought-tolerant maize. Indonesia has approved field trials of drought-tolerant sugarcane. Field trials of drought-tolerant maize, wheat, rice and sugarcane are in field trials in Argentina, Brazil, India, Egypt, South Africa, Kenya and Uganda (Marshall, 2014). It is hoped that the first drought-tolerant maize will be commercially available in sub-Saharan Africa by 2017.

In March 2008, a public-private partnership called 'Water Efficient Maize for Africa' (WEMA) was formed between Monsanto, which developed the drought-resistant technology; the African Agricultural Technology Foundation, which directs the partnership; the International Maize and Wheat Improvement Center; and five national agricultural research systems in East and Southern Africa (including Kenya, Mozambique, South Africa, Tanzania, and Uganda). WEMA is working to make the drought-resistant technology available to smallholder farmers through local and regional seed companies. The crop is being developed using conventional breeding, marker-assisted selection, and genetic modification to find the optimal crop for local conditions. Confined field trials thus far show 20–30% higher production than conventional hybrids. Sites were selected specifically for their dry conditions. The five national research systems are coordinating the field trials. WEMA hopes to offer at

least five "farmer-preferred" IR maize hybrids with and without the drought-tolerant gene by 2017, pending field trials and regulatory approval. It is undergoing field trials in Kenya, South Africa, and Uganda, but the regulatory regimes in Mozambique and Tanzania so far prohibit field trials.

The 2008 food crisis demonstrated the effect of an increase in demand and a tightening of supply on the price of rice. After severe flooding in 2007 and 2008 decimated rice production in Southeast Asia, twelve countries including India and China responded by initiating export restrictions. Riots broke out in Haiti, Bangladesh, and Egypt. Although the food crisis affected all grains, a shortage of rice would prove disastrous. According to the International Rice Research Institute (IRRI), in 2005, rice comprised 20% of global calories consumed; in Asia, 30%. In addition, "two-thirds of the world's poor . . . subsist primarily on rice." With consumption and prices rising, production declining, and climate change effects expected to grow (*e.g.,* Asia currently loses approximately $1 billion from flooding), IRRI estimates that "by 2015 the world must grow 50 million tons more rice per year than the 631.5 million tons grown in 2005. This will require boosting global average yields by more than 1.2% per year, or about 12% over the decade" (Normile, 2008).

Furthermore, 25% of the global rice supply comes from flood-prone regions. One solution has been to isolate the gene present in a variety of Indian rice that allows plants to survive after up to 3 weeks underwater. In collaboration with IRRI, researchers at the University of California at Davis used marker-assisted selection to breed this gene into locally important varieties. The result is a variety of rice that can tolerate flooding but which also retains the capability to produce high production. IRRI partnered with PhilRice, a nonprofit organization in the Philippines, to distribute the rice free of charge to seed growers and certain farmers who can disseminate further to other farmers. In 2011, over one million farmers in the Philippines, Bangladesh, and India planted the rice (Clayton, 2009; Ronald n.d.) So far, it has led to production increases of 1–3 tons after 10–15 days of flooding. Other varieties are also being studied, including drought tolerance, heat and cold tolerance, and salt tolerance. In Africa, IRRI is partnering with the Africa Rice Center (AfriRice) to develop rice that can tolerate poor soils.

Two other crops in the pipeline are being developed to resist cold temperatures (eucalyptus) and drought (sugarcane). These examples prove that agricultural biotechnology has the potential to increase the resilience of crops to climate change.

3. Regulatory Implications and Outlook

The claim that transgenic crops have no societal benefits is clearly false. As population growth, climate change, and rising food prices become more important, it is imperative to consider all options for increasing agricultural productivity. Transgenic crops offer one option in the agricultural innovation toolbox, and must be considered as such. To be sure, transgenic crops are not without criticism. However, biotechnology is an important tool that society can use to address food security. Risks should be taken into account and the technology strengthened, but to deny farmers the right to grow transgenic crops would be irresponsible.

Combating these production, economic, nutritional, and environmental challenges necessitates the expansion of the agricultural innovation toolkit, which includes agricultural biotechnology. It is important to note, however, that agricultural biotechnology is one option among many for increasing food security. To truly have an impact, it must be viewed in a context of system-wide improvements in agriculture (Juma and Gordon, 2014).

Agricultural biotechnology, which was commercialized on a large scale in 1996, refers to the application of scientific information and methods such as genetic modification of crops or animals to select certain traits that are more productive or desirable. Plant breeders have long sought to improve crops through traditional methods such as cross-breeding and hybridization, a time-consuming process that results in the presence of undesirable traits mixed in with desirable ones. Genetic modification is a significantly faster, more precise technology that is designed to achieve similar results as conventional plant breeding techniques by allowing the transfer of one specific gene to another plant.

The major types of transgenic crops commercially available are herbicide-tolerant crops that are resistant to broad-spectrum herbicides such as glyphosate and gluphosinates; insect-resistant crops that include genes from a specific bacterium, *Bacillus thuringiensis* (*Bt*), which is poisonous to certain insects and not humans; and crops with a combination of both (stacked trait). HT and IR traits help make weed and pest control more efficient, as crops need fewer applications of herbicides and/or eliminate the need for pesticides. HT crops are the most common, comprising more than ½ of the 175 million hectares of transgenic crops grown globally in 2013,

followed by stacked-trait crops at 27%, and IR crops at around 16% (James, 2014a; James, 2014b).

Both first- and second-generation transgenic crops are produced commercially; most consist of animal feed, fiber, and biofuels. First-generation crops typically have a single trait introduced. Newcomers, such as Burkina Faso, benefit most from adopting second-generation transgenic seeds, which contain two or more genes to resist specific pests or weeds. Monsanto's Genuity™ Bollgard II® cotton, for example, "work[s] against leaf-eating species such as armyworms, budworms, bollworms, and loopers . . . [and] cotton leaf perforators and saltmarsh caterpillars" (Juma, 2011a, p. 37). Second-generation cotton is a superior technology because it takes longer for pests to develop resistance. First-generation transgenic technology is still beneficial but will break down sooner in terms of pest resistance. Researchers and scientists have come a long way since developing these early-generation crops. Today there are also multi-HT crops such as corn, cotton, and soybeans that provide farmers with even more options for combating weeds. It is important to note, however, that most transgenic crops grown today are either cash crops or are used in animal feed, cooking oils, and biofuels (Rotman, 2013). Opposition to transgenic food crops has been so strong that investment in their development has been limited. There are, however, transgenic crops in the pipeline have the potential to offer significant societal benefits if they can overcome regulatory hurdles and reach the market. These crops will be discussed in the following sections.

Developing countries have seen clearly the potential of transgenic crops to increase agricultural productivity, income, and food security. Since their commercial introduction in 1996, transgenic crops have been one of the "fastest adopted crop technologies in recent history" (James, 2014a). In 2013, "a record 175.2 million hectares of biotech crops were grown globally . . . at an annual growth rate of 3%" (James, 2014a). This is a 100-fold increase from 1996, when 1.7 million hectares were planted. Of the 28 countries that plant transgenic crops, 20 are developing countries. Finally, 90% of those who grew biotech crops—that is, more than 16 million—were resource-poor smallholder farmers in developing countries (*Ibid.*). The impact of transgenic crops at the farm level has been significant. In 2011 alone, net economic benefits were $19.8 billion, and cumulative economic benefits amounted to $98.6 billion since 1996. The key point is that the "majority of these gains (51.2%) went to farmers in developing countries" (Brookes and Barfoot, 2013, p. 74).

Yet countries worldwide could benefit even more from adapting biotechnology to address local problems. The technology used to delay the ripening of tomatoes, for example, could be applied to tropical fruits, which ripen too quickly and end up going to waste due to lack of proper storage or transportation infrastructure. Another problem that is prevalent in tropical countries is soil acidity. "Acidic soils comprise about 3.95 billion ha . . . about 68% of tropical America, 38% of tropical Asia, and 27% of tropical Africa. In spite of its global importance . . . problems that affect acid soils are investigated by only a handful of scientists in developed countries" (Herrera-Estrella, 2000, p. 924). This problem is not limited to soil acidity. In fact, there is much scope for developing countries, especially in Africa, to invest in their own science and technology research institutes, which would allow local scientists to come up with solutions specific to local contexts. This is also relevant for the United States, which is spending millions of dollars combating citrus greening in Florida, Texas, and California, where the simplest and most cost-effective solution would be to employ agricultural biotechnology.

Despite the obvious benefits, however, transgenic crops and animals for human consumption face some the most stringent regulatory processes throughout the world. As an example, a Massachusetts-based firm, AquaBounty Technologies, developed a transgenic salmon that could mature in ½ the time while retaining material equivalence with its natural counterparts. In 1995, the firm applied to the U.S. Food and Drug Administration (FDA) for approval of AquAdvantage salmon. By the end of 2013, the fish had passed all the human health, environmental safety assessments required by FDA but still has not been granted approval. Transgenic crops face identical regulatory hurdles.

Society must overcome strong regulatory barriers to adoption of transgenic crops. One of the biggest barriers to adoption is the controversy over the safety of transgenic crops, both in terms of human consumption and their effect on the environment. However, recent studies tend to support the safety of transgenic crops. For example, the European Commission funded more than 50 research projects involving 400 researchers at the cost of €200 million to evaluate this issue and found that "the use of biotechnology and of GE plants *per se* does not imply higher risks than classical breeding methods or production technologies" (European Commission, 2010, p. 16). A literature review covering the last 10 years of transgenic crop safety and effects on biodiversity and human health concludes that "the scientific research

conducted thus far has not detected any significant hazard directly connected with the use of GM crops" (Nicolia, *et al.,* 2013, p. 2).

Despite the growing body of scientific evidence, many countries around the world still follow a strict interpretation of the European regulatory model, which uses the precautionary principle to evaluate transgenic crops (as opposed to the United States, which evaluates the crop itself). Given the differences between U.S. and European regulatory systems, there is a lack of harmonization that hinders the adoption process. A final barrier to adoption is that farmers in emerging countries have little political power and cannot make the case for adoption, despite comprising such a large percentage of the population. This is not always the case, however. South Africa, for example, has produced transgenic crops for the past 18 years and has a particularly effective biosafety regulatory framework and R&D investment. South Africa also trained farmers and scientists and embarked on a substantive public awareness campaign. In addition, farmers groups (including both large-scale and smallholder farmers) were supportive of the adoption of transgenic crops (Adenle, *et al.,* 2013).

Similar forward-looking strategies need to be adopted in emerging countries. The focus should first be on developing strategies, policies, and laws aimed at promoting biotechnology. Biosafety should be part of a broader biotechnology development strategy, not the other way around. Such an approach should seek to create a coordinated biotechnology research strategy that involves government, national research institutes, universities, the private sector and relevant civil society organizations. A broad consultative process should be launched that seeks to enable emerging countries to leapfrog in biotechnology in the same way they did in mobile technology. Failure to do so would be to mortgage emerging economies to the forces of technological stagnation, agricultural decline, and economic decay.

Conclusion

The future of the role of transgenic crops in addressing global challenges will be influenced greatly by advances in science and technology. New developments in genomics, molecular biology, and other allied fields will expand technological options in ways that will address some of the current uncertainties. The growth in technological abundance will also play an important role in democratizing biotechnology and bringing more players into the field. This will go a long way in helping to spread the societal benefits of biotechnology.

However, advances in biotechnology research can only be translated into societal benefits with the help of enabling policy environments. More important, regulatory processes need to be brought in line with the state of knowledge on the benefits and risks of biotechnology. The United States has historically played a critical role in the creation of the biotechnology industry by crafting founding legislation. The time has come for the United States to renew its leadership role by ensuring that regulatory processes help to spread further the benefits of biotechnology.

References

Adenle, A.A., Morris, E.J., and Parayil, G., 2013. *Status of development, regulation, and adoption of GM agriculture in Africa: View and positions of stakeholder groups.* FOOD POLICY, 43, pp. 159–166.

Arjó, Gemma, *et al.* 2013. *Plurality of Opinion, Scientific Discourse and Pseudoscience: An In Depth Analysis of the Séralini,* ***et al.*** *Study Claiming that Roundup™ Ready Corn or the Herbicide Roundup™ Cause Cancer in Rats.* TRANSGENIC RESEARCH, 22(2), pp. 255–67.

Belay, M. and Nyambura, R., 2013. *GM Crops Won't Help African Farmers.* GUARDIAN POVERTY MATTERS blog, [blog], 24 June. Available at: *http://www.theguardian.com/global-development/poverty-matters/2013/jun/24/gm-crops-african-farmers* [Accessed 1 November 2013].

Brookes, G., and Barfoot, P., 2014. *GM crops: global socio-economic and environmental impacts 1996–2012.* PG Economics Ltd.

Brookes, G. and Barfoot, P., 2013. *The global income and production effects of genetically modified (GM) crops 1996–2011.* GM CROPS AND FOOD: BIOTECHNOLOGY IN AGRICULTURE AND THE FOOD CHAIN 4(1), pp. 74–83.

Butelli, Eugenio, *et al.* 2008. *Enrichment of tomato fruit with health-promoting anthocyanins by expression of select transcription factors.* NATURE BIOTECHNOLOGY 26(11), pp. 1301–08.

Carpenter, J.E. 2013. *The socio-economic impacts of currently commercialised genetically engineered crops.* INTERNATIONAL JOURNAL OF BIOTECHNOLOGY 12(4), pp. 249–268.

Clayton, S., 2009. *Filipino farmers welcome new rice varieties.* IRRI. [media release] 4 June. Available at *http://irri.org/index.php?option=com_k2&view=item&id=8151&Itemid=100588&lang=en* [Accessed 1 November 2013].

Dill, G.M., Cajacob, C.A., and Padgette, S.R., 2008. *Glyphosate-resistant crops: adoption, use and future considerations.* PEST MANAGEMENT SCIENCE, 64(4), pp. 326–331.

Edmeades, G.O., 2013. *Progress in Achieving and Delivering Drought Tolerance in Maize—An Update.* Ithaca, NY: ISAAA.

European Commission. 2010. *A Decade of EU-funded GMO Research.* Brussels: European Commission. *ftp://ftp.cordis.europa.eu/pub/fp7/kbbe/docs/a-decade-of-eu-funded-gmo-research_en.pdf.*

Goering, L., 2012. *FEATURE—'Green bullet' innovations aim to feed world of 9 billion.* Reuters, 2 May.

Gonsalves, D. 2004. *Transgenic papaya in Hawaii and beyond.* AGBIOFORUM 7(1–2), pp. 36–40.

Hammadi, Saad. 2014. *Bangladeshi farmers caught in row over $600,000 GM aubergine trial.* GUARDIAN. June 4. *http://www.theguardian.com/environment/2014/jun/05/gm-crop-bangladesh-bt-brinjal*.

Herrera-Estrella, L.R., 2000. *Genetically Modified Crops and Developing Countries.* PLANT PHYSIOLOGY 124(3),pp. 923–926.

Huang, J., Pray, C. and Rozelle, S., 2002. *Enhancing the Crops to Feed the Poor.* NATURE, August 8.

International Service for the Acquisition of Agri-biotech Applications (ISAAA), 2013. *Global biotech/GM crop plantings increase 100-fold from 1996; developing countries, including new adopters Sudan and Cuba, now dominate use of the technology.* ISAAA Brief No. 44. [press release] 20 February. Available at *http://www.isaaa.org/resources/publications/briefs/44/pressrelease/* [Accessed 1 November 2013].

International Rice Research Center (IRRI), n.d. *Climate change-ready rice.* [Online briefing]. Available at *http://irri.org/index.php?option=com_k2&view=item&id=9148&lang=en* [Accessed 1 November 2013].

James, C. 2013. Executive summary. *In Global Status of Commercialized Biotech/GM Crops: 2012,* ISAAA Brief No. 44. Ithaca, N.Y.: ISAAA.

James, C. 2014a. Executive summary. *In Global Status of Commercialized Biotech/GM Crops: 2013,* ISAAA Brief No. 46. Ithaca, N.Y.: International Service for the Acquisition of Agri-Biotech Applications.

James, C. 2014b. ISAAA brief 46–2013: Slides & tables. *2013 ISAAA Report on Global Status of Biotech/GM Crops,* February 2014, *http://www.isaaa.org/resources/publications/briefs/46/pptslides/default.asp*.

Juma, C., and Gordon, K. 2014. *Leap-frogging in African agriculture: the case of genetically modified crops.* In FORESIGHT AFRICA. Washington, D.C.: Brookings.

Juma, C., Conceição, P., and Levine, S., 2014. *Biotechnology and food security.* In S. Smyth, D. Castle and P.W.B. Phillips eds. 2014. HANDBOOK ON AGRICULTURE, BIOTECHNOLOGY AND DEVELOPMENT. Cheltenham, UK: Edward Elgar.

Juma, C. 2013. *Growing the nutritional revolution: a plea for niche crops.* Nestle Foundation Report. Lausanne, Switz: Nestle Foundation, pp. 34–36.

Juma, C., 2011a. *The New Harvest: Agricultural Innovation in Africa.* New York: Oxford University Press.

Juma, C., 2011b. *Preventing Hunger: Biotechnology Is Key.* NATURE, No. 479 (November 2011).

Juma, C., Ismail Serageldin, *et al.* 2007. *Freedom to Innovate: Biotechnology in Africa's Development.* Report of the High-Level African Panel on Modern Biotechnology. Addis Ababa, Ethiopia, and Pretoria, South Africa: New Partnership for Africa's Development, African Union. *http://belfercenter.ksg.harvard.edu/publication/17382/freedom_to_innovate.html*.

Kathage, J., and Qaim, M., 2012. *Economic Impacts and Impact Dynamics of **Bt** (**Bacillus thuringiensis**) cotton in India.* Proceedings of the National Academy of Sciences 109(29),pp. 11652–11656.

McHughen, Alan. 2013. *GM crops and foods: what do consumers want to know?* GM CROPS AND FOOD: BIOTECHNOLOGY IN AGRICULTURE AND THE FOOD CHAIN 4(3), pp. 1–11.

National Academy of Sciences (NAS). 2010a. *Strategic Planning for the Florida Citrus Industry: Addressing Citrus Greening.* Washington, D.C.: NAS.

National Academy of Sciences (NAS). 2010b. *Impact of Genetically Engineered Crops on Farm Sustainability in the United States.* Washington, D.C.: NAS.

Nicolia, A., Manzo, A., Veronesi, F., and Rosellini, D., 2013. *An Overview of the Last 10 Years of Genetically Engineered Crop Safety Research.* CRITICAL REVIEWS IN BIOTECHNOLOGY, 34(1), pp. 77–88.

Normile, D., 2008. *Reinventing Rice to Feed the World.* SCIENCE, July 18, pp. 330–333.

Pray, C.E., Nagarajan, L., Huang, J., Hu, R., and Ramaswami, B., 2011. *The Impact off **Bt** Cotton and the Potential Impact of Biotechnology on Other Crops in China and India.* In C.A. Carter, G. Moschini, and I. Sheldon, eds. 2011. FRONTIERS OF ECONOMICS AND GLOBALIZATION, Vol. 10. London: Emerald. Ch. 4.

Qaim, M., and Kouser, S., 2013. *Genetically Modified Crops and Food Security.* PLOS ONE, 8(6), pp. 1–7.

Ray, D.K., Mueller, N.D., West, P.C., and Foley, J.A. 2013. *Yield trends are insufficient to double global crop production by 2050.* PLoS ONE 8(6), pp. 1–8.

Ricroch A.E., Bergé, J.B. and Kuntz M. 2011. *Evaluation of Genetically Engineered Crops Using Transcriptomic, Proteomic, and Metabolomics Profiling Techniques.* PLANT PHYSIOLOGY, 155(4), pp. 1752–1761.

Redfern, S.K., Azzul, N., and Binamira, J.S. 2012. *Rice in Southeast Asia: facing risks and vulnerabilities to respond to climate change.* In BUILDING RESILIENCE FOR ADAPTATION TO CLIMATE CHANGE IN THE AGRICULTURE SECTOR. Rome: Food and Agriculture Organization.

Ronald, P., n.d. *New flood-tolerant rice offers relief for world's poorest farmers.* Ronald Laboratory, University of California at Davis. [press release]. Available at *http://indica.ucdavis.edu/news/new-flood-tolerant-rice-offers-relief-for-worlds* [Accessed 1 November 2013].

Rotman, D. 2013. *Why we will need genetically modified foods.* MIT TECHNOLOGY REVIEW. December 13. *http://www.technologyreview.com/featuredstory/522596/why-we-will-need-genetically-modified-foods/*.

Searchinger, T., *et al.* 2013. *Creating a Sustainable Food Future.* Washington, D.C.: World Resources Institute. Available at *http://www.worldresourcesreport.org*.

Séralini, Gilles-Eric, *et al.,* 2012. *Long Term Toxicity of a Roundup Herbicide and a Roundup-Tolerant Genetically Modified Maize.* FOOD AND CHEMICAL TOXICOLOGY, 50 (11), pp. 4221–31.

Sexton, S. and Zilberman, D., 2010. *How Agricultural Biotechnology Boosts Food Supply and Accommodates Biofuels.* NBER Working Paper No. 16699. Cambridge, MA: National Bureau of Economic Research.

Shukman, David. 2014. "Genetically-modified purple tomatoes heading for shops." BBC. January 14. *http://www.bbc.com/news/science-environment-25885756*.

UK Council for Science and Technology. 2013. *GM Science Update.* London: Council for Science and Technology. *https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/292174/cst-14-634a-gm-science-update.pdf* [Accessed 6 July 2013].

United Nations Food and Agriculture Organization (FAO). 2009. *Declaration of the World Summit on Food Security.* Rome, Italy, 16–18 November, *ftp://ftp.fao.org/docrep/fao/Meeting/018/k6050e.pdf*.

Vitale, J.D., 2010. *The Commercial Application of GMO Crops in Africa: Burkina Faso's Decade of Experience with **Bt Cotton.*** AGBIOFORUM, 13(4), pp. 320–332.

Wamboga, P., 2011. *Vitamin A and Iron-rich bananas under trial in Uganda.* BIOVISION, 16 (February) [newsletter]. Available at: *http://www.biovisioneast africa.com/publications/Biovision-16.pdf* [Accessed 1 November 2013].

World Bank. 2008. *World Development Report 2008: Agriculture for Development.* Washington, D.C.: World Bank.

Zilberman, D., Sexton, S.E., Marra, M., and Fernandez-Cornejo, J., 2010. *The Economic Impact of Genetically Engineered Crops.* CHOICES, 25(2), pp. 1–25.

Acknowledgements

This submission is based on Juma, Calestous and Gordon, Katherine (Forthcoming), *Transgenic Crops and Food Security,* in Ricroch, A., Chopra, S., and Fleischer, S. eds. PLANT BIOTECHNOLOGY—EXPERIENCE AND FUTURE PROSPECTS. Dordrecht, The Netherlands: Springer. Additional information was derived from the author forthcoming book, *Innovation and Its Enemies: Resistance to New Technology.*

Biographical Summary

Professor Calestous Juma, a Kenyan national, is an internationally recognized authority on the role of science, technology, engineering and innovation in sustainable development. He is Professor of the Practice of International Development and Director of the Science, Technology, and Globalization Project at Harvard Kennedy School. He is also Faculty Chair of the Mason Fellows Program and Faculty Chair of the Innovation for Economic Development Executive Program.

Professor Juma directs the School's Agricultural Innovation Policy in Africa Project funded by the Bill and Melinda Gates Foundation. He teaches graduate courses on innovation for economic development and resistance to new technology

as well as an undergraduate seminar on biotechnology and sustainability. Professor Juma has been selected as a Dr. Martin Luther King, Jr. Visiting Professor at the Massachusetts Institute of Technology over the 2014–2015 academic year.

He has conducted extensive policy research on biotechnology, having written his first book on the subject, *The Gene Hunters: Biotechnology and the Scramble for Seeds* (Princeton University Press and Zed Books) in 1989. His previous positions include: founding Executive Director of the African Centre for Technology Studies in Nairobi; Director of International Diffusion of Biotechnology Programme of the International Federation of Institutes of Advanced Study in Maastricht, The Netherlands; Executive Secretary of the UN Convention on Biological Diversity (where he oversaw the initiation of the negotiations that resulted in the adopted of the Cartagena Protocol on Biosafety); and Chancellor of the University of Guyana.

Professor Juma co-chaired the African Union's High-Level Panel on Modern Biotechnology and the High-Level Panel on Science, Technology and Innovation. He has also chaired or served on committees of the U.S. National Academy of Sciences dealing with agricultural biotechnology. He is currently on the judging panels of the Queen Elizabeth Prize for Engineering and the Africa Prize for Engineering Innovation. He has served on the boards of numerous international organizations and universities including WWF International and is currently a trustee of the Aga Khan University.

In recognition of his research, Professor Juma has been elected to several scientific and engineering academies including the Royal Society of London, the U.S. National Academy of Sciences, the World Academy of Sciences (TWAS), the UK Royal Academy of Engineering, the African Academy of Sciences. In 2006 he was honored by the Order of the Elder of the Burning Spear (EBS) by the President of the Republic of Kenya for being a respected international diplomat who has assisted governments to solve diplomatic problems.

Professor Juma holds a D.Phil. in science and technology policy studies from the University of Sussex (UK) and has received numerous international awards and honorary degrees for his work on sustainable development in general and biotechnology in particular. He is editor of the peer-reviewed *International Journal of Technology and Globalisation* and the *International Journal of Biotechnology.* His latest book, *The New Harvest: Agricultural Innovation in Africa,* was published in 2011 by Oxford University Press. His forthcoming book, *Innovation and Its Enemies: Resistance to New Technology,* covering case studies spanning the period 1490–2014, is currently under consideration by a publisher.

Mr. DAVIS. Thank you, Dr. Juma.

We will go next to Dr. Olga Bolden-Tiller, an assistant professor at Tuskegee University. Dr. Bolden-Tiller.

STATEMENT OF OLGA BOLDEN-TILLER, PH.D., ASSOCIATE PROFESSOR, TUSKEGEE UNIVERSITY, TUSKEGEE, AL

Dr. BOLDEN-TILLER. Thank you, and like the others, I would like to thank you all for the invitation.

As an Associate Professor at Tuskegee University and the chair for the department of agriculture, I would like to share with you a little bit about why the utilization of technology feeding the world is an old idea.

In his thesis entitled, *Plants as Modified by Man,* back in the late 1800s, George Washington Carver wrote ". . . the day is not far distant when man . . . will be able to use the tools nature has placed before him from a purely scientific basis, free from all conjecture.", which we are facing here today. At the time, the tools that Carver referred to were not biological tools, but the technology at his time were instead that of breeding, selection of varieties, budding, and grafting.

Carver noted that: "Ever since science overthrew the idea of spontaneous generation and established beyond doubt that no organism could have existence without a parent cell, the scientific world received a thunderbolt which was to be the means of its first great awakening." He also suggested in his thesis, "as the message was

heralded from one to another it aroused more careful investigation, stimulated advanced thought and opened up a new line of possibilities respecting the whole plant kingdom.", and this has led to us where we are today with biotechnology, and the development of these biological tools.

Technological tools and advances have been adopted in many fields. However, when posed for agricultural products, some hesitate, and this is disturbing. Even Carver noted back in his thesis that, "the chemist takes original elements or compounds, breaks up their combination or combines them into various proportions to suit his purpose . . ."

Today, this would be new medications and the development of other products, such as with material science engineering. This is not said to attack those fields but to draw parallels as these scientists are working within the laws of nature to formulate these new derivatives.

Similarly, biotechnology allows those in life sciences who work with plants and animals to do is same. As the laws of nature themselves are not being violated, we are simply utilizing the laws of nature with these new biological tools in order to create and propagate new varieties of existing products.

In his thesis, Carver suggested that: "This was the dawn of a new era. [and that] . . . man was not simply to assist nature in producing endless varieties, but be the actual progenitor of new creations." He went on to reference several scientists' work that had resulted in the development of novel and more robust crop varieties, similar to what we talk about today with biotechnology, through the uses of these new technological tools that have resulted in increases in yields.

When we consider the benefits of biotechnology to society, we can focus on any single area of agriculture and identify the positive impacts of technology. For instance, to address the issue of poor nutrition in developing countries, a derivative of the sweet potato produced at Tuskegee University was shown to have increased protein content up to 500 percent. If consumed by individuals in areas where protein sources are scarce, these individuals will have at their fingertips a food source that can mean the difference between malnutrition and survival.

When we consider food production here in the U.S., a developed nation, it is clear that food production requires many resources and labor to manage crops. Utilizing technology will allow us to do this in a very sustainable manner.

With every great awakening, scientific or otherwise, questions will arise. Skeptics will ensue; however, it is critical that we as a society look at the facts, and the facts are these: The incorporation of GMO crops into operations in developing countries result in increased farm incomes and reduced labor associated with agricultural practices. This allows for more time for education and other avenues of income. It is predicted that food production must double within the next 30 years to meet the demands of the predicted population, and biotechnology provides scientists with answers to these things in a very affordable and sustainable way.

The science is advancing. What is not advancing adequately is the communication and conversations about biotechnology with all

components of our society. Creativity and resources must be increased to bring all members of the U.S. family along, in terms of sharing in the benefits of these new technologies in order to improve our quality of life not only here in the United States but around the world.

Thank you.

[The prepared statement of Dr. Bolden-Tiller follows:]

PREPARED STATEMENT OF OLGA BOLDEN-TILLER, PH.D., ASSOCIATE PROFESSOR, TUSKEGEE UNIVERSITY, TUSKEGEE, AL

Technology Can Feed the World: An Old Idea

In his thesis "Plants as Modified by Man," George Washington Carver wrote over 100 years ago that, ". . . the day is not far distant when man . . . will be able to use the tools nature has placed before him from a purely scientific basis, free from all conjecture." At the time, the tools to which Carver referred were not biotechnological tools, but instead tools and techniques that we find common today, including breeding and selection of varieties, budding and grafting. Carver noted that: "Ever since science overthrew the idea of spontaneous generation and established beyond doubt that no organism could have existence without a parent cell, the scientific world received a thunderbolt which was to be the means of its first great awakening." He also suggested in his thesis that, "as the message was heralded from one to another it aroused more careful investigation, stimulated advanced thought and opened up a new line of possibilities respecting the whole plant kingdom." Fast forward . . . the evolution of biotechnological tools have yielded another Awakening; one that has grown exponentially, resulting in an ever increasing amount of data, which has led to the subsequent development of additional biotechnological tools being used to understand and apply this new knowledge.

Technological advances are used in many fields of science (*e.g.,* medicine); however, when posed for agricultural products, some hesitate. Even Carver noted in his thesis that, "the chemist takes original elements or compounds, breaks up their combination or combines them into various proportions to suit his purpose . . ." be that purpose to design new medicines or other products, such as those that result from material science engineering. This is said not to attack those fields, but to draw on parallels, as these scientists are working within laws of nature to formulate these new derivatives,; similarly biotechnology allows those in the life sciences who work with plants and animals to do the same, as the laws of nature themselves are not being violated, thus the resultant products continue to propagate with targeted outcomes. In his thesis, Carver suggested that: "This was the dawn of a new era. [and that] . . . *man was not simply to assist nature in producing endless varieties, but be the actual progenitor of new creations.*" He went on to reference several scientists' works that had resulted in the development of novel and more robust crop varieties through the usage of the new technological tools of that time, such as selection, cross fertilizing and cultivating, with resultant increasing fruit and flower yields up to four-fold.

When we consider the benefits of biotechnology to society, we can focus on any single area of agriculture and identify the positive impact(s) of the technology. For instance, to address the issue of poor nutrition in developing countries, a derivative of the sweetpotato, produced at Tuskegee University, was shown to have increased protein content, up to 500%. If consumed by individuals in areas where protein sources are scarce, these individuals will have at their fingertips a food source that can mean the difference between malnutrition and survival. When we consider food production here in the U.S., a developed nation, it is clear that food production requires many natural resources and labor to manage crops. However, varieties of crops that require less labor, less water and less land have resulted in lower food costs, making food products more affordable domestically. This also results in sustainable agricultural practices that are necessary to reduce the human footprint on the environment. Further, as we yield food surpluses, we also are able to export them to countries that may not have the ability to produce adequate food for their needs allowing the U.S. to play a significant role in feeding the world.

With every "great awakening," scientific or otherwise, questions will arise; skeptics will ensue; however, it is critical that we as a society look at the facts. And the facts are these: (1) the incorporation of GMO crops into operations in developing countries result in increased farm incomes and reduced labor associated with agricultural practices, allowing for more time for education and other avenues of income; (2) it is predicted that food production must double within the next 30 years

to meet the demand of the projected population; (3) biotechnology provides scientists with answers that can result in the production of more affordable foods while sustaining the environment. This is not to say that technology should be haphazardly implored, as care must be taken and questions must be asked. Carver suggested that "man is simply nature's agent . . . to assist her in her work, hence the more careful and scientific the man, the more valuable he is as an aid to nature in carrying out her plans methodically . . . ." Irrespective of one's positions, it is sure that society must be educated about current biotechnology and forthcoming tools to come for the future.

The science is advancing; what is not advancing adequately is the communication and conversations about biotechnology with all components of our society. Creativity and resources must be increased to bring all members of the U.S. family along in terms of sharing in the benefits of the new technologies to improve in their quality of life.

Mr. DAVIS. Thank you, Dr. Bolden-Tiller.

And last, I would like to go to Ms. Joanna Lidback.

STATEMENT OF JOANNA S. LIDBACK, OWNER, THE FARM AT WHEELER MOUNTAIN, WESTMORE, VT; ON BEHALF OF AGRI-MARK, INC.; NATIONAL COUNCIL OF FARMER COOPERATIVES

Ms. LIDBACK. Mr. Chairman, Ranking Member, and other Members of the Subcommittee, thank you for inviting me here today.

I am here on behalf of Agri-Mark Dairy Cooperative and the National Council of Farmer Co-ops. My husband and I have a small 45 cow dairy located in northeast Vermont. We also make extra hay to sell. We raise Jersey steers to process and sell beef locally and market a small amount of compost and manure. We have two young boys ages almost 3 and 16 months.

My husband and I are both proud to be first generation dairy farmers. We believe in the science and the capability of biotechnology and its role in protecting the sustainability of our farm. Biotech crops are essential to feeding our cows and calves. We feed both GMO corn and soy products year round along with pasturing and a grass-based silage.

GMOs are also key to our economic sustainability. For instance, in speaking with our dairy nutritionist earlier this week, he pointed out that the only non-GMO grain he could get us right now was organic. Our grain costs would go from $344 per ton to $758. We use about 15 tons of grain per month. Over the course of the year, our costs would increase by nearly $75,000. I don't see how we could survive, let alone farm profitably with those increased feed costs.

Beyond GMOs, we utilize other products derived from biotechnology across our operation, from genomic testing of our Jersey cattle to the medicines, vaccines, and tests we use to keep our animals healthy.

In the future, we are also considering growing our own corn and adding alfalfa to our mix. Given our location, we would need a shorter-day corn variety. Without genetic engineering, we would not have this opportunity, and economically, it would not make sense.

I personally believe that there is room for many different styles of farming. I also believe that biotechnology plays a major role in our collective ability to not only feed a growing global population but also to make individual improvements on our own farms. As a

mother and as a consumer, I do not purchase organic or non-GMO food in the store. I generally do not believe in paying a premium for foods that provide no added nutritional, health, or environmental benefits. I feel secure in the steps taken to ensure the safety of the food I give my two growing boys.

So you must be aware that recently my State of Vermont passed a mandatory GMO labeling law. However, it is important to note that consumers do currently have choices in the grocery store aisle, whether it is a certified organic label or a voluntary non-GMO label. As my fellow panelists can and have attested, the science shows that GMOs are safe and bring tremendous benefits to farmers, consumers, and the environment, but we in agriculture have failed to connect with the public, and this has allowed misinformation to spread.

Related to that debate, I recently wrote to the editor of my local paper and posted it on my blog, *farmlifelove.com.* It was responding to an organic farmer's letter that berated conventional farmers and their use of GMOs. I was more nervous about the possible backlash from my local community than about anything I had ever posted on my blog. It turned out I had no reason to be. I found support, good questions, and many thank you's for speaking up. I am happy to continue to speak up to our right to farm in whatever we choose, which in our case includes biotechnology and the use of GMOs.

It is important to share my knowledge about the opportunities and challenges we face as modern day farmers and as modern day parents. When I have one person or ten people reach out to me for a question or appreciating my hands on and practical perspective from the farm, then I have succeeded.

We know more now than we ever have about growing food and caring for animals, and this helps us to achieve a level of productivity and sustainability that previous generations of farmers would envy. All of this leads to lower food costs for the consumer. I am proud of how far the American farmer has come just as I am proud of how far we have come on our own farm. If my sons choose to continue in farming, I want to know that my husband and I have provided them with a firm foundation to build on.

Thank you again for the opportunity to be here today and to share my experience with biotechnology. I look forward to answering any questions you may have. Thank you.

[The prepared statement of Ms. Lidback follows:]

PREPARED STATEMENT OF JOANNA S. LIDBACK, OWNER, THE FARM AT WHEELER MOUNTAIN, WESTMORE, VT; ON BEHALF OF AGRI-MARK, INC.; NATIONAL COUNCIL OF FARMER COOPERATIVES

Chairman Scott, Ranking Member Schrader, and other Members of the Subcommittee, thank you for inviting me here to talk about the benefits of agricultural biotechnology. Today I am here on behalf of Agri-Mark Dairy Cooperative and the National Council of Farmer Cooperatives.

My husband and I have a small 45 cow dairy located in northeast Vermont. We also make extra hay to sell, raise Jersey steers to process and sell beef locally, and market a small amount of composted manure. We rent our farm from my husband's aunt and uncle, and it consists of over 200 acres of tillable land, including roughly 50 acres of pasture where we graze our herd in temperate months. We also raise all of our own young stock or replacement heifers. We have two young boys, ages almost 3 and 16 months.

Along with being an active partner on the farm, I have a full-time job with a Farm Credit Association that allows me to work remotely from our home, and serve

as first vice president of our county Farm Bureau and as a dairy cattle judge for various youth and 4–H dairy shows across New England. I did not grow up on a farm but got involved in agriculture through a 4–H dairy project as a young girl in 1989. Since then, I have not let go of my Jersey cows. I boarded my animals on neighboring farms and as fate would have it met a newly-minted dairy farmer who I would eventually settle down with, bringing my Jerseys along. I have a bachelor's degree from Cornell University where I focused on agribusiness management and a master's in business administration from the F.W. Olin School of Business at Babson College.

My husband and I are both proud to be first-generation dairy farmers. We are excited to be raising our sons in a farming lifestyle—one which we think is extremely challenging at times but ultimately tremendously rewarding.

We are proud to farm in the Green Mountain State but sometimes that fact comes with some preconceived notions. To approach our farm with its rolling green hills and the cows grazing quietly in the pastures—taking note of the humble nature of our small farm—many passers-by have mistaken us for organic dairy farmers. However, we believe in the science and capability of biotechnology and its role in protecting the sustainability of our farm, which produces safe, affordable food for our fellow citizens.

To us, sustainability means living and farming in a way that meets today's needs while ensuring that future generations also can meet their needs. Every time I look into my sons' eyes, I realize that they are that next generation, which makes our responsibility that much more tangible.

Biotechnology crops are essential to feeding our cows and calves. When New England's harsh winters and late springs keep us from pasture feeding our livestock, we feed both corn and soy products. This gives us a unique perspective on the importance of GMOs. We believe that GMO varieties improve the efficiency and productivity. I also believe that GMOs lessen the environmental impact that growing can have because less fertilizer and pesticides are used to grow an abundant crop.

The use of GMOs is also important to the economic sustainability of our farm. In speaking with our animal nutritionist in preparing for this testimony, he pointed out that the only non-GMO feed he could get us right now was organic. An organic basic 20% protein complete feed pellet would cost $758 per ton; the same non-organic feed is $344 per ton. On our small farm, we purchase around 15 to16 tons of grain per month. So, using 15 tons, that would more than double our grain bill, or in hard numbers we would spend $5,160 per month for regular feed or $11,370 per month on organic feed—a difference of $6,210 a month or $74,520 per year. I do not see how we could profitably farm in the long term with those increased feed costs.

The most recent example of biotechnology that we have utilized is genomic testing on our cattle. This not only helps us more accurately identify physical traits that impact our breeding decisions for future offspring of the animal, but also captures any genetic issue of concern. For example, the Jersey Haplotype 1, recently identified in Jersey cattle, is associated with early embryonic loss thereby reducing conception rate by an average of 3.7 percent. We choose to use sires that have been identified as JH–1 free, particularly if we know we have a cow that is a carrier. In doing so, we increase our chances for a more efficient reproductive cycle and ultimately less stress on the cow.

We also rely upon biotechnology for some of the medicines and vaccines we use for our cattle. Tests using Polymerase Chain Reaction (PCR), a DNA screening test, help us determine specific causes of mastitis in cows. This advancement in mastitis testing increases the speed and accuracy to a quantitative level in order to treat the specific cause of the infection. The PCR process can reduce result waiting time by as much as a week, providing the animal with more immediate infection relief using the most precise and effective treatment.

In the future, we also are considering growing our own corn and adding alfalfa to our mix. Given our location, we will need a shorter-day corn variety, meaning it would grow in less time than average. Without genetic engineering, we would not have this opportunity. Economically it would not make sense.

We face a challenge brought on by what many in agriculture see as irrational consumer fears creating the potential for limiting our ability to use biotechnology in order to best utilize the resources we have in a sustainable way. In many cases, this has already happened as we saw with the controversy over use of recombinant Bovine Somatotropin (rBST), a technology that has no adverse effects on human health. Consumers, not understanding the science and being driven by fear stirred up by anti-agriculture activists, rejected this technology for no sound reason. While many said that rBST was an example of the evils of "big agriculture," the truth is that many small dairy farms used rBST as a way to improve and grow their busi-

nesses, better utilizing existing resources and without needing more capital expenditures. Now, driven by the marketplace, our cooperative generally must restrict its members from using rBST.

I personally believe that there is room for many different styles of farming. I also believe that biotechnology plays a major role in our collective ability to not only feed a growing global population, but to also make individual improvements on our own farms be it 45 cows or 4,500 cows; a cash crop operation or an apple orchard; a multiple-generation farm or a beginning farmer. Even though less than two percent of the U.S. population now lives on farms or is actively involved in farming, agriculture comes in all different sizes and shapes.

As a mother and a consumer, I do not purchase organic or non-GMO food in the store. I will support my local community, however, and may purchase organic or non-GMO food at a farmers' market or directly at a farm stand. I generally do not believe in paying the higher premium for these foods because they provide no added nutritional or other health benefits. With a growing family and a growing farm business, we have lots of other places to spend our hard-earned money. Furthermore, I feel secure in the steps that have been taken to the food produced and available for sale in the grocery store to ensure it is safe to feed my family.

The fact is that American farmers offer consumers more food choices, while providing the safest food supply than any time in our nation's history. Of course, living and working on a farm and being exposed to farm publications and reports, I may have a more intimate knowledge about the way food is grown than the typical mom. That's not to say that the typical consumer does not have a right to a better understanding of how the food they purchase is grown. The information is readily available. It's just a matter of getting it from reliable sources.

Moreover, I feel even better knowing that food produced with GMOs or GMO ingredients has been done so with some sort of advantage in mind—whether it's environmental, health or otherwise. I certainly do not believe a mandatory GMO label is necessary; in fact there are more responsible ways to spend [my] taxpayer monies. Be that as it is, if consumers are to drive some sort of label requirement I believe it should be done in a cohesive way at the Federal level. Regardless, the marketplace is already figuring this out without legislative mandates with a non-GMO and certified organic labels.

You must be aware that recently my state, the State of Vermont, passed a mandatory GMO-labeling law. As you can guess, there has been a fair amount of coffee shop talk about it. I am frustrated with it. I believe that there are better uses of the state's time, and taxpayer resources, than imposing regulations on a technology that has been used and proven safe for over 2 decades. I am also concerned about the impact this law will have on the cost and availability of food in Vermont's grocery stores.

I might also add that our farm is not too far from the border with New Hampshire; we can get there in under an hour. Doubtless there will be consumer confusion over having one label on food in Vermont, and another on the exact same products in New Hampshire and the rest of the country. This serves no one's interests—not consumers, not farmers, not food producers.

I recently posted a letter that I wrote to the editor of my local paper on my blog, *farmlifelove.com*. It was in response to an organic farmer's letter who said that GMOs only perpetuate a wedge between organic and conventional farmers. I actually agree with his sentiment. However, in an attempt to defend organic farming, he went on to berate conventional farmers, or those farmers whom I believe are open to new technology—whether it's naturally derived or not. The funny thing is, I was more nervous about sending this letter in to my local paper than about anything I had ever posted on my blog. I was nervous that people in my community, my local beef customers for example, would take issue with my open stance on the use and labeling of GMOs. What I found was completely the opposite. I found support, good questions and many thank you's for speaking up.

I am happy to continue to speak up for our right to farm in the best way we know possible; which in our case includes biotechnology and the use of GMOs. I will continue to pursue an active presence on Facebook, Twitter and Instagram as well as more traditional communication routes via newspapers, church meetings or everyday conversation, sharing articles and ideas along with my knowledge about the opportunities and challenges we face as modern-day farmers as parents. If I have one person or ten people reach out to me for a question or appreciating my hands-on and practical perspective from the farm, then I have succeeded. And I have.

We know more now than we have ever have about growing food, or caring for animals, and this helps us to achieve a level of productivity that previous generations of farmers would envy. I am proud of how far the American farmer has come, just as I am proud of how far we have come on our own farm.

Thank you again for the opportunity to be here today and to share my experience with biotechnology.

About Agri-Mark

Agri-Mark, with $952 million in 2013 sales, markets more than 300 million gallons of farm fresh milk each year for more than 1,200 dairy farm families in New England and New York. The cooperative is headquartered in Methuen, Mass., has been marketing milk for dairy farmers since 1913, and actively represents their legislative interests in the Northeast and in Washington, D.C.

Agri-Mark owns three cheese and dairy product manufacturing facilities in Vermont and New York State and has a butter/nonfat powder plant in Massachusetts. Agri-Mark has also invested in operations to manufacture and market valuable whey proteins globally while also marketing fresh fluid milk from its local farm families to the region's largest dairy processors.

About the National Council of Farmer Cooperatives

Since 1929, NCFC has been the voice of America's farmer cooperatives. NCFC values farmer ownership and control in the production and distribution chain; the economic viability of farmers and the businesses they own; and vibrant rural communities. We have an extremely diverse membership, which we view as one of our sources of strength—our members span the country, supply nearly every agricultural input imaginable, provide credit and related financial services (including export financing), and market a wide range of commodities and value-added products.

American agriculture is a modern-day success story. America's farmers produce the world's safest, most abundant food supply for consumers at prices far lower than the world average. Farmer cooperatives are an important part of the success of American agriculture. Cooperatives differ from other businesses because they are member-owned and are operated for the shared benefit of their members.

Farmer cooperatives enhance competition in the agricultural marketplace by acting as bargaining agents for their member' products; providing market intelligence and pricing information; providing competitively priced farming supplies; and vertically integrating their members' production and processing. There are over 3,000 farmer cooperatives across the U.S., and earnings from their activities (known as patronage) are returned to their farmer members, helping improve their members' income from the marketplace.

Mr. DAVIS. Thank you, Ms. Lidback. As a parent, I can understand your emotion.

The chair is going to move to the question and answer period now, and the chair would like to remind Members that they will be recognized for questioning in order of seniority for Members who were here at the start of the hearing. After that, Members will be recognized in the order of arrival. I appreciate the Members understanding.

I am going to start with a quick question for Dr. Just. While this is not intended to be a hearing about regulatory policy, it is important for us to understand the impact of government regulation on our ability to innovate. Can you talk about the cost of various regulatory interventions such as the trend of states to impose labeling mandates?

Dr. JUST. Sure. So, when we impose labeling mandates or things along those lines, it creates a really complex issue for the companies that are producing these innovations.

First off, because they have to respond to how consumers are going to perceive those labels, but beyond those labels, it also creates this level of uncertainty as to whether the government will even be allowing the types of innovations they are going to make to be marketed once they get to the other end. For the risk-takers, just like everyone else, when they have that uncertainty, it is going to lead them on the margin to not invest in some of these innovations that they worry are going to be regulated out of usefulness in one way or another.

So we definitely would see a dampening of innovation when we have that policy of uncertainty and we already are seeing that sort of dampening of innovation, not just big firms but also within the universities.

Mr. DAVIS. Well, Dr. Just, do you think consumers perceive that government-mandated labels as somewhat of warning labels?

Dr. JUST. Absolutely. Well, it depends a little bit on what these labels look like. If we are talking about a front of pack label that says, *contains genetically modified organisms,* or something that has a whole bunch of large words that are difficult for them to understand, it is a warning label. It is something that says this is dangerous and you want to stay away from it. If it is in the list of ingredients right along with water on the back of the pack, they won't ever notice it.

Mr. DAVIS. Well, I have one last question for you during this round, and we understand the nature of scientific research and appreciate the credibility that researchers bring to their work. Activists tend to demonize research if the data doesn't support their own agenda. Likewise, they attempt to discredit the researcher, particularly if the funding comes from a source that they find objectionable. Can you talk about the professional code of ethics you adhere to within the academic community?

Dr. JUST. Sure. I can speak to this in general. Each research university, we are forced by contract to disclose all of our funding sources to our university each year where a third party goes through and determines if there are conflicts of interest and in addition, every time we publish a paper, we have to talk about where that funding came from.

And if it were to come out that somebody had lied or hidden that sort of the funding, it would be extremely embarrassing and the study, most likely, would be withdrawn from publication. I think it is clear that when we read these journals, that we can trust at least where that source of funding comes from.

That said, in every instance I am aware, when a faculty member who is into research is signing a contract to do consulting work for a major firm, they include in there that they have to be able to publish everything, including those things that that firm may disagree with, with the firm getting informed about what that is ahead of time so they can have time to react.

I think everybody who is an honest researcher would have to put that into that contract; otherwise, they just wouldn't be willing to sign, but in any case, published research is fairly trustworthy, and we can at least look at where that funding source came from and judge based on that funding source, whether we believe it is in one way biased or not.

Mr. DAVIS. Thank you very much for your responses, Dr. Just.

I now recognize the gentleman from Oregon, the Ranking Member, Mr. Schrader, who I want to let the panel know is a graduate of the University of Illinois, Veterinary School of Medicine which happens to sit in my district, so I like to tout that.

Mr. SCHRADER. Thank you very much, Mr. Chairman. I am also an undergraduate of Cornell University, so I traveled around this great country well before my stint here in Congress.

I will start with Dr. Juma. You indicated in your opening remarks that in your previous life with work you had done with a group of folks in agency, there was some expectations that genetically modified produce or crops or organisms would have some real serious deleterious effects environmentally, health-wise, *et cetera.*

And you have indicated, I guess, in the testimony, that that has not been proven to be the case, and yet it would seem that a lot of the rhetoric we are hearing that would be against hybrid or genetically modified improvements to crops still persist. Do you think the original prejudices still hold sway or has there been some new evidence to indicate there is unsafe or unhealthy problems with these genetically modified crops?

Dr. JUMA. Thank you very much for that question. The evidence does not support those claims. The balance of the evidence, which are the studies that have been done that summarize all the previous studies that exist have come to the conclusion that the risks associated with the genetically modified products are similar to those associated with conventional products. That is the balance of evidence.

That is both in the United States with the studies of the National Academy of Sciences. Similarly, the European Union has conducted similar studies spending millions, up to €300 million over a 10 year period reviewing the evidence and came to the same conclusions.

Mr. SCHRADER. So, if I may interrupt, Dr. Juma, so why does the EU still have their labeling? If they have come to the same conclusions, why have they not, frankly, informed their consumers that there is no difference?

Dr. JUMA. The EU is not a homogenous body. You have the commission with its scientific advice that has conducted these studies. You have the legislative body that is influenced very much by the consumer organizations that have not changed their position, and then you have a third component, which is a continuation of a report that basically misinforms the public, that are never challenged.

In the case of scientific research, we disclose where our funding comes from. The opponents of the technology normally don't disclose where their funding comes from, so the standards that are used to guard against misinformation in the scientific community are not applied when it comes to those who oppose the technology. It has been my view that in fact those who oppose the technology need to be held to the same standards of ethics being questioned publicly in the same way as scientists get questioned publicly.

Mr. SCHRADER. There is this call we have in this country by a group of folks that purport to be strong, environmentally oriented, and health oriented for our consumers that we should base our decisions on good science, and that is a concern I see with this unfortunate agenda trying to demonize something not based on the science but based on one's personal inclinations.

Listening to you, it is obvious that while the science in the EU is incontrovertible about the health and safety benefits of genetically modified hybrid crops, that because of politics, people are afraid to lead and inform consumers about what is really going on. Certainly, people should have all the information they need, but

hopefully it should be accurate information, peer reviewed information, if I listen to you in particular, that should be the dominant theme, not just someone's theory taken off the Internet or from your next door neighbor or some preconceived notions that have since been proven false.

Next, a question to Dr. Bolden-Tiller: You indicated in your testimony a little bit like my opening remarks that what we have here is some problems with the society and communication aspect of the genetic modification not keeping up with the technology and the consumer is not really aware. Could you elaborate on how we in Congress or the industry or grocery stores or researchers, agriculturalists should get the word out not in a threatening or overbearing manner but one based on hopefully giving people good information and make good decisions?

Dr. BOLDEN-TILLER. Indeed, it needs to be a holistic approach, and it doesn't need to be something that is just put here and there strategically, if you would. It should just be a part of everyday life, as many things are.

Every day we hear about new medications and how they are coming to fruition and things of that nature, but we don't hear that development piece when related to agricultural products, and I think that when we look at the best approach, we need to look at it in that vein.

When we talk about medication and science in general, it starts from kindergarten on up, and I think that we need to incorporate and have an understanding from our youth on up how it is food is produced, where does our food comes from. A lot of questions that people have and a lot of hesitations that they have really is from a lack of knowledge in regard to where food actually comes from.

Mr. SCHRADER. Very good. Thank you.

And I yield back, Mr. Chairman.

Mr. DAVIS. The chair would like to recognize the gentleman from California, Mr. LaMalfa, for 5 minutes.

Mr. LAMALFA. Thank you, Mr. Chairman.

I appreciate the panelists traveling as they have had to today to be here.

You know, I am, as you may know, I am a farmer myself in California. We farmed rice on our farm for our 83rd year, so Ms. Lidback, this is your first generation, my congratulations to you getting started here. It was a common joke that how do you make a small fortune farming, you start with a large one, but it is a good life and we have done well, and I appreciate it.

Dr. Bolden-Tiller, when we look at the different technology, different things we have done over the years like, for example, my family would grow seed rice for other farmers' use the following year, and so we have improved in California for many years, for maybe 4,000, 4,500 weight per acre as a yield, so we are in the 2000s now, and we have done it without GMO so far this point. No California rice is GMO.

But we have also used land leveling. We are using laser and now GPS guided technology to level the land within ⅛ of an inch, so we are very frugal with water as we face drought and more and more problems with our water supply as well that enables us to use less materials to control weeds or other pests like that.

So, we have done a lot of things outside of the GMO process to maximize what we have. It seems like we are at the point where maybe we are about tapped out on new technologies or what have you to extract more grain from an acre or and other crops as well. So, if we are going to move forward with the goals of increasing food production, as the Chairman and others mentioned, we are looking at a population of nine billion in not that many years on this planet. Where are we going to find the space to get more yield with available technologies?

And we could in several ways. You could increase acres, California can be tough due to water supply and many other things. There are certainly avenues to do so. Increase the use of fertilizer, that may not be popular. What are we have going to do to increase and meet the goals of the world's needs?

Dr. BOLDEN-TILLER. Well, I think that is what brings us here today. The beauty about technology is that you can target specifically what areas need to be adjusted, and you can do it in a very refined way such that you are addressing the specific needs. So if there is a drought issue, you can specifically target genes that will resist drought, and so you don't need more water, you don't need more land, you don't need any additional resources, and you can utilize the technology that we already have.

I think that is why we are here today, to discuss and help people understand that in order for us to move forward, when we are running out of land, I mean, you speak of rice. I was in India a couple of years ago, and they are tapped out with regard to land, and they have one of the largest increasing population, and although they can go higher with buildings in terms of housing people, there is no more land that they can really tap into in order to grow more food. We have to look at how can we more efficiently use the land that we have and the other resources that we have, and biotechnology will definitely allow us to do this by specifically targeting the issues at hand.

And the beauty of it is, is that as we understand the genomes of the different plants and what have you, we can target them specifically for regions, so if you have a water issue in California but you have a drought issue in Florida, well, you can target varieties to be developed specifically for those regions so that we can more efficiently utilize our resources broadly.

Mr. LAMALFA. Thank you.

Dr. Just, for example, again, when we talk about food supplies already being fairly tight, or about undernourishment, especially in third world countries, *et cetera,* we have heard with biotechnology that you can actually increase the nutrient value per unit of grain or whatever it is. Would you talk about that a little bit and what that can mean for children around the world that are dealing with not enough to eat. We can even look at our own border situation in this country right here, what is happening right now, what are we doing with this biotechnology to increase what we have per child per unit of food they are getting?

Dr. JUST. Sure. And actually the problem is addressed in several different ways by this technology.

First, there is the ability to change the types of crops that are being grown in third world countries to enrich them with the par-

ticular proteins or other vitamins that they may be specifically lacking, and that is going to reduce disease, that is going to prevent starvation and malnutrition, and a lot of the other sorts of diseases that go along with that.

But in addition, we can also broaden the types of land that can be used agriculturally by allowing better tolerance for drought or wet conditions, and even just having higher production here in the United States lowers the prices so that we end up having more freely available foods elsewhere. I can't imagine exactly what things would have looked like during the food riots from the price spikes over the last several years if we hadn't had biotechnology that really did make something that looked a lot like dust bowl in terms of climate almost negligible in terms of yield.

Mr. LAMALFA. Let's not lower the prices too much, though okay. We have to stay in the black. We have to get this farm program behind us.

Thank you. I yield back, Mr. Chairman.

Mr. DAVIS. Thank you, Mr. LaMalfa.

The chair would like to recognize the gentlelady from Washington, Ms. DelBene, for 5 minutes.

Ms. DELBENE. Thank you, Mr. Chairman.

And thanks to all of you for being here. You know in my home State of Washington we had an initiative on the ballot in 2012 regarding GMO labeling, Initiative 522. It did not pass, but it definitely started a big conversation in our state and raised a lot of questions on this complicated issue. People are confused and still looking for answers to questions, and this will be an ongoing conversation in our state and I am sure across our country and around the world.

I started my career in biotechnology on the life sciences side, and I definitely agree with the comments that Mr. Schrader made that we need to use the best science available as we put together policy and put together policy that gives us and our communities, consumers, and producers the best results.

And in that regard, Dr. Just, you were talking about some of the confusion around biotechnology and that people kind of lump everything together into one category as a GMO.

Do you have ideas of how this can be better explained and maybe what different types of modifications there are out there and how we talk about them?

Dr. JUST. So, to begin with, just using long scientific sounding words, makes it sound like it has been grown in a test tube and people get scared of it, but talking about the individual modifications, and not even talking about them in terms of modifications, but, corn that allows you to reduce pesticide use, right, or technology in terms of the actual benefit. When you start talking about those benefits, people change their minds. They recognize this is science used in their interest, not for some nefarious purpose that they don't quite understand.

Changing the debate to be about those specific technologies and the specific modifications and the reasons for those modifications really does change people's minds, and makes it much harder to argue that this is something that we need to be afraid of and need to make sure every consumer is aware of and notified of.

Ms. DELBENE. Given the breadth, how do you think you practically go about doing that?

Dr. JUST. I really think putting a human face on it is the first best option, is picking out the few technologies that have had some real significant health impacts such as Golden Rice that has been mentioned, or some of these modifications that are addressing diseases in Africa and other places where they face malnutrition. Talking just about a very few specifics can change the conversation.

Ms. DELBENE. Thank you.

Dr. Juma, you were talking a little bit about the EU and some of the challenges there. Are there both positive and negatives we can learn from how other countries have addressed this issue that could help advise us as we move forward here in the United States?

Dr. JUMA. Yes. Thank you very much for that question.

One place to watch closely is the United Kingdom, which joined the European Union in following the same standards that were hostile towards biotechnology, and as they have started to develop their own biotech products, they realized that the laws that they put in place were undermining their own industries, and there has been a review in the UK Parliament not only to change the laws but to call on the European Union to change the way it regulates biotechnology.

This process of revisiting the rules in light of advances in science and technology is something that needs to be done fairly regularly, because the techniques that are in place right now, which have very precise methods of editing the genes, are making the process of genetic modification look very much like conventional plant breeding and even safer than conventional plant breeding because they are becoming more precise about it, and therefore, the rules need to reflect that reality.

And so this continuous review of the rules, including the duration of FDA approval needs to be revisited in light of advances in technology.

Ms. DELBENE. Thank you.

Ms. Lidback, when you talk to your customers, how do you—do you get questions? What types of questions do you get, and how has that conversation gone in terms of helping folks understand how you farm *versus* how others might farm?

Ms. LIDBACK. Thank you. Great question actually. I just went through this with one of my Jersey beef customers who was very skeptical of GMOs and Monsanto, in particular, and we had a great conversation and I just shared with her that I didn't think that she could believe everything she read on the Internet. She said, "Oh, no, no, no, I watched a movie about it," and I said, "Great, but let's watch more movies and let's keep talking about it."

And the tricky part is, every myth that has been put out there about GMOs can be debunked or disproven that so far that I have encountered, and when you start sharing information like that, as long as the other person has an open mind and is willing to hear you, then you are able to accomplish something.

But you are affecting what they believe. This is their belief system. It is part of how they have operated or they have started oper-

ating, if you will and I haven't heard from her for a couple of weeks. I thought, oh, my gosh, maybe I lost her as a customer, but then, sure enough, she just called this past weekend, just great timing really and got another order of Jersey beef, and so I didn't scare her away and we opened the doors to discussion.

We are going somewhere with that, and I would like to think that she is—she trusts me, certainly, and she trusts that I would make good decisions for our farm and the way we do things, so we just need to be better communicators about what is going on and what we do and what we use every day.

Ms. DELBENE. Thank you.

Thank you, Mr. Chairman. I yield back.

Mr. DAVIS. Thank you.

Now, I would like to recognize another veterinarian, my colleague from the great State of Florida, Mr. Yoho, for 5 minutes.

Mr. YOHO. Thank you, Mr. Chairman, I appreciate it, and I do have a background in food animal production for the last 30 years and equine medicine, and on inclement days I would work on dogs and cats in the clinic, as I am sure you did, Kurt.

I come from an area in north central Florida. I live in a county called Alachua County and in a small town called the Town of Alachua. We have the Sid Martin Biotech Center. It is an incubator. It has been the Biotech Incubator of the Year in 2013 for the research they have done, cutting edge technology.

One of the companies, Pastoria, has taken a genetically modified bacteria, placed it on soybeans, and it produces anemicide, so it decreases the amount of herbicides or anemicides that we have to spread in a field, and it is cutting edge technology, it is going to be better for the environment, will increase crop yield.

And when you look at Dr. Borlaug, back in the 1960s, which the research that he has done and the motto that he has that has been tagged with them, the man who saved a billion lives, and that was in the 1960s and if we look today, how many lives do you think have been saved by the genetically modified wheat that he has produced? Anybody want to guess? It is in the billions. But yet there is this attack on the GMOs, and the other Members have brought up, we in the scientific community, you in the ag community, and I commend you for, first, starting, second, educating your clients, and you three researchers, it is our duty to educate the public, the media in particular.

Because they run with stories, and make sure that the research is scientifically peer reviewed articles and that we can prove what we are saying, we can back it up, because billions of lives have been saved by genetically modified wheat, corn, rice, other products, but yet nobody can come out and give us a definitive diagnosis of how many people have died from that. It is our duty as Members of Congress, people in ag communities, and researchers to educate the people out there.

And so my question is, could anyone give their—one of the other things that has come up, too, for example, in the 1990s, it took the U.S. Government about 6 months on average to bring a new ag biotech product to market. As of 2013, the average was 30 months with some products taking nearly 45 months.

And so these researchers, these companies are going through just a mountain of regulations and more testing and more testing, and I understand we want to be safe with the product that we bring to market, but it is getting to the point where it is crippling our market, it is crippling the innovation in America, and companies are leaving here; whereas in Europe, they can get these done a lot quicker, which is, you think they would be more restrictive than we are. Can you give your thoughts on why this is happening? We will start with you, Dr. Just.

Dr. JUST. So I can't speak to specifics about why it is happening, but I do believe there is this growing worry about biotechnology in general, and it is leading to this additional scrutiny.

Mr. YOHO. Who is leading that charge? Is it the scientific community, or is it the outside groups?

Dr. JUST. No, it is outside groups. It is activists that are outside of the academic community that are misinformed and don't understand the science that is behind it.

Mr. YOHO. Dr. Juma, what is your opinion?

Dr. JUMA. I think there is a certain degree of hesitation on the part of political leadership not to do something, to take decisions that they think their voters might not support. And as the voices against biotech increases, leadership becomes less and less willing to take tough decisions. The case of transgenic salmon in this country is a very good example of that.

Mr. YOHO. You hit on a very important part. Because if politicians aren't going to back the research, that is why it is so important on a Committee like this, the Agriculture Committee, especially the biotech, that we have the information and we go out and talk it with a authoritative voice and educate our Members so that they can carry that back. And I appreciate you bringing that up.

Another question I have, can the U.S. consumers, with all the hunger and health problems we currently face, afford an unpredictable regulatory system, driven by anti-modern ag products in the public interest groups? I mean, we just can't afford that, can we? I mean, would you agree? Anybody want to comment on that?

Ms. LIDBACK. I would agree. I would definitely agree. I think that what we are hearing today is that there are a lot of great things out there. For example, peanuts. What if we had a peanut that people could consume that had peanut allergy? I mean, when you have a kid who has a peanut allergy, it affects all the rest of the kids that they go to school with or they are in daycare with. You can't bring any peanut products or whatever the case may be.

Again, it comes to communicating what the benefits are specifically and getting the message out there. So far, we have done a poor job of that. And so that is why we are here today, to get the word out, get the message out.

Mr. YOHO. I am out of time, but I want to thank you for coming up here. That is what we are here for, to educate the public. Thank you, Mr. Chairman.

Mr. DAVIS. Thank you, Mr. Yoho.

We are going to do another round of questions. And I am going to recognize the Ranking Member, Mr. Schrader, for 5 minutes.

Mr. SCHRADER. Interesting topic. And again, the gist of the panel's remarks are we need more education.

So, in that spirit, I guess, Dr. Juma, what is the current regulatory status of Golden Bananas and Golden Rice? How much of this is getting into consumers' hands?

Dr. JUMA. In the Philippines, with the Golden Rice, there is a law in place that would allow the country to approve it, but there is fierce opposition, which is not just domestic but internationally, that is putting pressure on the Government of the Philippines not to move on their approval.

In Uganda, where there is a serious problem with the bananas—it is a staple for Uganda, a low content of Vitamin A—Ugandan scientists have developed a variety that is rich in Vitamin A, Golden Bananas. They have a different problem there. The activists won't let the parliament approve a law that would allow the government to determine whether to release the product or not. So we have two situations where there is a law, opponents won't allow the government to use that law. Then you have another case where there is no law, and the government has been trying for 10 years to put in place a law, and every time it comes to parliament, opponents, both international and local opponents, come and kill the law. So, in both cases, it is basically opposition that is depriving the public of the benefits of biotechnology.

Mr. SCHRADER. Thank you. Yes. So misinformation and we politicians conspiring to misinform and, frankly, harm consumers and people that really are in desperate need of increased nutrition, at the end of the day. Dr. Just, what are the ill effects of GMO-produced products? What health hazards are we facing now because stuff has been GMO made?

Dr. JUST. I am aware of no specific health harms from GMO products. You know, it is certainly possible to produce genetically modified foods that would be harmful, but it is possible to produce any sort of thing that might be harmful. You know, it is a bit like complaining about a tool, like a wrench, rather than the actual—the actual food itself. It is a just a tool to create that modification. We could obtain the same modifications by using traditional means and crossing our fingers and hoping it happens. It is just a much more efficient means. But it doesn't present any specific health harm.

Mr. SCHRADER. Thank you.

Dr. Juma, would you agree with that?

Dr. JUMA. I would agree with that. And I would go further and say that, in many cases, not using biotechnology carries more risks than using it. If you take the environmental area, for example, if we didn't use biotechnology techniques, we would need additional land, which is close to twice the size of Texas, to grow the food that we grow today. So if we took away biotechnology, it would have greater risks. So my claim would be that not using it carries more risks than using it.

Mr. SCHRADER. Following up on that, I remember—you have a little gray hair, sort of like me—that back in the 1960s, 1970s, there were a lot of predictions that we were going to have world hunger because there is not enough arable land to feed the world. Why didn't that come true? Is that just bad science, or what happened between then and now that changed that paradigm?

Dr. JUMA. I think that most predictions underestimated two things: first, is the potential advances in technology to address those problems, and second, human creativity.

Mr. SCHRADER. Both of which are sort of on trial these days it would appear. I appreciate that.

Dr. Bolden-Tiller, would you agree? What are the bad ill effects that you have seen or studied when you read the scientific journals with GMO crops?

Dr. BOLDEN-TILLER. Well, looking in the literature as well as working with scientists, we have not seen any as a matter of fact. And what we have found is that individuals who, once they understand the science behind it, they are very receptive to the use of GMO products.

Mr. SCHRADER. Dr. Just, for whatever reason, it doesn't seem like there is a very valid reason, but people have their own opinions, I get that, and this is a great country, if you don't like GMO produce or a crop or seed, isn't it true you can just buy—you can go organic, develop organic? Isn't organic a different way to go if that is your concern?

Dr. JUST. Certainly. Organics are available, and they are GMO-free. So people can always choose to go a different direction.

Mr. SCHRADER. So why do we need a whole other labeling deal or whatever if we already have organic?

Dr. JUST. I don't know specifically that we do. I really worry that the labeling does more harm than good, that it leads too many people away from it, and it diminishes the market for GMOs that are the solution to a lot of the problems we face.

Mr. SCHRADER. I will just make a final comment, Mr. Chairman. You have been very indulgent here. Besides the misinformation that this whole discussion would lead to, I am very worried about how it divides the agricultural community. As a farmer, as a veterinarian; frankly, as people who live and work the land provide the safest health, food, and fiber in the world—Ms. Lidback is one of them—we are a small group. We are less than three percent of the population in this great country. But we feed not only ourselves but most of the world. And there is a variety of ways to go about that. Organic is a very valid way to go, and I am a proud organic farmer. I think that is great. There are people that are sensitive to different chemicals, not to gene changes but to other things that we see out there, and it serves a legitimate purpose. People want to know different things. Organic works great.

And as an organic producer back when it wasn't popular to be organic, I remember being demonized by my friends in conventional agriculture on occasion. And I just hope we sit back and remember and say, "Well, I am not going to do the same thing now to my friends in conventional agriculture because they serve a purpose." And the opportunity to feed people in different countries, different parts of our great country, where the weather is not so conducive to growth of certain beneficial crops with high nutrition value, that we don't start demonizing one another. We have one agriculture, in my opinion, in this great country. And we ought to stick together to provide an intelligent message about the benefits.

Dr. Bolden-Tiller is right on target when she says we need to communicate more with the consumer all along the way about the

great advances, the positive advances. Frankly, if you get that stuff out early, we can get our pushback earlier, hopefully allay concerns or address real genuine concerns along the production cycle. Frankly, as a man who made my living off the land, I bear some responsibility for that. But I assure you, Dr. Juma, I am not going to be one of those politicians that sits back and is afraid to hopefully bring the message to the folks in the Fifth Congressional District of Oregon that are very interested in the GM debate. But I hope to have a more informed debate. I guess we will find the outcome on November 2.

Thank you very much, Mr. Chairman.

Mr. DAVIS. Thank you.

Let the record show that the GMO debate is not the General Motors debate today.

I would like to recognize for another round of questions my colleague from Florida, Mr. Yoho, for 5 minutes.

Mr. YOHO. Thank you, Mr. Chairman.

And again, the GMOs in my area, north central Florida, we have a kind of sandy loam type of soil. And when I graduated from vet school in 1983, we produced roughly 50 to 75 bushels per acre of corn. Today, we are pushing 300 bushels to an acre. And that is through the genetic modification of drought resistance, pest resistance. And I don't think anybody can argue with that. And of course, that drives down the feed price to cattle, as you brought up. You know, if we didn't have that, our price for our livestock feed would be way up. And then it would just change the whole dynamics.

Dr. Just, I wanted to ask you, because you have done a lot of research on marketing and consumer sentiment on this, what has your research shown that would be the increased costs of say a sack of wheat *versus* a variety—with an old variety of wheat? Do you have any idea on that?

Dr. JUST. So the increased cost?

Mr. YOHO. Yes, like if you had the GMO wheat that is producing 70 percent more yield *versus* an old one, would it be 70 percent difference?

Dr. JUST. So there are a lot of different ways this could impact the market. But if we were to talk about just eliminating GMOs altogether, the best estimates that are out there—we have something along the lines of a ten percent increase in commodity prices across the board. But that is different depending upon which commodities. Where it has been much more prevalent, it would be much larger than that.

Mr. YOHO. I agree. I think it would be huge. What has your research shown consumers, what will they tolerate, or when it comes to labeling GMO, what is the biggest drawback? Is it the ignorance of what the product is just from a lack of education?

Dr. JUST. So it is ignorance of the product, and it is a general skepticism of anything they eat that is too processed or treated in some way that they don't quite understand. You get the same reactions that you do if you have them read the ingredient list with all the words that they don't quite understand. It is just a general stigma and a general pushback.

And frankly, it is because they don't understand the alternatives that they are facing. They don't recognize that a lot of those contain things that are much more dangerous but aren't genetically modified.

Mr. YOHO. Yes. We need to remind them that yogurt is a genetically engineered modified product. I think beer is, too, right?

Did you say that there was an agreeable cost savings that people would consume GMOs? What was that cost?

Dr. JUST. So there have been several different studies done along these lines. And for most consumers, it is something around 25 percent of a discount that they start to switch and be willing to take on GMOs when they have that label.

Mr. YOHO. I can just see them, I don't like this product, it is bad for you, but man, if I can save 25 percent, we are going to consume it. We had a veterinarian that taught us animal health. And if a cow died, people would call him up. And the farmer would always say, "My cow died; can I feed it to my wife and kids?" And he said, "Well, yes, you can, but they are going to die." And he says, "Okay."

Anyway. I got off the subject. What trade barriers have you seen with other countries with our GMOs?

Dr. JUST. So GMOs are sort of a soft trade barrier, where you have required labeling in places and other sorts of barriers like that. And what it does is, it is cutting off markets where it is not possible to grow traditional crops at volume, right? So in places where we do have traditionally poor agriculture and don't have high yields, they can't access Europe unless they use the traditional crops that don't have the high yields. It is a trade barrier, but it is put in place in a way that is acceptable internationally.

Mr. YOHO. I appreciate your time.

Mr. Chairman, thank you for indulging me.

Mr. DAVIS. Thankfully, the gentleman's time has expired.

Thank you for not letting me come to your veterinary practice.

But it is a privilege to have each and every one of you here. And as today's temporary Chairman, I get the opportunity to end this hearing. But before so, I wanted everybody to have a chance to ask their questions before I got to a few more.

And I would tell you I appreciate you bringing up another product that could be considered genetically modified. And you mentioned beer. And my staff over there is going, what is he going to say right now? But I did some research.

It wasn't peer reviewed, Dr. Just.

After three Fourth of July parades, I stopped by a store in Decatur, Illinois, and I was getting a six pack of that adult beverage product that Mr. Yoho mentioned. And the young man who was helping me mentioned to me that he had read a story that the product I was buying was bad for you because it was carcinogenic because it included GMO corn in that beer. And I ironically had read the same story that has been going around the Internet about different types of beer that are carcinogenic. And I wanted to remind the young man that he actually had number one and number two mixed up. Number one was carcinogenic because of a so-called caramel coloring product. Number two was supposed to be carcinogenic because it could include genetically modified corn.

And this goes back to the labeling issue we talked about earlier, Dr. Just, that even without labeling, what is out there, what is being placed out to the American consumer about GMO products gives the warning to individuals like this young man and others like me, who don't have an agricultural background, who could take this information and make judgments that are just not based on science and fact?

And that is the purpose of this hearing today. Even with that limited research I was able to see—I was able to see it in action. And that is what we are trying to address with this hearing.

In Decatur, Illinois, I am proud that one of my constituents is Howard Buffett. And I would urge each and every one of you to read his book called, *40 Chances*. It is one of the last books that I have read. And I didn't read it just because he was my constituent. But it is a great view of how agriculture impacts the rest of the world and how global agriculture is. I come from central Illinois. We have some of the priciest but most fertile farm land in America. And I often say that we feed the world, and it is underappreciated. In our agricultural sectors, we have seen from each and every one and heard from each and every one of you today, is being impacted by this zealousness to go after genetically modified seeds and genetically modified foods that include these products, when they are perfectly safe and they are helping to feed the world.

Now, Howard, my friend, he believes that biotech is a part of the solution to solving world hunger. I can remember sitting in Decatur, Illinois, at Millikin University, 25, 26, 27 years ago, I don't remember which years it was there, but I got to listen to Dr. Paul Ehrlich tell us that in the next 20 years, the world was going to have a starvation problem. I would like to think Dr. Ehrlich was—the starvation problem still exists, but not nearly to the extent because of what he considered the population explosion, not nearly to the extent that he led us to believe because of human interaction, development in biotechnology. And I would urge you to continue to work in that direction.

But let me get back to Mr. Buffett. He was in Winnipeg for the World Congress on Conservation Agriculture just a few months ago and even hinted that debating the merit of GMO crops is actually a step in the wrong direction. I want to read you a quote from the *Manitoba Co-operator*. Howard said, "I think we just have to be inclusive and understand that there is a place for everything, and that if we can get those things in the appropriate places at the appropriate use, then we are going to have a lot of wins." He said that adding that he believes even debating the merit of genetically modified crops is a step in the wrong direction. "If all we are going to do is spend our time debating what is good and bad, and alienate everybody, and pick sides, we are going to lose a lot more than we are going to win."

And I have a question. I want to start—each of you feel free to answer this question, but I am going to start with Ms. Lidback. In your view, how do you think we can achieve consensus on this issue so that we can focus on results and feeding hungry people? Or as my constituent Howard Buffett puts it, how can we achieve more wins?

Ms. LIDBACK. Great question. I think you have heard it a lot today. I think we need to do a better job of communicating the specific benefits that we get from biotechnology. There are a lot more benefits that we have from other types of biotechnology on our farm that I didn't quite go into detail today. About how it affects the animal welfare of the cows that we have, and how we keep them healthy, and we are able to keep them healthy or we are able to treat them right away when they get sick. In so communicating those efforts that we have made on my blog or in my social media outlets, I think that I get—we get more believers, we get people who trust me, who trust what we are doing on our farm and then, maybe when they are looking at other products or other areas of biotech, aren't quite so scared. Because a big issue is people are afraid of what they don't know.

And so to get the information out there is key to achieving more wins. I mean, people talk about they have a right to know, and that is why they need a label, a mandatory label on GMO products. Information is already out there. They don't need to wait for a label. They can go and do their own research and find it. That is what I would say. Because at the end of the day, like Mr. Schrader said, we are all farmers, we are all doing the best that we can in the best way that we know how do it. And it is all about producing a quality product, nutritious product for our consumers.

Mr. DAVIS. Dr. Bolden-Tiller.

Dr. BOLDEN-TILLER. Yes, I would just like to chime in, actually, I indicated that it is communication. A very perfect example, just about a week or so ago, we had some individuals from our community. Tuskegee University is a big name, but it is in a very small town. And because of that, the individuals in the community are our neighbors. And by "us," I mean the people at the university are our neighbors, our friends, members of our churches. And so they felt very comfortable going to our dean and saying, Dr. Hill, who is accompanying me today, we would like to have a frank conversation with you about genetically modified organisms and what have you.

And so some of us got with them, and there was just a frank conversation. And it was very clear to us after that conversation that they were open to understanding, but they had not had or utilized us as a resource previously. And lot of their misconceptions had nothing to do with the technology itself but some of the names of companies or what have you, as you indicated for your consumer, associated with the science. So it was not even the science itself that they had any issue with. But once we were able to talk to them about the science and even invite them onto our campus to take part in a workshop so that they can actually do some hands-on work in biotechnology, they are very open to it, very appreciative of it. I think that is really what we need to do more of.

Mr. DAVIS. Thank you, Dr. Bolden-Tiller.

Anybody else, you are welcome, or we can move on to another one.

Dr. JUMA. Yes. I think that a better understanding, a better science-based understanding of the risks and benefits of the products could help us to move towards a regime of coexistence so that the two products could coexist. We have had this story in this coun-

try with margarine, where it was 60 years of laws, state laws restricting, enforcing labeling on margarine. I don't think this country wants to go the route that it went with the war between butter and margarine. I think today we have coexistence between the two products. I think that the lessons from that case could inform how we approach the GMO debate.

Mr. DAVIS. Thank you.

I am going to go ahead and move onto the next question. And I want to initially start with Dr. Bolden-Tiller. How in your view does the U.S. compete with other countries when it comes to biotech research and development of biotech products?

Dr. BOLDEN-TILLER. Can you repeat?

Mr. DAVIS. Yes. In your view, how does the U.S. compete with other countries when it comes to our biotech research and development of biotech products? And just in a global competitiveness type of request?

Dr. BOLDEN-TILLER. I think that we compete very well. I think that we can look at the United States as being at the forefront just because of our government and our scientists and our academic freedom, we have had the opportunity to move forward on some things. When I look at our interaction with other countries, we do quite a bit of work in West Africa, and to work with scientists in those areas who don't have the freedom just to explore some of these technologies, and we have that. I think that that has put us in the forefront.

Mr. DAVIS. Anybody else?

Dr. JUMA. There are 28 countries that grow genetically modified foods. I think those countries provide a very interesting basis for a trade arrangement in GM products. They can trade among themselves. I think that is what is going to generate pressure on countries that don't want to participate in the GM revolution to actually become players. If they see that it is 26 that are providing leadership, which is the largest section of the global community anyway, I think there is a basis there for new trade arrangements.

Mr. DAVIS. So 26 countries?

Dr. JUMA. Twenty-eight countries.

Mr. DAVIS. Twenty-eight countries are using GMO products that they are exporting?

Dr. JUMA. On a commercial basis. And the numbers are going up. And most of the new players that are coming along are from developing countries. It puts the United States in a position to really play a new role in a new field of international trade.

Mr. DAVIS. Could be a job creator here in this country.

Dr. JUMA. Absolutely.

Mr. DAVIS. That actually leads me to my next question.

Dr. JUST. Do you mind if I make a comment on this?

Mr. DAVIS. Yes, because you just ruined my transition. No, go ahead, Dr. Just. I am kidding.

Dr. JUST. This is an important point I hope. We are well placed to be the leader. And we do have a comparative advantage, given our university research structure and the freedoms that we enjoy.

At the same time, I had a conversation just 2 days ago with a colleague who is a—someone who works in biotech and developing new technologies. And they lament that a lot of the research is dis-

appearing at the universities because of the public pushback. And it is pushing a lot of that research back into the corporations, into the Monsantos. And that means we are not making a lot of the innovations we should otherwise. So this pushback is not just a problem in terms of production but also the innovation.

Mr. DAVIS. That is a great point. And thank you for interrupting me.

Actually, I do want to get back, because I had another question. And this is my last question, unless you guys say something that allows me to ask more.

But my good friend Mr. Buffett actually has done a great deal of work in the African continent.

And you mentioned developing countries, Dr. Juma, and you talk about 28 countries exporting GMO foods, GMO seed-produced foods. What can we do to address the hunger in countries, especially in the African continent that Howard is focused on, what can we do in addressing those hunger needs with genetically modified seeds for the new users of those products in developing nations that could eventually become exporters of agricultural products, rather than just consumers? So can you tell me how biotech is going to be used as a valued tool to help developing nations not only feed their own population but also to possibly grow economically?

Dr. JUMA. Yes. Thank you.

The main challenge, particularly for African countries, is the weak capacity in universities to conduct biotech research. And this creates a very unique opportunity for collaboration between U.S. and African universities. That collaboration could then lead to investment in research in additional products, additional agricultural crops. There are hundreds of indigenous African crops that are not currently consumed widely that could become part of the global food basket. But conducting that research, particularly with the use of biotechnology tools, would require a closer collaboration between African and American universities.

Mr. DAVIS. Thank you.

Dr. Just, I will go ahead and go to you next.

Dr. JUST. So certainly we need to have that sort of collaboration with the U.S. university system. As well, developing varieties specifically for the production conditions within Africa, within other developing countries is a huge boon to these potential trading partners. The big problem they face right now is that there are so many economies that are relatively closed or closed to GMOs. And it makes it very difficult for them to take advantage of these innovations in the way that could alleviate poverty there. There is a colleague of mine at Yale who essentially says Europe has blood on its hands for the way they have treated GMOs and the impact that it has had specifically on Africa.

Mr. DAVIS. Thank you.

Dr. Bolden-Tiller, Ms. Lidback, feel free to offer any comments.

Dr. BOLDEN-TILLER. Yes, at Tuskegee University, we have a number of our professors are who are from some of these African countries, and so they do have inroads to working with some of the scientists there. And one of the things that we are very proud of is our collaborations with them and the scientists there, as well as

some of the legislatures, it is just to help give them an opportunity to understand the sciences. And what we have found, in particularly biotechnology, and what we have found is that instead of us having to change their mind, instead of them depending solely on the naysayers from Europe and where have you, instead, they are making their own decisions about their food choices.

And in Ghana, for instance, they were able to pass some of the biosafety regulations allowing them to do field studies with some genetically modified organisms.

Mr. DAVIS. Thank you.

Ms. Lidback?

Ms. LIDBACK. Mr. Chairman, I was just sitting here thinking about your original question. I hope you don't mind if I add a little bit more to it.

Mr. DAVIS. Go ahead.

Ms. LIDBACK. You asked how we could better communicate the benefits and sort of get past debating about whether the science is good or not, whatever the case may be. I was just thinking, Dr. Just brought it up earlier, if we have a label that specifically conveys what benefit of whatever GMO product or tool was used in that food product, in the ingredient list, convey the benefit of it, of a voluntary label, that would be a way to convey the information.

I am worried about a piecemeal approach. I mentioned I am from the State of Vermont. We just had a mandatory labeling law passed in our state. And I am worried that it is going to affect—consumers in Vermont won't be able to get as many products available to them. Small businesses in Vermont, food-related businesses in Vermont won't be able to have the freedom that other companies have outside of the State of Vermont that don't have to have tiers and labels. So if there is a voluntary effort by a company to show the benefits of whatever the GM product or the GM process was that was used in the making of that food product, I think that might actually be a positive way to approach and to get past the debate and to not be afraid of what—and not to perpetuate fear of how the food was made and processed.

Mr. DAVIS. Thank you. Thank you very much.

And Dr. Juma?

Dr. JUMA. Can I say something that won't provoke you to ask more questions?

Mr. DAVIS. Sure. I reserve the right to go ahead and ask. So, yes, feel free.

Dr. JUMA. I just wanted to add in terms of the U.S. competitiveness——

Mr. DAVIS. Yes.

Dr. JUMA.—that so far, we have been focused almost entirely on crops. There is a real potential in expanding biotechnology to livestock that would expand really the capacity of this country to engage and compete internationally a lot more than it is doing at the moment.

Mr. DAVIS. A very good point. And I will save you from another question, too.

I do want to actually refer back to something you said earlier, sir, a couple things. And you talked about the weak research and development at institutions of higher learning in the African con-

tinent as helping to hold back some of the opportunity that those developing nations could have in developing more products and developing their economy. I would also argue that it is also due to some political instability and weak governments in these countries to actually set up the institutions that are necessary.

And you said something earlier that I know Ranking Member Schrader mentioned. It was about political courage and political will. Now, we are sitting here today at this hearing to talk about the benefits of GMO products. And I would not be surprised if Ranking Member Schrader and I have already been vilified in social media for even having the audacity to talk about the benefits of biotechnology to our agricultural sector. So, hopefully, just by having this hearing, we can at least demonstrate to each of you, who give us a very well-rounded, scientific approach to biotechnology, hopefully, we demonstrated in a small way that we do have the political courage to stand up and ensure that we are putting the facts of science over hysteria.

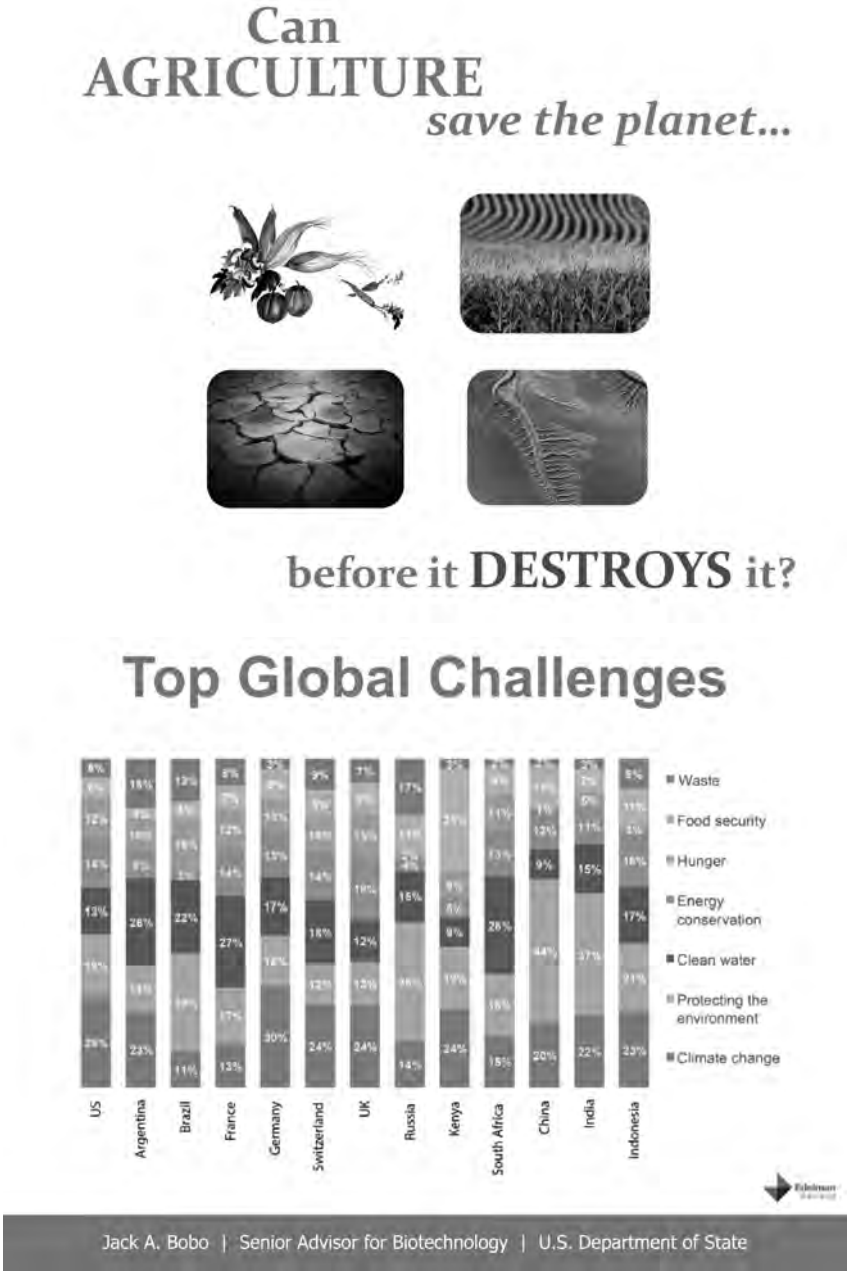
Now, the gentleman has waived his closing remarks. And I will use those as my closing remarks, and thank each and every one of you again for being here today and being a part of this hearing. I learned a lot, I know, and I hope that the rest of my colleagues and those in the room have done the same. And I hope none of you minded our humor, because sometimes in Washington, we have to have a little sense of humor. And thanks for participating.

Under the rules of the Committee, the record of today's hearing will remain open for 10 calendar days to receive additional material and supplementary written responses from the witnesses to any question posed by a Member. This hearing of the Subcommittee on Horticulture, Research, Biotechnology, and Foreign Agriculture is adjourned.

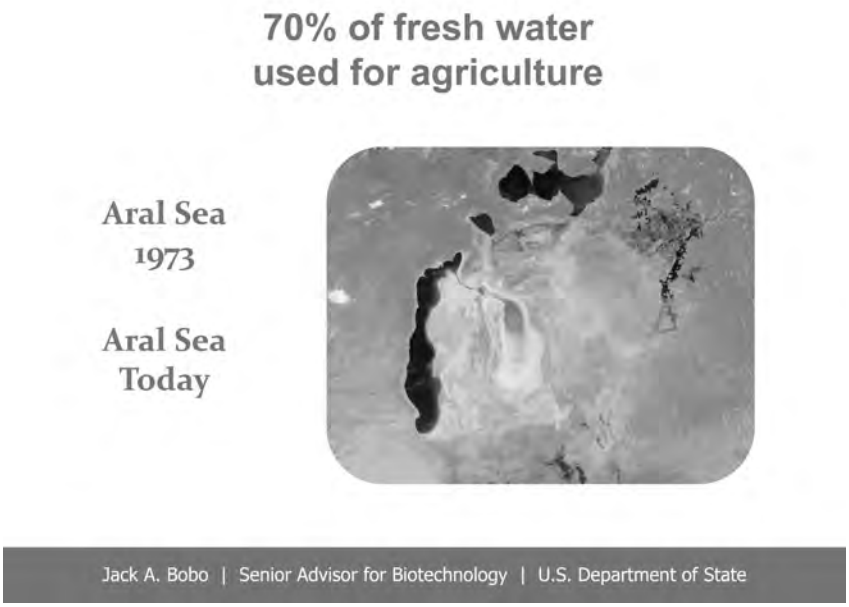
[Whereupon, at 11:40 a.m., the Subcommittee was adjourned.]

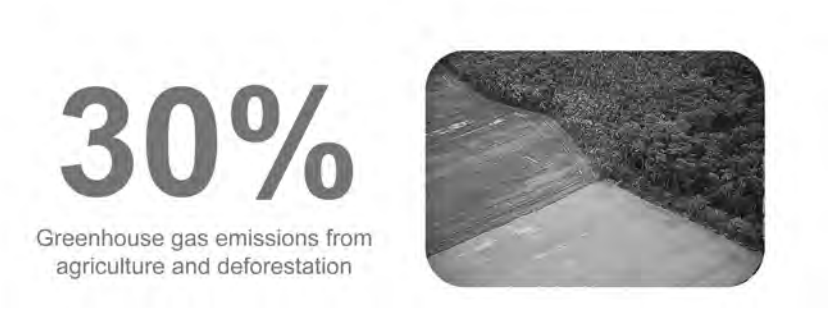
[Material submitted for inclusion in the record follows:]

SUBMITTED MATERIAL BY HON. AUSTIN SCOTT, A REPRESENTATIVE IN CONGRESS FROM GEORGIA



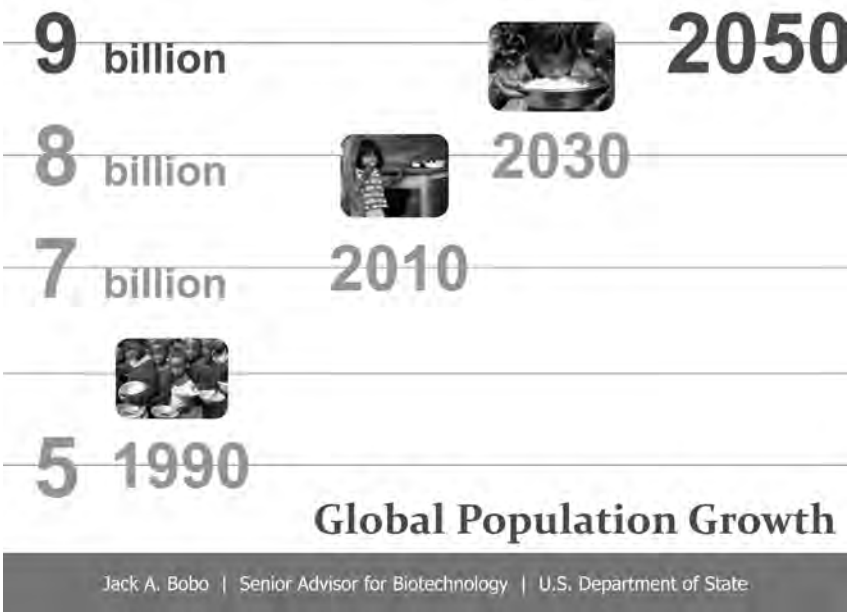

40%
Jack A. Bobo | Senior Advisor for Biotechnology | U.S. Department of State


70% of fresh water
used for agriculture
Aral Sea
1973
Aral Sea
Today
Jack A. Bobo | Senior Advisor for Biotechnology | U.S. Department of State



Together, these represent more emissions than from nearly any other industry




9 billion
2050
8 billion
2030
7 billion
2010
5 1990
Global Population Growth
Jack A. Bobo | Senior Advisor for Biotechnology | U.S. Department of State


That's 75 million
more people each year
About the number of people in Germany
Jack A. Bobo | Senior Advisor for Biotechnology | U.S. Department of State

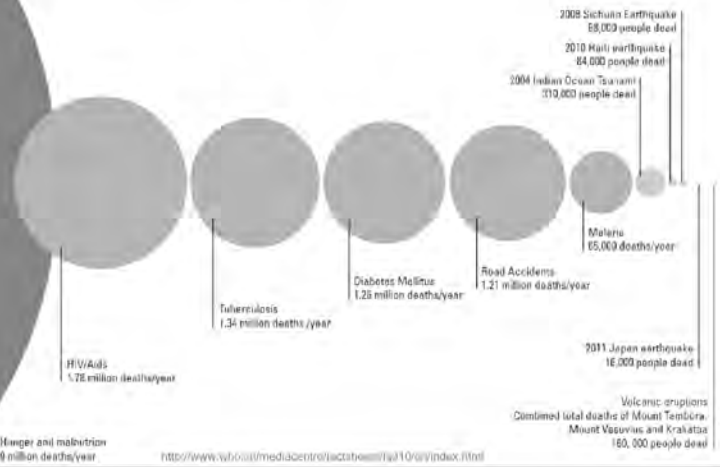
We all need to eat



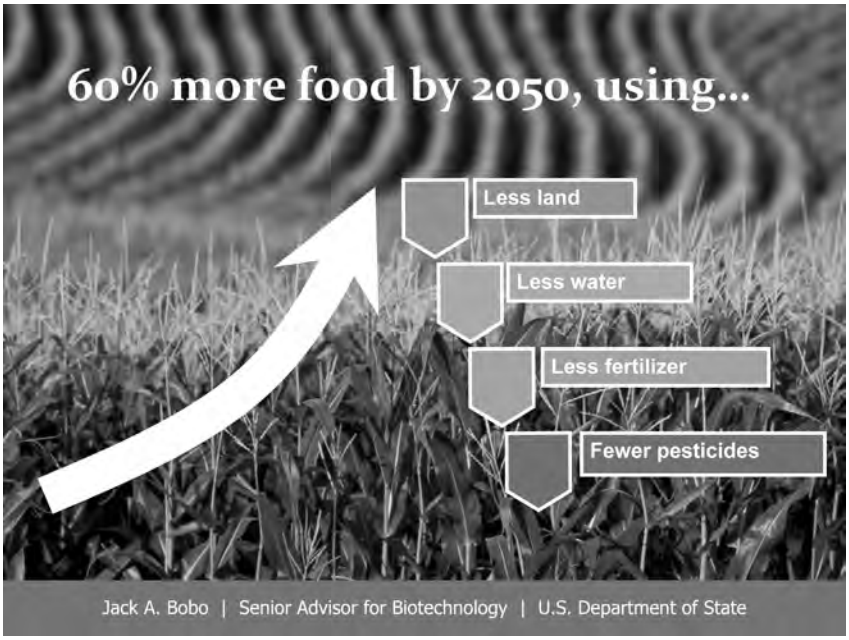
And yet almost **1 billion**
don't have enough food today

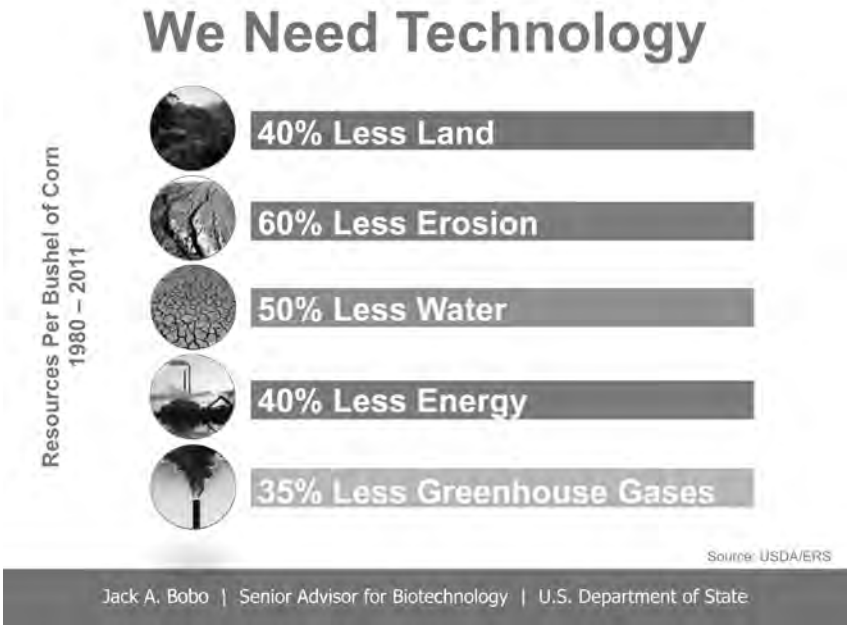
Jack A. Bobo | Senior Advisor for Biotechnology | U.S. Department of State

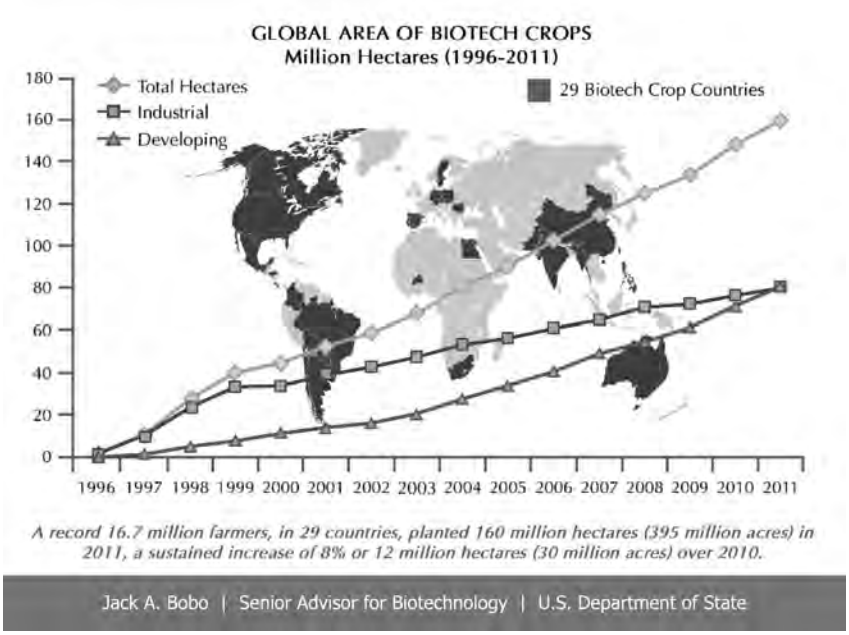
People dying due to hunger vs other causes



Jack A. Bobo | Senior Advisor for Biotechnology | U.S. Department of State


60% more food by 2050, using...
Less land
Less water
Less fertilizer
Fewer pesticides
Jack A. Bobo | Senior Advisor for Biotechnology | U.S. Department of State


We Need Technology
Resources Per Bushel of Corn
1980 – 2011
40% Less Land
60% Less Erosion
50% Less Water
40% Less Energy
35% Less Greenhouse Gases
Source: USDA/ERS
Jack A. Bobo | Senior Advisor for Biotechnology | U.S. Department of State



Bangladesh – Bt Eggplant

- 25% of All Vegetable Area
- 50,000 Hectares
- 50-70% Yield Loss
- 50+ Pesticide Sprays
- 30-45% Gain for Bt Eggplant





Competing World Views





Slow Food **Fast Food**

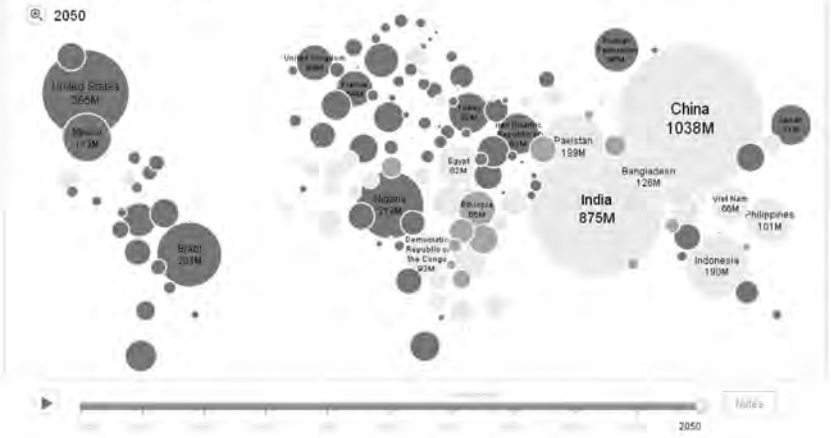
Jack A. Bobo | Senior Advisor for Biotechnology | U.S. Department of State

unicef

AN URBAN WORLD

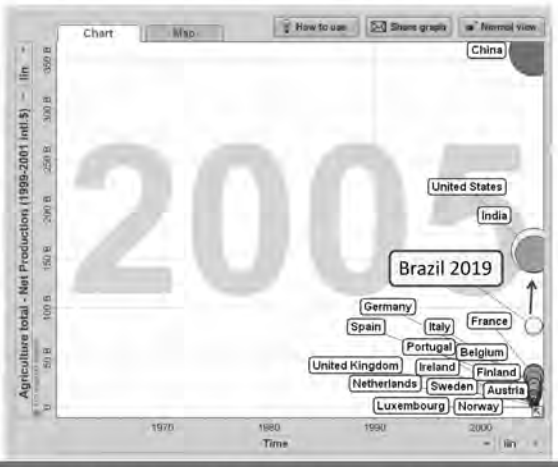
This graphic depicts countries and territories with 2050 urban populations exceeding 100,000. Circles are scaled in proportion to urban population size. Hover over a country to see how urban it is (percentage of people living in cities and towns) and the size of its urban population (in millions).

Urban Population
- Greater than 75%
- 50% - 75%
- 25% - 50%
- Less than 25%



Jack A. Bobo | Senior Advisor for Biotechnology | U.S. Department of State

Different Choices



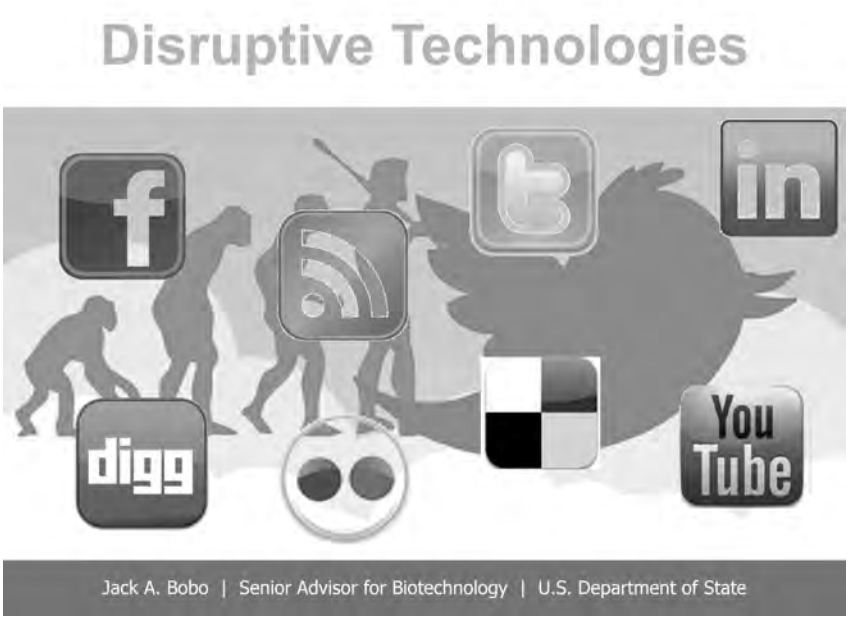
Jack A. Bobo | Senior Advisor for Biotechnology | U.S. Department of State

Different Voices

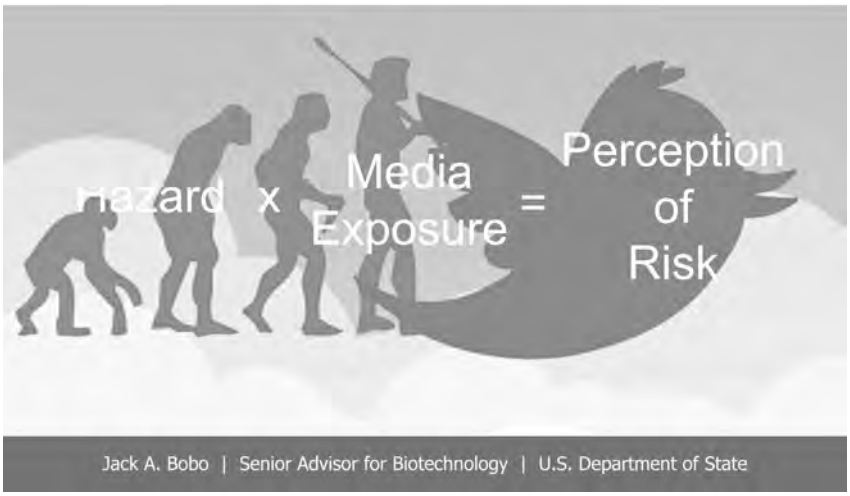


Jack A. Bobo | Senior Advisor for Biotechnology | U.S. Department of State


Old School Risk
Hazard x Exposure = Risk
Jack A. Bobo | Senior Advisor for Biotechnology | U.S. Department of State


Disruptive Technologies
digg
You Tube
Jack A. Bobo | Senior Advisor for Biotechnology | U.S. Department of State

New School Risk



The Tweet-*ification*



Disconnect

Marketing versus reality



By the way, this is dog food

Jack A. Bobo | Senior Advisor for Biotechnology | U.S. Department of State

Health Scares

Versus

Scary but Healthy



Jack A. Bobo | Senior Advisor for Biotechnology | U.S. Department of State

How to communicate?



WHO Theory



Media Reality

Jack A. Bobo | Senior Advisor for Biotechnology | U.S. Department of State

When to communicate?

Risk High



Media Attention Low

Risk Low

GMO
OMG

Media Attention High

Jack A. Bobo | Senior Advisor for Biotechnology | U.S. Department of State

What to communicate?

Language that turns people off:

- Amount is miniscule
- Research shows it's safe
- Let us feed the world
- Keeps prices low
- Better for the environment

Lesson: If you lead with the science, you may lose with the science



Jack A. Bobo | Senior Advisor for Biotechnology | U.S. Department of State

Food doesn't have to be scary



Jack A. Bobo | Senior Advisor for Biotechnology | U.S. Department of State

What's in a name?

Has anybody eaten Chinese gooseberries?



Jack A. Bobo | Senior Advisor for Biotechnology | U.S. Department of State

What is "pink slime"?

Lean Finely
Textured Beef





March 2012

Yuck factor

Jack A. Bobo | Senior Advisor for Biotechnology | U.S. Department of State

What does "pink slime" have in common with Belgium?

400 million

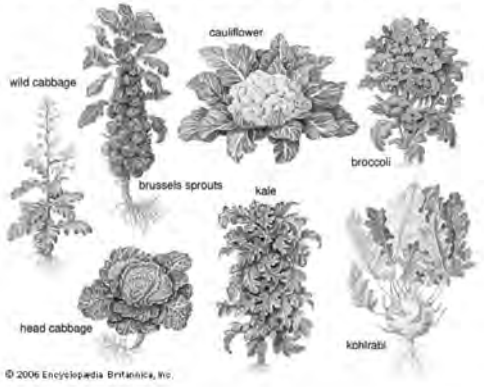


Without LFTB nearly 400 million pounds of beef would be disposed of as food waste each year

About the same amount wasted in Belgium each year

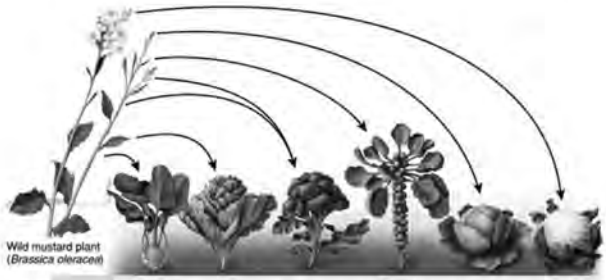
Jack A. Bobo | Senior Advisor for Biotechnology | U.S. Department of State

What do they have in common?



Jack A. Bobo | Senior Advisor for Biotechnology | U.S. Department of State

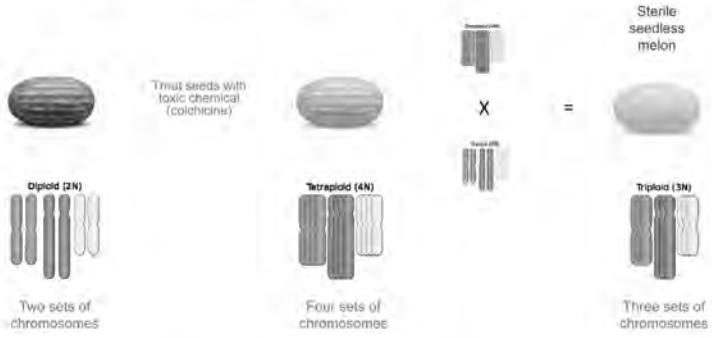
Almost everything



Strain	Kohlrabi	Kale	Broccoli	Brussels sprouts	Cabbage	Cauliflower
Modified trait	Stem	Leaves	Flower buds and stem	Lateral leaf buds	Terminal leaf bud	Flower buds

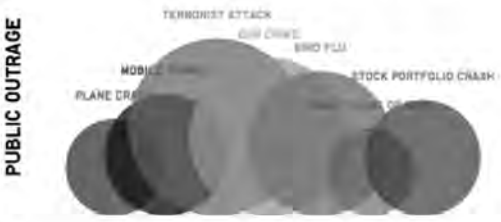
Jack A. Bobo | Senior Advisor for Biotechnology | U.S. Department of State

How do you get a seedless watermelon?



Jack A. Bobo | Senior Advisor for Biotechnology | U.S. Department of State

Risk in Context



"The difference between risk and the perception of risk is the difference between action and reaction."

Jack A. Bobo | Senior Advisor for Biotechnology | U.S. Department of State

Scientist as Storyteller

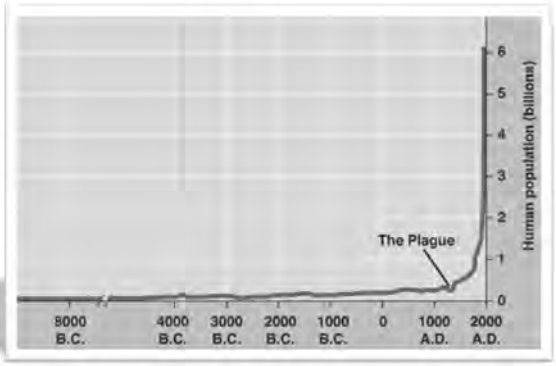


Personalize
Acknowledge
Connect
Build Trust

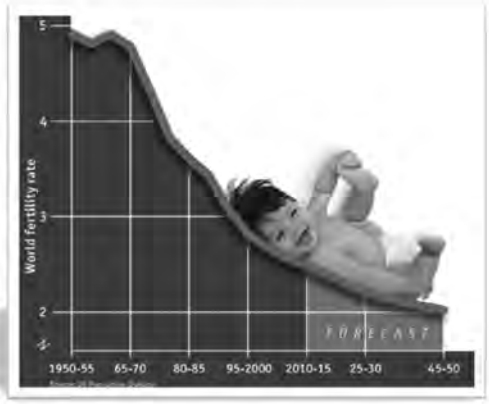
Only then can we talk about the science

Jack A. Bobo | Senior Advisor for Biotechnology | U.S. Department of State

Baby Boom



Baby Bust



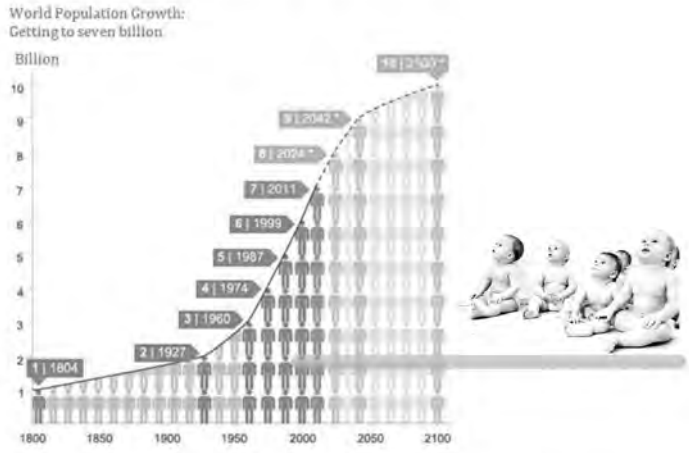
The Economist

Peak Child



Jack A. Bobo | Senior Advisor for Biotechnology | U.S. Department of State

Peak Child



Jack A. Bobo | Senior Advisor for Biotechnology | U.S. Department of State

Parting Thought

"You can't tweet common sense...
But you can provide a link."

Jack A. Bobo, JD, MS
Chief, Biotechnology and Textile Trade Policy Division
Senior Advisor for Biotechnology
202-647-1647
boboja@state.gov



Jack A. Bobo | Senior Advisor for Biotechnology | U.S. Department of State

SUBMITTED STATEMENT BY HON. AUSTIN SCOTT, A REPRESENTATIVE IN CONGRESS FROM GEORGIA; ON BEHALF OF ALVIN JONES, PRINCIPAL, JONES LAFFIN COMPANY, INC.

Mr. Chairman and distinguished Members of this Subcommittee, I appreciate the opportunity to submit for the record the following statement regarding today's hearing, "To consider the societal benefits of biotechnology."

As principal of the Jones Laffin Company, Inc., of Albany, Georgia, I want to provide an overview of the public-private partnerships Jones Laffin has had with the U.S. Department of Agriculture's (USDA) Agricultural Research Service (ARS) and, in particular, how we feel the joint features present significant potential societal benefits of biotechnology.

In 2012, Jones Laffin entered into a Cooperative Research and Development Agreement (CRADA) with ARS in order to ultimately commercialize technologies to effectively dispose of dangerous environmental hazards such as acid whey. As you know, disposing of acid whey is threatening to derail the growing Greek yogurt industry and its benefits not only to our economy but our national health. As the Greek yogurt market has skyrocketed to become one of the biggest success stories in food over the past several years, we remain committed to working with ARS to develop solutions designed to offer the dairy industry an opportunity to turn a disposal expense into a new revenue enhancement.

Greek yogurt production creates the byproduct acid whey, which is a natural byproduct of not only Greek yogurt but cream cheese and cottage cheese production as well. Five parts milk generally yields one part cheese or yogurt and four parts acid whey. The byproduct can pollute streams and is difficult to dispose of, even in landfills. Our ongoing research and progress with ARS has led to a process using specialized equipment that not only neutralizes acid whey but also captures valuable protein and lactose remaining in the byproduct. The new process is an all-natural method of separating the component ingredients of raw acid whey (water, lactose and protein) and turning them into valuable commodities which can be sold as ingredients in the food industry. Test results strongly indicate the technology will have a crucial environmental impact and contribute to economic benefits resulting from costs saving and additional potential revenue streams for the dairy industry.

In addition to the acid-whey technology, Jones Laffin and ARS have been developing a revolutionary technology which continues to yield positive results for food manufacturers seeking to appease consumers' insatiable appetite for more nutritional and healthier protein products. Scientists have taken whey protein and *texturized* it, allowing formulators to increase nutrition and improve flavor and overall eating quality. Again, early test results hold particular promise in providing additional societal benefits.

Perhaps most encouraging are results showing the texturized whey protein (TWP) performs extremely well in recipes and formulas at significantly higher percentages than customary whey protein—without altering the taste, texture or other natural characteristics in end products such as pasta, cereal, soups, beverages and baked goods. The hope is by utilizing TWP, manufacturers won't have to change product designs and formulations simply to increase nutrition; they should be able to more successfully create new uses for protein.

The TWP applications, interestingly enough, have also been used to increase protein levels in yogurt without increasing sugar amounts. As further testing ensues, the TWP technology is expected to enable the conversion of regular yogurt into Greek-yogurt-like protein values while incurring less expense. Based on preliminary reviews, the yogurt example entails a more rapid production process that actually achieves similar protein levels as those in Greek yogurt, absent increased sugar intake.

In conclusion, I want to thank the Members of this Subcommittee for supporting USDA's ongoing efforts to promote American agriculture by conducing cutting-edge research designed to foster public-private partnerships and develop solutions to the myriad of challenges facing our country's agriculture and dairy industries. Via the cooperative projects in which we've engaged with ARS, we believe the technologies being developed should lead to increased production of environmentally conscious, healthier commodities to address consumers' growing demand for products containing more protein.

○