

UNIVERSITY OF CALIFORNIA DAVIS WORLD FOOD CENTER:
LAUNCHING A NEW INITIATIVE - FOOD FOR A HEALTHY WORLD
Panel Moderator: *Roger Beachy*
October 14, 2015 -3:30 p.m.

Introduction:

Ambassador Kenneth M. Quinn
President - World Food Prize Foundation

So I want to now invite our next panel to come up to the stage, and it will be my pleasure to introduce the moderator, Dr. Roger Beachy. A couple of things about Roger – first of all, I’m hoping he wasn’t in the room before when I talked about Louise Fresco and Wageningen being the number one research university, because I hear my talking points – and they’re from California Davis, which we know is the number one research university. I used to get away with that when I was a diplomat, but it’s hard now.

So I met Roger Beachy when I first came. He was one of the first persons I met when I came back to take over the World Food Prize. And he came up and was talking to people up here about what he was planning to do in St. Louis with the Donald Danforth Plant Science Center. And I said, well, this is an engaging young guy. You know, maybe someday he’ll make something of himself. And what, 15 years, what a journey. Of course, he had a great journey before that, and I didn’t know. But he was Director of the National Institute of Food and Agriculture at the U.S. Department of Agriculture. He was founding president, of course, of the Donald Danforth Plant Science Center, was involved as a professor of biology at Washington University St. Louis where so many incredible - happen, been elected to the U.S. National Academy of Sciences, fellow AAAS, American Academy of Microbiology, and now is the new Director of the new World Food Center at the University of California Davis.

We talked on the phone with him, with Dan and talked about their vision. And I said, “You’ve got to come to the World Food Prize. You’re welcome every year. You’ve got a slot in the symposium for what you’re talking about, because we’re so interested here in measuring and assessing each year. So, welcome, and we’ll see you next year and the year after that.” So please join me in welcoming Roger Beachy.

Panel Moderator:

Roger Beachy

Founding Director, World Food Center, University of California, Davis

Panel Members:

Joseph Glauber

Senior Research Fellow, International Food Policy Research Institute

Christine Stewart

Associate Director, Program in International and Community Nutrition,
University of California

Daniel Sumner

Frank Buck Professor of Agricultural and Resource Economics, University of
California, Davis and Director, Agricultural Issues Center, University of California

Roger Beachy

Thanks, Ambassador Quinn, and to the new laureate, Mr. Fazle, and other former laureates. Thank you for staying around. It's really great to see M.S. Swaminathan and others that I've known for many years here at this event.

The reason that we were asked to join, UC Davis, at the World Food Center, we began and asked ourselves if we could contribute in a new way to a challenging part with the university as an outstanding place where science and education in a full-service university kind of way. And as we looked at the challenges in agriculture in the future, we looked not only at the challenges of people in climate and so forth but also at the requirement for increasing nutrition.

And when Monty and his colleagues in the previous panel talked about Ebola and the susceptibility, impact on farm, one wonders what the role of nutrition is in the response to Ebola. If there had been better nutrition, would there have been a different outcome, if there was this, if there was something else that would play in this part, what role might agriculture play that's different than the role today.

And so Dan Sumner and I began talking, some suggestions from colleagues and developed a symposium and a workshop, rather. And we want to use this opportunity to tell you a little bit about where we're headed, a bit about where we're headed so that we can lay the groundwork that we hope will be a very productive partnership with the World Food Prize. So, Ken, judge whether or not we come or go the next year based on how well we do today.

So just a few words. Our panel is Joe Glauber from IFPRI. You have, by the way, the brief bios of each in your program. And Christine Stewart, who is at UC Davis, a nutritionist. I'll talk then following – these are the topic areas in general – and Dan will wrap up, and then we'll lead the discussion amongst the panel and with the audience if there are questions from you.

So just briefly, the World Food Center is a new initiative at the University of California Davis, and this is our mission statement. We try to increase the impact of what we in the land grant university do, by making better use of all the skills and knowledge across the entire institution, from medical school to agriculture to policy to veterinary school, to nutrition and engineering and so on.

In so doing, we identified, of course, ensuring a stable future for food and nutrition. So in the topic that you saw – Food for a Healthy World – we think of the health of the environment and the natural resource base, as well as the health of those of us that consume. So think of this in the largest context that you can. And so what does this require in general?

First, it's an understanding and an adaptation to the change of climate and the challenges that producers, farmers around the globe are facing, making sure that we provide a diverse food basket to promote a better nutrition based on diversity, while reducing obesity and improving health. And thirdly, to ensure that we innovate, use the knowledge that comes to our institutions, the creativity of those who work in the institution in an innovative way, and push that innovation out, allow that innovation to be pulled out into society so that there is a better chance that what we do in these institutions will have that impact that we expect, based upon the brain trust, the investments made by taxpayers and by tuition of parents – how do we get the most out of all that we have been able to acquire in these institutions?

We became painfully aware through repeated studies at the FAO and IFPRI and other organizations that, regardless of what we were doing in providing calories, we still had an enormous shortfall in the important things of health; and that is that the micronutrient deficiencies remained prevalent, regardless of increasing the stocks of corn or rice or soy, there were still needs in nutrition.

Second was that, as we saw and as we all know, the challenges of overweight and obesity are continuing to rise. And the challenging part, the surprise to many of us, was that this transition between economic transformation and health related to obesity and other parts of dietary deficiencies were mirrored in the economics of the country or the region that one would look at.

So this link between poverty and good nutrition was pretty apparent. We all expected this to be the data, but what was found by IFPRI and others who looked at these data points was the fact that it's more severe than what we had anticipated. So as a consequence, Dan and I organized a workshop, bringing scholars from around the U.S. and around the world to UC Davis campus and matched them with our own UC Davis scholars in fields that range across the entirety of the food system and began to approach the question as a systems question, not a disciplinary question and then asked ourselves how we measure progress so that in 20 years we're not still saying there are 820 million malnourished or undernourished people. How do you go from here to there? How do you measure progress? And how do you engage the next generation of scientists, of entrepreneurs, of STEM scientists in this battle?

So this was the name of our symposium, I mean, our workshop rather. It was really a workshop, and what we want to do is present a basis on which we built the conclusions that will find its way into a white paper. And Ken and I have talked about how to use this most effectively to engage more in this battle.

So our first speaker is Joe Glauber from IFPRI. After Joe, we'll just move down the line to Christine, me and then Dan, and then engage you, hopefully, in the discussion. Thanks very much. Joe, the place is yours.

Joe Glauber

Great. Well, thanks very much, Roger, and thanks for the invitation to come here. In my previous job, I often helped write speeches for people coming to the World Food Prize, but this is the first time for me, so I'm delighted to be here.

As Roger said, I'm going to give you a little overview and just talk a little about setting the stage here of looking at some of the big trends that are going on, particularly in sort of the basic supply and demand of commodities, which I think is an important backdrop. And then Christine and others are going to treat some of the other nutrition and some of the other issues.

First, when we talk, we're transitioning to the Sustainable Development Goals. We look at two Millennial Development Goals that actually we've done pretty well on. One is reducing extreme poverty. Extreme poverty is measured by the World Bank as existing on essentially \$1.90 a day. And you can see that, since the Development Goals were launched back in 2010 or so, that we've reduced poverty by about a billion people; and that's an incredible accomplishment, I think. Now, a lot of that, of course, reflects the fact that we've seen good growth emerge in parts of the world that had been very stagnant during the '80s and '90s. But again in the fact that 700 million people still remain in extreme poverty is a horrendous number. But just to say, that at least on that goal, fairly good progress.

And on another one in terms of reducing malnourishment, the numbers that just came out from FAO earlier this year show again the numbers down significantly, not quite close to where the Millennial Development Goal had been to cut the number in half; but if you look at the percent undernourished, there the numbers are closer to the 50% reduction that was the goal that was looked at. But it does very regionally, and as you can see areas, like Sub-Saharan Africa and other areas where still there are very large undernourishment remains and with only small cuts since the Development Goals were launched. And, as Christine will get into and as Roger alluded to, there are still serious problems of malnutrition, and here are listed just a few with particularly obesity and other chronic stunting and wasting that we see among children.

So if you look in the near term, though, we've seen some pretty positive developments. And I recall just over the last ten years we've seen three major spikes in food prices. Starting in 2007, '08, again in 2010 and '11, and then most recently with the big droughts in North America and parts of Eastern Europe, we saw big record high prices again in 2012, carrying into '13. They have come down substantially over the last 12 months, and in fact I think the month before was one of the largest drops in the FAO food price index as they had seen in about ten years.

But the longer run, again, there is some real uncertainty. Are these trends going to continue that we've seen? I could have taken this graph back to the post-World War 1940s or so and with a very long (or earlier in fact), seen a very long, downward trend of prices once they're adjusted for inflation. Or as some would say, no, we're in a new environment where the most recent downturn is the anomaly and that we should be seeing prices pick back up. I think there is the crux, and the real issue is, how does productivity gains and other sorts of things compare to what we are seeing in growth and demand?

If you turn first to the growth and demand, well, the United Nations now is projecting population in 2050 not at 9 billion but at 9.6 billion, and that's a revision up from just ten years

ago. They revise these numbers, and when they make the revisions, they look at things like fertility rates in various areas of the world, they project what those fertility rates will do over time; and you can see here with different scenarios you get a very big variance in what the potential numbers could be. So there again, 9.6 billion but with a variance of over 2 billion people between their high scenarios and their low scenarios; and that obviously can make very a big difference in so far as food production needs are concerned.

The other thing is where that growth is occurring. And if you look at areas like Europe, North America, South America, Australia, there you see growth rates that are either declining or relatively flat. Where you do see continued growth in terms of where is coming out of South Asia, but that is beginning to slow. And then Sub-Saharan Africa, we're projecting, or the U.N. is projecting Sub-Saharan Africa to be, by 2050, adding the most people. And that again, because of where people are consuming food and where they are producing food, that's going to have all sorts of implications. The other big thing is urbanization, and as you can see in that chart, you can see that the percent of population living in urban areas has exceeded 50% over the last few years, and by 2050 will likely be about two thirds of the population will live in urban areas.

That has implications for a number of things, and I think a lot of studies have shown what that means for things like meat consumption, dairy consumption and other things. Here's a chart that just shows per capita meat consumption. Again, people looking at it as being a function of income growth and urbanization. Now, over the last 10 or 15 years, we've seen what that has meant in a country like China where per capita consumption of meat has increased substantially, has begun to slow; and I think as we look over the next 10, 20, 30 years, that will slow considerably. But we do see continued increase in per capita consumption of meat. And that has implications not just for meat production but also for feed stuffs that feed those animals, things like corn and soybeans.

These are projections made by the FAO in terms of what is anticipated in terms of per capita consumption for various food stuffs. And again these are very imperfect estimates based on income growth, based on the trends that we've seen witnessed over the last 10, 15 years. But you can see, particularly for things like meat, particularly things, for dairy, vegetable oils – all those have very, very high percent gains; and again that has implications for food.

The other big thing, of course, that's been talked about, and really I'd say ten years ago in particular was a big focus, was the rapid increase in biofuel production in the world; not just in the U.S. but in Europe and other places we saw some rapid run-up in production of things like corn-based ethanol and also biodiesel, primarily from things like soybean oil but also palm oil. There at least for corn-based ethanol, we've seen the slowdown here in the U.S. and really from about 2011, 2012, very modest growth with projected growth fairly flat as well, both tied to projections about what the mandates themselves under the Environmental Protection Agency sets out under the renewable fuel standard but also just in terms of how much gasoline can be absorbed in the U.S. gasoline supply. However, I'd say over the long run, the real factor that's going to... whether or not ethanol and biodiesel, real growth and consumption of those products for industrial use will depend a lot on oil prices. These are price projections that were made by the Department of Energy a year ago, and we know that prices have come down a lot since then; and I presume when they come out in the next month or so with their price

projections that these will look lower and may be closer to those low price scenarios that we see there. But it's just to say, at high prices it doesn't matter if there are mandates or not; corn-based ethanol can be very, very competitive then over the longer run, I think the tie between energy and commodity prices will be a very important one to watch.

Well, all of that means that we are obviously looking at growing food demand, and if you look at the estimates done by FAO—and these are very careful, again crude but very carefully done, I would say—looking about a 60% increase in food demand by 2050. And again that's from 2005-07, which translates to roughly a 50% or so increase from where we are today. And about a third of that is going to come from Sub-Saharan Africa and about 25% of that from South Asia, again, those growth areas I was showing you before on the charts on population. And in fact about 70% of the projected increase is due to population growth, the rest coming from changes in income, precipitating higher per-capita consumption and also changing diets.

To meet the productivity, when one looks at the existing resource base out there, there is just not a lot of land to convert. We do know there's land in Latin America, in South America that can come into production. Eastern Europe, we've seen Ukraine and Russia become again major exporters of grain. But if you look at the, for grain production, oil seed production, you're really looking at yield increases as being the big source of the production increases.

So with that, let me wrap up and just say that I think there has been a lot of progress made just in terms of two of the Millennium Development Goals. But again malnutrition remains in some case a growing problem. If we're looking at population and income growth, that's going to correspond to about a 50 to 60% increase in food demand. And again these numbers vary, again a lot of uncertainty based on things like population projections; but one way or the other, I think this is a challenge to be met. And it's a challenge particularly—and I think Dan will get into this a bit—is talking about things like climate change, water quantity issues, quality issues and the sort of environmental pressures that they face. And again on the yield side, if indeed 80% of this has to come from yield developments, then again that means challenges on the research and development side, which I think Roger is going to get.

And with that, let me turn it over to Christine.

Christine Stewart

Hi, everyone. Thanks. It's really an honor to be here and to be standing on this stage with having followed so many noble speakers before us. So I want to thank you for taking the time to listen.

Now, I've focused my talk on the goal of trying to orient us towards thinking about nutrition and nutrition security as being key and essential to achieving our food security goals and towards our goal to end hunger.

And so many of us are well aware of the recently released SDG to end hunger by 2030. Prior to the release of the SDGs, the World Health Assembly had released their own set of targets focused on maternal, infant and young child nutrition, and those are listed here. The six targets include the measurement of factors, such as child stunting or the prevalence of children who are

too short for their age, measuring the prevalence and achieving a reduction in anemia among women of reproductive age, reducing the burden of low birth weight, seeing no increase of child overweight over time, increasing the rate of exclusive breastfeeding in the first six months, and reducing and maintaining childhood wasting.

Now, of these six targets, only two of them have been included in the SDGs, and I see this as, it's a real shame that they haven't included more of the nutrition-specific targets. And that's because maternal and child nutrition is so important. Maternal and child nutrition contributes enormously to the global burden of disease. Malnourished children are more likely to suffer from infection, they're at greater risk of mortality, they perform less well in school, and they go on as adults to earn less as adults; and this has significant consequences on our communities and our societies.

(I've lost one of my slides.) Pregnant women and young children are really the most vulnerable to malnutrition. They are at greatest risk because this is a period of the life course where micronutrient deficiencies are high and the demand for micronutrients are also high to meet the requirements for rapid growth and development. The World Health Assembly targets thus focus on women and children both for their nutrient requirements and also because of the importance that focusing on this period of life has on individuals throughout their life course as well as on communities.

Now, to achieve the World Health Assembly targets, we really need a whole of society approach. There's of course a need to focus on nutrient-rich and diverse food, but we also need to focus on other aspects, including clean environments and reducing the burden of infection, providing access to health services. Both of these two factors contribute significantly to child stunting risk. We also need to pay attention to consideration for the mothers and other caregivers in the household, and to provide strong social safety nets and education systems for women and girls. Now, I won't have time to talk about all of these different approaches, but I will focus on the pathway through which agriculture and food systems can ideally have an impact on malnutrition as well as healthier diets and healthier foods for the future.

So now child stunting is decreasing, and this is something that was just spoken about. Over the past 20 years, the prevalence of child stunting has decreased dramatically, and yet the total number of children who are suffering from stunting as an indicator of chronic malnutrition has decreased over time. But there have been sporadic improvements or differential improvements across different regions of the world. And in fact across Sub-Saharan Africa and South Asia, the reductions in stunting have not been as steep as you've seen in other parts of the world. So there's still a need to focus on this important factor.

But slowly the problem of overweight and obesity is growing, and it's becoming more and more of a problem with urbanization and with changes to diets and lifestyle patterns around the world. And so this is a problem as we look towards the future.

Now, poor-quality diets are now considered to be the number one contributor to the global burden of disease, but the recently released version of the Global Burden of Disease Report, an estimated 10% of all disability adjusted life years can be attributed to dietary risk factors. And this would include factors such as high intake of processed meats, high sodium intake, low fruit and vegetable intake, low intake of healthier fats, and an overall lack of diversity in the diet.

Now, this, of course, contributes to adult chronic disease risk and premature mortality. But we can also think about the contribution of maternal and child malnutrition. Up until a few years ago, maternal and child malnutrition was the leading contributor to the global burden of disease. It's now dropped to number three, but nevertheless, when we think about these two factors together, both undernutrition as well as the quality of our diet, this contributes to over 15% of the total global burden of disease. And it's by far the leading risk factor for morbidity and mortality worldwide, more than any other risk factor.

And our food supply, by and large, isn't adequate to meet our nutrient requirements. Now, what this is showing is just three countries as an example – Bangladesh, Senegal and Cameroon. And what we're showing here is the difference, or the gap, between what's available in the food supply in terms of micronutrients and what would be needed to meet the needs of 80% of the population. And so you can see in particular for nutrients such as vitamin A, vitamin C, folate, zinc and calcium, there are large and obvious gaps in what the food supply can provide. Now, iron is also one that's not shown here but is also a very important nutrient that is necessary for anemia risk reduction, as well as for child development. And that's also often a limiting nutrient.

Now, these types of nutrients are abundant in animal source foods or in green leafy vegetables or in fruits. And so it's important that we're focusing on those types of food products when we think about meeting our nutrition security goals of the future.

Now, looking forward, it's important to look beyond just the nutrients that the food supply provides but also the overall diversity that our food supply can provide. Now, looking just at Cameroon as an example, we can see that the food supply is not meeting the population's needs in terms of dairy, fruits, meat, poultry, fish and eggs, as well as vegetables, in order to meet an overall healthy diet pattern that would be consistent with one which would be a more cardio-protective type of diet pattern, one that would reduce the risk of cardiovascular disease.

Now, both of these two slides that I was just showing were from food balance sheet data. So this represents the aggregate food available at the population level, but it likely underestimates the magnitude of the food insecurity problem among the poor. Now, some estimates of the differential between what the FAO food balance sheet will provide versus what individual dietary surveys, what those data will show us, is that the FAO data will overestimate fruit and vegetable consumption by up to 75%, or it will overestimate meat consumption substantially. And so, particularly when we think about these critical foods for meeting our nutrient requirements, there's likely to be an even greater problem than what I had just shown.

So why do I focus on meat, and why do I focus on animal-source foods? These food sources are really important for meeting maternal and child micronutrient requirements. Meat is the most bio-available source for iron and zinc and B12. Milk is a really incredibly important source of calcium, B12, vitamin A. Eggs are also a very rich source of vitamin A and riboflavin and vitamin B12. And these are all nutrients that are often limited in the food supply. And these food sources have also been associated with improvements in child growth, particularly for milk. And, in part, that is likely due to the micronutrients that milk provides but also due to some of the other bioactive components in milk that are likely growth promoting. So it's important that we think about ways in which we can improve access to animal-source foods for women and children.

And fruits and vegetables are also, of course, very important for their role as providing micronutrients in the diet. Provitamin A carotenoids, vitamin C, vitamin E and so on and so forth. They're also rich sources of fiber. They're abundant in phytochemicals that act as antioxidants and anti-inflammatory agents in our diet. And there's good and consistent evidence that diets rich in fruits and vegetables are associated with lower risk of cardiovascular disease, diabetes and cancers. And some of this is probably due to the nutrients that we know about, but it's also likely due to the fact that plant-source foods or plant-based diets are really rich in tens of thousands of phytochemicals that have bioactive properties that we're really only just beginning to understand, and that the health effects that we see are likely due to the interactions and the combinations of all of those bioactive compounds within the food matrix. And so it's important to consider fruits and vegetables as part of our healthy diet.

And so one thing I think is important is for us to also orient ourselves to thinking about dietary diversity and achieving a goal of dietary diversity for vulnerable population groups. Now, the World Health Organization adopted the indicator of dietary diversity for infants and young children in 2008. And since that time, there has been a greater investment and a number of surveys that have been conducted to monitor dietary diversity among young children and really highlighted how limited the diversity is within young child's diets and how monotonous their diets often are. And with this dietary diversity indicator, which you'll notice has three out of the seven food groups are animal-source food groups, it's much more likely that a child is going to meet their micronutrient requirements.

Now, more recently a dietary diversity indicator for women has been adopted, but it has not been around for quite as long of a period of time; and so there's not as much data at the country level to compare, but it's also likely that... and what we hope is that, with a greater use and monitoring of women's dietary diversity patterns, we can also track the overall quality of diets for both of these two vulnerable groups.

So where is action needed? What should we be doing? And what I think is really important is that we need to increase the availability and access to meat, dairy, fruits and vegetables for everyone. That may include increases in production or reduction in post-harvest losses. There's also a need to increase demand for healthy foods. Some of that might be through education and through behavior change methods, but it might be through other approaches that address the limits that poorer families have to accessing these high-quality foods.

We also need to address inequities to access within our communities and across countries. It may be that some countries or some communities, we're eating more than enough meat, but among those who really need it, there's an inadequate access and inadequate availability of meat or animal-source foods for those who really could benefit from them.

And then I also want to just emphasize that there are proven, effective nutrition programs that also need to continue to invest in in the future, even while we're focusing on trying to diversify and improve the quality of the diet. Programs such as micronutrient fortification of the food supply, maternal supplementation or supplementation of other vulnerable groups, protection, promotion and support of breastfeeding programs, promoting adequate complementary feeding, and treatment of the severely malnourished.

So in summary, poor quality diets are the leading cause of morbidity and mortality globally, and these comprise micronutrient inadequacies, low intakes of fruits and vegetables, low intake of healthy fats, and an overall lack of diversity. And many countries have large gaps in the supply of animal-source foods, fruits and vegetables to meet their population's nutrient requirements and a healthier diet pattern. And so it's important that we do a better job in assessing and monitoring the situation so that we can have the hope of improving the situation in the future.

So I just wanted to thank a few people that contributed thoughts and ideas to this presentation today, and I'll turn it over to you.

Roger Beachy

As you can see from the comments that Joe made and Christine, we began to scope the nature of the problem, what's available in commodities, what are the needs in the nutrition sector to increase quality of life and quality of health.

Innovation is an important part of this discussion, and as we got people together at the workshop, we looked at innovation across the system and asked where the opportunities were to stimulate innovation; and then we looked back at what has already been done. And in this country... I'm not sure about the rest of the world, but in this country there's been a significant larger investment on the big crops, on the big commodities. And the question is, and the challenge in this – if our needs are in nutrition and health and wellbeing and the diversity is required, then we need to change the model on what we work on, and that means across the entire system. The delivery system is different for a bushel of corn than for a kilo of tomatoes.

So the challenges that we began to look at as we had our discussion really looked at, looking at challenges across the entire system and the multiple components that are in that system; and we realized, to solve the problem, we need broad-based experiences, skills and knowledge, not narrowly based but very broadly based.

And then we need to identify those areas where intervention can be impactful and can have an outcome that can be measured and then innovate towards those goals, whether it's goals in policy or education and training, resource management, production of nutrition-rich crops, develop process for preservation and reduction of waste, and so forth. And overriding all of this is this importance of collecting the information, using the information and data appropriately so that you can have a platform that everyone can benefit from.

We know that diet knowledge is increasing globally. There are many countries that have our version, the U.S. version, of what a healthy diet is. It's different in the different locations, it looks different, it's comprised of different types of food; but there are many countries that set goals for themselves. Because the challenge is – why aren't we meeting those goals? If we know this much about what's needed, we know where to head. At the same time, science is giving us an enormous amount of information about human genomics and health, about the microbiome in our gut, about the nature of the chemical molecules – Christine mentioned more than a hundred thousand, I think; phytochemists have estimated 400,000 different components in

different kinds of plants. How they contribute to health and wellness is another question, and it's a scientific challenge. And eventually, if we get to the area of really personalized nutrition in the advanced countries or even producing and providing sufficiency in developing economies, we need to have information that's science based and linking that composition to health, at the same time asking what happens when you have stresses on the environment, whether it's weather or climate related or preservation – but the impacts of those on the chemistries that affect our health.

So there's a lot of knowledge to be learned, but there are steps in between that we can have impact and make changes. So there are opportunities in that health and nutrition space in terms of education, from agriculture to health providers, in traceability of food, sourcing according to taste and other good goals – ensuring safety of foods, increasingly putting food safety and nutrition together as we did in AFRI, at NIFA, says that we think there is, we know there is a link in some, in many cases about the safety of foods and the impact that that has on nutrition value of the food. And then the promising future of food, nutrition and health is that we begin to match the information of our virogenome, of our microbiome, of food chemistry to make it work. But then match those up for those who are in critical need, for those in healthcare facilities or in the NICU, the neonatal units around the world, how to make those, make it possible to survive the challenges of all.

I want to turn next to this other area, because we think a lot in this country about food production and storage and processing and reducing waste. And we have spent so much time on this upstream side. The take-home message from the next six or seven slides is – we need to invest more in those nutrition-rich crops.

But the science and technology that can get us there is a wonderful, just pictures of wonderful advances in knowledge gain. I wish Rob would have said today in his remarks that agriculture is a STEM-rich field. It's a knowledge-rich enterprise, and what you do as a farmer or a food processor is based in the STEM education field; because in fact it's highly knowledge rich.

We know that we need to enhance the resource base, take care of the environment to make sure the agroecology and the agroecological sort of basis of our agriculture must improve if we want to ensure future productivity, it goes without saying, is the number one challenge that we have in our ag economies. We need to maintain and go towards sustainable intensification of production, match local crops to local needs, increasing yields, better practices, better seeds, and so forth. And we need to ensure resilience to climate change and weather variability. That kind of tolerance to drought and heat is a real challenge, because it will also, and it also reflects in these changes in climate with the likely impact the increases of diseases and pests as a consequence, and then reducing the input costs, making more of our agriculture based on what's produced and provided in the environment with reducing usage of unneeded chemicals as much as we can. And better surveillance – gets back to the data management, data collection, data management and data sharing electronically. Every farmer in India has got a handheld cell phone. How do we use that information flow more easily to make sure that it's the best agriculture culture possible in the most remote parts of that country, to say nothing about the continent of Africa and other parts of the globe?

So we need to maximize the use of... and I'm going to talk a little bit about the use of natural biodiversity and advanced genetic technologies. I am, after all, a biologist, a geneticist in

agriculture. But let's change the tune so that we place the priority on nutrient-rich crops, not on the starch and protein rich only but on the other nutrients and ask ourselves if we're paying as much attention to those as we do in the field crops.

But because of the nature the researchers have done, I want to draw from the first, that is, the advances made in some of our commodities.

One of the things that will change – and I'm really pleased to see this one – is there will be increase, I think, we have increased exploration of the biodiversity of the microbiome of our environment, I mean, our environmental microbiology, soil microbiology, the microbiology that's inside the plant, that's on the surface of the plant or in the skin of the animal. The role that those play in the health of the organism, both positive and negative, because there are some very symbiotic relationships outside of rhizobium or the real intimate symbiosis.

There are other kinds of symbiotic relationships that will happen, and we see a tremendous opportunity to use the microbiome as another way to enhance agriculture, to bump the agriculture productivity upward; because there is an enormous amount of biological information around the globe. A crop that's grown in the deserts or the harsh environments that might be experienced in some parts of Mexico versus the middle of Iowa will be very different. And knowing what's in the harsh environment should teach us about how to survive under harsh environmental conditions. So looking at the biodiversity of the microbiome in crop and non-crop species around the globe is a target that's underway and I think a great potential to match those microbes with seed. It turns out that the more we cultivate seed, the more we lose that natural microbiome component. Let's find that magic and put it back together so that we increase the biological diversity or the potential by tapping in several kinds of biodiversity.

Great advances going on in heat and drought tolerance and genetics, and it's great to see small companies, academic institutions, larger companies recognizing the importance of heat and drought tolerance. Perhaps some of the challenges in heat tolerance we know about because of the combination of heat and then drought; we know that there's greatly reduced in fertility in soya and in maize. Well, it happens also in rice and in cotton and in canola and other vegetable crops. Yet great advances are being made.

This is a company I happen to know about. By the way, I'm just choosing examples, because I have them in my Rolodex, in my file. In this case, you can drive canola to be able to produce at five degrees centigrade higher than its normal limits – that is transferable to other crops as well.

There was an example of wheat rust, and I want to come to wheat rust, because it is so important in wheat. But it shows the power of genetics and studying the natural biodiversity. This represents some work of Jorge Dubcovsky at the University of California Davis, an outstanding geneticist in his own right but a plant breeder more importantly. And he sort of traces where he found, where he looks for his information.

And there is mapping diversity in wheat and its relatives across the world, and Jorge and his other colleagues around the U.S. funded, I'm proud to say, by the National Institute of Food and Agriculture at USDA and other institutions, and they're finding that diversity has helped them remarkably to solve the wheat rust problem. In one case, they've identified a locust that came out of a wild species; he found a second locust that gave resistance to a very severe strain

of wheat rust that first showed up in Uganda, UG-99 strain that was referenced in passing earlier. And you can bring that genetic diversity into cultivated wheat by several methods, either by backcrossing in a standard way or by genetic engineering, and create the solution.

In that same pool, he found also loci that protect the crop from taking up cadmium and therefore having cadmium-rich seed. So he's now gotten to the issue of food safety, which affects the nutrition piece. The resources that George has used as a consequence of looking around has affected the uptake of cadmium, as well as looking for modifiers of the starch composition so that we have not a high glycemic and we can match high glycemic index starch or low glycemic, depending upon what's necessary in the market and what might be useful in treatment of obesity or obesity prevention. It really tells you the power of exploring as much as you can that genetic diversity to find the solutions to the answers that you're after.

Another one, once you get to that point, is of course tools, there are tools and techniques to use to follow these through genomic analysis. There's a project at UC Davis by Bart Weimer and a number of colleagues around the globe that's called the Hundred K Pathogen Project to map the genetics and the composition and the sequence of a hundred thousand microbes that are affected with food, food production, food processing and health, including human health. So that alone has led to so much more information and the ability of diagnostics to follow through, to be useful in traceability of food. Think of the power of that tool and technology if we can get this to a ten-cent or a one-cent analytics that could be useful in every farm in the world, including in Africa.

So think about where knowledge can take you, but then put this in the context of food and nutrition and placing as much priority on nutrition-rich foods, whether it's cassava from natural variations or genetic engineering variations and varieties that work best for nutrition where you are, or potatoes that don't brown, or papaya in this case with high carotene. But think about what we can do as a society differently if we were facing not a food per se, a food shortage but recognizing this is a nutrition shortage rather than placing it in the context of food per se. And again, the golden rice picture that many of you have seen before.

So what is missing? And so our group in the workshop said we need to recognize the need for investment in nutrition-rich crops, investment to reduce those losses, engaging agriculturalists in nutrition, and nutritionists in agriculture asking the question differently, and innovating throughout the full system, food systems that are effective at local levels as well as larger system economy levels, and policies that reward production of nutrition rather than food production per se.

I think that's my last slide, and we'll move next to the... Oh, I'm sorry. I did miss one but as a biotechnologist I recognize as critical – the regulatory practices that encourage innovation while ensuring food safety.

And next, over to Dr. Dan Sumner, also from UC Davis. Dan.

Dan Sumner

Thank you, Roger. As the last speaker in this session, I was also the timekeeper. It is an efficient way to do things, and we are on time, and this group wanted to make sure we had enough time to interact with the audience, and I think we can do that. So let me move quickly.

What I'm going to focus on is some metrics. And it's all well and good to talk about the exciting research we're all doing, and that's what we do every day all day at the university and research establishments, sister organizations all over the world in this goal of nutritional security where you emphasize the word "nutrition" and the word "security" in a "sustainable" way. And so those are the three key words for us.

We set ourselves a short-term task, anyway, of thinking about progress towards measuring things, trying not to compete with lots of other folks around the world that are doing something similar. So Joe, for example, talked about the IFPRI Hunger Index that came out just in the last few days. The Economist Intelligence Unit, together with DuPont, puts out some indices. We think that we can use scholars from a variety of areas that Roger mentioned, from sustainability science to ecologists to nutritionists, economists, biologists and on around, to think about – how do we measure, not just where we are but where we are relative to a goal. So where are we in terms of making progress? Where do we see bottlenecks coming? And that requires measurement, and that's what I want to focus on for a few minutes.

And here's an example of the IFPRI Global Hunger Index that was just released. They have done a wonderful job over the last 20 or 30 years of data. They've been doing it for about a decade, but they've gone back with it. It's quite a simple index. It's a couple of measures about children, two or three measures about children and one global malnutrition index. It doesn't get into the kind of richness that Christine was telling us about. It doesn't get into the kind of richness about policy or about regulation or about sustainability that we all know are crucially important – and doesn't try to look forward.

And what is that looking forward? Joe mentioned how much more food would be needed by 2050, and these projections are done by economists who don't really know – let me be very clear there. They hinge on assuming we're going to have a positive outcome in terms of economic growth. If we didn't have economic growth, in fact, we don't need this much more food; food growth would keep up with population, barely. It's an optimistic forecast to say we need 50% more food in the next 35 years that builds within it places in Africa like Sierra Leone will in fact get back to growth, and when they get back to growth, they're going to demand better food. And so a lot of this additional food demand is in fact better food.

A lot of it is nutrition-rich individual foods, but some of it is meat or livestock products, more broadly. And here's another picture of the graph that Joe showed where this, just to raise different countries. This is just history, but this history tells us a lot about what's likely to be coming in the future. And one thing I will say is we know that, for direct human consumption, intensely nutritious food is important for us. But it's also true that we are in fact going to be feeding livestock – there's just no question about that's going to happen, because people are going to demand animal products as they get wealthier. And those animals are going to be eating lots of starch. So let's not neglect the corn and the soybeans, because we're going to need those to feed those additional animals, whether it's eggs or dairy products or whatever that

people are really going to need. Put on top of that, the R&D for the fruits and vegetables and the other nutrition-rich foods that Christine emphasized.

One thing we did at our workshop was emphasize putting agriculture in a broader context, and in fact several of us reminded that the agricultural economy is connected to the rest of the economy. And agricultural sustainability is tied to sustainability for the whole society. And so we think about the goals being not just nutrition but a good life. That reminds us that most people don't just eat for nutrition. People eat the foods they like. They eat the foods that are consistent with their culture, and we really have to remember that – that the foods we eat are..., and this is everybody on the planet. And as people get more income, they will emphasize food that they want to eat, and we want to help make sure that what they want to eat is also nutrition-rich foods. And Christine emphasized this metric of information and education about the foods themselves.

A lot of emphasis on the asset base, and it's an economic word to talk about assets, but what we mean by that are the knowledge base, knowledge assets, human capital, natural capital, the human resources we use, and social capital, the kind of information and structures that allow us to function in society. When something like Ebola hits, that social capital is so crucial; I mean, that is something you have to invest in in a society, and when you have it, it really pays off to make a society resilient. And that's using an economic word to talk about something that's so crucially important socially, so that when we set ourselves to having metrics of how we're doing towards a nutritious future, a future that's sustainable, these kind of capital measures are also important to us.

And every company in the world... I picked at random one company having to do with food here, General Mills, but every company in the world focuses on sustainability. We know that 30 or 40% of the land on the planet is being used today for agriculture. Some of that's grazing, some of that's intensive crops, some of it's extensive crops. But we also know that that land footprint probably isn't going to increase for agriculture. We've actually expanded cropland over the last decade or so. We've probably hit the limits of what we're going to do – not every place; there's certain places on the globe. Joe mentioned Eastern Europe that has expanded intensive use of cropland. But there's other places where we may well be reforesting for climate change sorts of reasons. On balance, we probably don't have a lot we can do, and what that means is expansion of crop production won't continue. I mean, excuse me, expansion of crop production area won't continue, and that means intensification, and Roger talked in particular about intensifying the output we get from each of those scarce natural resources, whether it be the land we use, the water we use, or increasingly the greenhouse gases we emit. If we think of that as a scarce resource we don't want to use up, we have to cut back on, that's a crucial metric for us to think about. That means accelerating yield growth – it just has to mean that. And that's not just plant growth, but of course that's livestock yield as well. And they may well be more intensive pasture or genetics on livestock. There's a whole series of measures there that we have to take.

And this is a picture I like that talks about potential yield attainment. This is across the major crops, and you can see parts of Africa look very good there. We're very close to the yield potential according to some measures. This is from a paper from West and others in science a

year or so ago in other places on the globe that are more in the light green or the yellow, this says we have some real potential in those places.

And what this sort of information gets to is – where do we make investments? And one of those investments is, of course, food waste. And one reason I like this chart – and these numbers are sort of starkly presented here – just two parts of the world, North America and Oceania; Northern Europe’s much the same, and Sub-Saharan Africa and South Asia is much the same. Both have losses at the harvest level, for different reasons, but they both lose output, food output, maybe for good reason – it’s expensive. I mean, you can label it as waste, but that doesn’t mean it’s free to get rid of it.

But where you see a huge difference is in post-harvest that stage right after the harvest before you get to processing and moving through the distribution chain. And in Sub-Saharan Africa you have substantial losses – they’re more than 10%, 12% losses there. In the rich countries, relatively little loss there. This is spoilage, loss out in... It’s the kind of storage you’re doing, the kind of immediacy you have in processing, the kind of refrigeration you have for vegetables, etc. When you go to the other end, when you get to developing countries, consumers aren’t wasting their food, they’re not losing. And if you look at the rich countries there, that’s where you have another big chunk of loss.

So on average it’s about the same across these countries – across the world there’s not stark differences in total food loss or food waste, but there are stark differences in where it happens. And this helps us know how to target things. Here’s another little chart that makes a somewhat different point. Think about producing something close to 5,000 calories and move through the chain, just calories here. And Christine gave me special dispensation to talk only about calories for a few minutes, because, you know, we could do the same thing with protein or some micronutrient. And the question is, what happens as we go down the chain? And the answer is, we lose it at the post-harvest, so we lose it somewhere along the line at the household, somewhere along. And if we target on where can keep this stuff in the food system and actually used for human nutrition, that’s a positive.

So let me come back to some metrics. On the economic side, the extent of the degree of extreme poverty is probably the most important signal for the availability of nutrition. A family that isn’t in dire straits economically can find that nutrition, mostly, in most places. As Joe pointed out, we’ve made remarkable progress in removing extreme poverty. I’m optimistic that’ll continue. That’s part of the story.

The other part of the story is either affordability, accessibility, availability of nutrition-rich foods. And that’s the other part of the economic story there is – what’s happened to prices? And Joe showed us that there are a couple of ways to slice those. We can be fairly optimistic about a long-term path. We can be fairly optimistic about the very short-term path the last four or five years. It’s that intermediate space between about 1990 or so and 2015 where that trend is not down, it’s up. And is that the longer-term path we’re on? And there’s a number of people that are very worried about that.

And one reason they’re worried about it is the natural resource stock, the climate especially. Have we done things to the climate that’s going to make it that much harder to produce our food? And the other is the R&D base. Are we investing enough, and have we invested enough,

particularly in public R&D? Have we made those investments? And public R&D, this picture just is a pie chart telling you where that research is getting done – this is only on the public side, not the private firms. This is a couple of years ago, three or four years ago, the last time we had good data; and high-income countries were just above the developing world, middle-income and developing world here. By now it's switched, and it's more of the research is being done in the poorer countries of the world.

I would submit to you it's more important where the focus of the research is than physically where the research is. So Roger mentioned Jorge Dubcovsky doing lots of work on wheat varieties, developing work on diseases that don't exist here in North America. They're primarily diseases in the developing world. The fact that some of that work is being done in a lab at Davis doesn't really matter – the focus is where it can be done most effectively for the purpose of poor countries.

That said, agriculture is a little different than some kind of science in the sense that local adaptability really does matter. That means some of the science really has to be done in the places where it's going to be used, because that's how you know what's going on. That's even true, of course, in nutrition. So someone like Christine finds herself around the planet at any given time of the year, because she's working in the places where the nutrition issues arise.

Roger mentioned policy and regulation. And let me just say there, the subsidies and barriers that cause higher cost and stifle innovation, they reduce the rate of growth of income, and income is what really matters to getting people to get nutrition.

The other thing I want to emphasize is trade being so important to resilience. Storage is important. Storage means you can hold food over time, but moving food across space; when one place has a shortfall, the next place is ready to fill in the gaps. The more we have information about that, for example, climate patterns or weather patterns forecast ahead of time... We know when el niño is coming. We know enough now – which we didn't know 20 years ago – we know enough now what that's going to mean for yields in different parts of the country and different parts of the world. So we know certain parts of South America is going to be under stress; certain parts of Asia are going to have a different kind of stress; other places are going to have better than normal yields. And we can plan ahead for that. And this is the kind of data-rich science that we didn't have just a few years ago. It's one reason I'm optimistic, and I like... I stuck this slide in just in the last day or so.

There was another was another prize announced this week that is also a kind of a food prize. Many of you don't know Angus Deaton, an economist at Princeton. Much of his work in fact was on food demand. Here's a guy who has a Nobel Prize in economics who has dirty boots. He's walked around in India and Africa and other places, looking at questions of – how do you get data, individual-level data? So he's one of the guys that emphasized, we can't just use aggregate data on countries. He doesn't do macroeconomics. He does the microeconomics household by household. He also developed econometric techniques that every agricultural economist now uses to study the system of demand for foods across lots of different foods in a demand system. He's also a guy that his popular book, *The Great Awakening* or *The Great...*, yeah, *Awakening*, I think. Or, no. *The Great Escape* is the name of his popular book, is talking about the escape from poverty. He uses his family and others and is remarkably optimistic – recognizes lots of problems but optimistic in the sense that he's a man with a historical

perspective on things. And if you look at the really remarkable changes that have happened over the last century, 50 years globally, it's hard not to be optimistic, unless we hold ourselves back, unless we block our own resilience as humans, unless we do things to stop us from doing what we've done before— then we really do have a future. So I think this realistic optimism is a good place to stop, and I think that's what these final remarks say.

With that, we have a few minutes before five o'clock; and then given that we started 15 or 20 minutes behind, maybe we can stay for an extra 5 minutes or so, Ken. I know that some of you have a bus coming, so let me first ask my panelists if they have any amendments, remarks or responses to each other. And then if we have any remarks from the audience, we'll entertain those.

Roger I have just a little bit of comment while someone's coming to the mic. HarvestPlus who's table sits on this floor has promoted the importance of research and nutrition-rich crops for a number of years to the encouragement and support of the Gates Foundation. And as an example of what they've done, I think you can see changes happening in diets. So I wanted to give credit where credit was due in that early initiative, because it has been important for researchers to focus in those areas.

But my question is really... Now we have questions in the audience, and if need those, I'll use mine. Please go ahead.

Q Jim Hershey with the American Soybean Association's WISHH program. Roger, wonderful panel. Thanks very much. Question: What effect would an increase in the availability and affordability of protein have on undernutrition, especially stunting, and how could we achieve this?

Roger So I'm going to let Christine take that one. I'm going to be just a traffic cop here. Christine, to move quickly, we'll just turn that to you.

Christine So I would put the emphasis not so much on the protein but on the micronutrients. So I focus on animal-source foods quite a lot because of their importance in meeting iron, zinc, vitamin A, vitamin B12, and these critical micronutrients that are really important for young children for child growth, for brain development, for women during pregnancy. And so that's where I see the major gap rather than a protein gap per se. And so I think it... I don't have the economic numbers at my fingertips the way some of my colleagues might, but certainly price is a major barrier to access to animal-source foods. When incomes rise, purchasing of animal-source foods increases, so I think that price is very important when we think about access to those types of products that are really important for nutrition.

Roger We all recognize that there is a protein gap as well, and I guess the question from the ASA is around what's that role, or what should there be in addition to seed-based proteins. And I think imagination and creativity in that arena is burgeoning. We see it in Holland with insects and other cultures. So I think we need that protein base— that has to be there, I think you'd agree, but the micronutrients on top of that makes this a more whole answer.

Q Hi. Zenn Honeycutt from Moms Across America, and I really appreciate your taking on such an enormous task and your data and your research. In your consideration of nutrition – I really appreciate that you’re looking at that – have you considered that glyphosate is a chelator, and it draws out the vital nutrients of any living thing it touches, and it’s allowed on 160 of our foods by the EPA, and it’s being sprayed as a drying agent before harvest. Wouldn't that be chelating many different nutrients and vitamins that are needed, especially through the soil absorption and as a drying agent? Wouldn't that be a factor? I mean, as a mother, I’m gravely concerned that this chemical, which is being sprayed by the hundreds of millions of pounds around the years, has been connected to things like my son’s autism symptoms, food allergies – I almost lost my son’s life – and miscarriages. This is a huge concern, and I ask the international community to please consider the impact of glyphosate.

Roger I think some of the claims that have made are made without sort of the benefit of full science engagement, so I’d ask first that you look carefully at the information that you have, where it came from and what the intent is. And then let’s ask for additional... If more research is needed and it’s called for, rather than being anecdotal, we then have a basis on which to continue the research. So I’ve heard... many of us have heard these claims. We’re asking ourselves – how does that relate? Is there a correlation, or is it proof? And what we have are a few examples that bear looking at, but I think we need additional, firm, hard science that makes that correlation or not and helps to erase that question. Your fears are right – there are all sorts of reasons why diseases such as you recognize, that you mention are happening, and they are so complex, to make a simple analysis to a single compound is difficult for many of us, based on the history of the science that led up to a diagnosis of autism or other kinds of allergies or diseases that might have happened. Your concern is appreciated, and where there is more research necessary, we need to do it, but we have to be careful about accusations that are not backed by the scientific fact.

Q We have hundreds of scientific studies.

Roger So I’m balancing things back and forth because there isn’t enough science to say that there is a causative effect.

Q We have hundreds of scientific studies, and if there’s any doubt at all, I would ask the community not to use it on our food. Thank you.

Roger Thank you. Yes, sir.

Q I was wondering if Dr. Beachy could answer this: Do you foresee any plans to have organized, large-scale efforts to harvest the genetic resources in places with biodiversity like the Amazon, and use those resources for sustainability purposes to solve sustainability problems?

Roger I think the importance of collecting the important parts of biodiversity, whether they’re microbial or plant genetic resources has been made clear by a number of organizations, and you’re spot on... And what I think the research that Jorge and the

scientists around the world have done is say, this is where we're going to get some of the answers. I am sort of confused by the complexity of the challenge, because there are so many different examples, and the more we learn of a simple crop like rice and what genetic variability caused by a single nucleotide change might have in an impact on a phenotype that's useful or harmful, is just now coming to light. We need to have enough of that diversity to make sure we can draw on it in the future.

And I think the CGIAR and other resources or institutions around the globe have done a good job at collecting the germplasm or monitoring the germplasm of the major crops. What about those hundred or four hundred or how many other numbers of sort of orphan crops that are in Africa that are so important for local sustaining of the economy and of health, what about those? How do we prioritize those in the many things that we need to do to ensure that we meet the nutrient need? It has to be some big figure. It has to be in the calculus, but I'm not sure how much of a proportion of a research budget one would put towards one or the other; because we have immediate needs and long-term needs.

Your point's on the mark, because without that information, we will be disadvantaged and handicapped in years to come. But balancing that part of the solution versus a forward-looking approach that takes additional genetic..., uses genetic information from one crop that transfers it to another can be equally as important. But I'm going to beg off on knowing what percentage. I'd love to be able to say 35%, but it's probably going to be in the range of 5 to 10% but an important 5 to 10%, not to be forgotten.

Q No, I appreciate it. Do you think governments will cooperate on that?

Roger I think one of the challenges that we have in this, what we're setting out now to do it, setting metrics, the real challenge will be getting countries to recognize the importance of the nutrition side. Once that happens, I think it goes naturally to — how are we going to improve or enhance locally? And that's where the recognition of the importance of biodiversity comes. Which is first? Which one comes first? And I suspect a demand towards, I mean, a demand of the population or of the groups toward pushing policies, that putting nutrition close to the top of the agenda, not second or third or tenth but close to the top.

Sumner I think about some innovations going on on the fruit side, looking for drought-tolerant, for example, root stocks for fruit crops, grapes, for example, where it's not the Amazon that you're looking to but it's lots of other places, desert places where you find varieties of grapevines, for example, that are tolerated that don't have other productivity characteristics that you may want but have that kind of root tolerance for drought. And so there are lots of scientists really all over the planet that are searching for diversity that they can get a hold of to use and improve productivity while maintaining other quality characteristics in products that they want.

Roger To take one more comment to that point, Dan. Examples such as that wheat example that I just showed you and the rice example, I think can be used as evidentiaries that it's worth saving the germplasm and needs to be worked at. And so making that

correlation to a region that doesn't grow rice might be difficult, but there are informed people that need to be engaged in the policy side. I think we have an opportunity, but it's going to take some dedicated effort.

Dan So we'll move quickly. We have three people in line, and over the next few minutes we'll deal with those.

Q Thank you, good. David Lambert. Thank you for a great session. My question goes to our failure to communicate in trying to better understand why early child nutrition budgets are so severely inadequate. Would you not agree that we have failed effectively to tell the story of how adult diseases relate directly back to early child nutrition? For example, a legislator in developing country X, 60 years old with Type 2 diabetes, in his mind that's an issue with his health department, not with child nutrition, and when he makes budgetary decisions, he won't think about the pregnancy of his mother or his malnutrition in the first thousand days. And is that not one of the reasons we don't get better attention and more priority for early child nutrition?

Dan I'm going to turn that to Christine, but one thing that is true is I think we are making progress there. Just in the last five years, the sort of emphasis on that first hundred days really has improved, not in the United States with respect to policy, and not just nutrition but lots of other health and cognitive development in the life. But, Christine, I know that you have lots of expertise in this area.

Christine Well, I would agree, but I would also say that in 2008 there was the release of a *Lancet* series of papers that focused really front and center on maternal and child malnutrition. And that was, around about that time was when we really started focusing on this time period of the first thousand days, the period of time from conception to roughly two years of age. Because of the acknowledged importance of that period of life on the child's own health, the immediate health, pregnancy health, but also on later life, later health there's an increased risk of chronic disease, as you mentioned, lower economic productivity, and other things. So it's really important to focus on this period of time.

And since the release of that series of papers, there was also a huge advocacy effort to make nutrition goals more central to development and to scale up nutrition actions that we know are effective. And so I would say that there has been more attention that is being paid to nutrition. But I think that there's still a long ways to go and to go beyond the point of acknowledging it's importance but also to monitoring progress towards achieving the goals that we set in the area of maternal and child malnutrition and holding governments and agencies accountable to these goals and in order to make sure that maternal and child nutrition issues are really central to many government agencies and many organizations that may have the capacity to make an impact.

Roger Mr. Lambert makes an important point. We missed an opportunity in the past to link agriculture to health and wellbeing. And I think it's critical for policymakers and for the public to realize that linkage so that the kind of support that we need to move to

that next level of engagement and using foods for health comes through knowledge. And we've missed an opportunity in this country because of the abundance and the choice, I suspect. And it's affordability. It's not an issue for us, but it is in other places, and we have to recognize that we have a responsibility there as well.

Q Thank you. My name is Emily. I'm an undergraduate at Pennsylvania State. I wanted to talk about... You addressed the importance of meat and animal food consumption and micronutrient deficiencies and nutrition security. And we also talked about the importance of addressing climate change and ensuring nutrition security over time. Are those two goals compatible, given our knowledge on how livestock production contributes to climate change?

Dan So you ask a five-hour question with one minute left, I see. Let me address that very quickly. They have to be. They just have to be, because there's no question changing climate makes it harder to meet the nutritionists' goals that we have to get to. But we have to figure out a way to do that. So, yes, climate change will make life harder for agricultural researchers, for food and nutrition researchers; but we don't have a choice, so we have to do it. And it's one more challenge we face along with several others that have been mentioned here. I don't know what to say other than that in this short time.

Q Okay, thanks.

Dan And one last question?

Q Hi. I'm Julie Howard from Michigan State University, and it's really great to hear these issues discussed as a holistic system – so environmental sustainability through to nutrition and availability that are outcomes. I'm wondering – and I also really liked, Roger, your reflection on what's the next disruptor in terms of plant research. I'm wondering, from the economist, as we think about this holistic system, what are the innovations needed on the economic side to help us make better choices in this systemic framework? So considering an investment – do we plant almonds on this piece of land? What are the implications health-wise? What are the implications environment-wise? Sort of pulling all that back together in a framework, dare I say price framework, to help us make better decisions as a society – currently and for the future.

Roger Joe, I'll give you 30 seconds, and then I'll take the last 30 seconds.

Joe Let me just, I think, focus a bit on the sort of policy side, because there I think it's real clear, the work, the value of investment in research and development. And I think you look at things like Dan had mentioned, all the food policies that are in place around the world, support policies and other things, and just taking a fraction of that and putting it into research. We'll probably pay out this year alone in ARC and PLC payments two or three times that of what we're going to pay in public research dollars. Now, that doesn't mean... I'm not necessarily saying that's not needed by those, but it's just to say that in the grand scheme of things we don't give a lot of money to research. And I think that all of the studies show that research pays when

it's done in a sustained way and a developed way. And I think for meeting a lot of these needs, I think it's clear that we're going to need more research dollars in a more sustained effort.

Sumner But Joe was emphasizing the public sector research, not the private sector research. And I think what's crucially acknowledged by everybody is governments are in fact investing less now than they used to. And that's a real shame. That's not a path to sustainable nutrition.

I will emphasize one other thing. And really around the world, allowing farmers... not subsidizing but allowing them to grow with what is demanded and sell that product is crucially important. And the most important thing in that is people assuring that they actually have rights, they own what they think they own, so that they can make investments. Individuals and companies and others will make investments if they have security for those investments. And the problem, whether it's war or revolution or just changes in regulatory regimes, if you can't feel secure that you can get a payback on an investment, you won't make that investment.

I'll give you one example. In California we have a drought. Some of you may have heard. Crucial to that is how we handle groundwater. One of the problems with groundwater in California, it wasn't clear who owns it. So if a farmer were to say, "Gee, I want to pump groundwater to irrigate my crop next year." If he said, "This winter I have plenty of water. I'll invest in groundwater under my farm," the problem is, the farmer doesn't own that water. It's not his. Somebody else can pump it. So the farmer won't make that investment, and they don't. And until that—who owns what?—is cleared up, that ownership, that security of ownership, the investments don't get made. And you see that pattern worldwide. I gave you the example of water underneath the soil in California, but I could give you the same example for a poor farmer in Africa who isn't sure that if they make an investment in a farm, they'll still have that farm the next time something bad happens in the countryside. So that's the scary part for the world.

Q Do you think private markets are really sufficient? I mean, I guess I'm talking about analysis that will help governments plan. For 10 to 15 to 20 years in the future, what are the investments that need to be made, or what are the sort of policy signals we need to send to investors to make sure that we're not just planting our land to potatoes so everybody is eating French fries, or that we're not sending signals so that all the groundwater is used up over the next five or ten years. You see what I mean?

Dan And Joe started. I'll just finish here. Joe started talking about the agricultural R&D that really is what you're talking about, which is a government..., places where the private incentives are not sufficient. We know there are lots of others. There are environmental issues, sustainability issues, climate change issues where private incentives are not sufficient. But I guess I wanted to take... Given that he did that one, I wanted to take the side where one thing that governments can do is secure what people do own—that is another role for government, is to secure property rights side.

I just got a sign flashing at me saying, STOP. So I apologize, and if you have a last question, the panel is going to be here for a few more minutes.