

Remarks of Dr. Catherine Woteki
“New Horizons for Research”
USDA Chief Scientist and Under Secretary for Research, Education and Economics
Meeting of Agricultural Chief Scientists
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Thank you all for traveling here today to take part in this first-ever Meeting of Agricultural Chief Scientists and to our Mexican colleagues for hosting us. Your very presence is a vote of confidence that science can bring us the answers we need to face the challenges ahead, especially that of feeding more than 9 billion people sustainably by 2050. There is not a moment to waste if we're going to achieve that goal for our nations and the world. I – like you – have spent my life as a scientist and have had the opportunity to work with scientists around the globe. I've seen that, when scientists collaborate and coordinate their research, the pace of discovery can move forward by leaps and bounds. Our agenda here this week will help us make some crucial decisions about how we can do that for agricultural science, to the benefit of our citizens and our globe .

Today, I'd like to present some “blue sky” ideas to ignite this part of our discussion. At the U.S. Department of Agriculture, where I am also Chief Scientist, we work across a broad array of research areas, doing the long-term, fundamental research that private industry can't afford to do, or won't because it can't promise a fast return – or maybe any return – on investment. But that research has long been the foundation of important scientific discoveries and innovations that have driven the resilience of American agriculture. We also conduct and sponsor shorter-term problem-solving research, responding to the immediate needs of farmers and ranchers. This

combination has helped our country have some of the lowest food costs in the world, and allowed us to be such a large exporter of food to other nations.

When I was appointed to this position, I directed the agencies in my area of the Department to come up with an “action plan” that was framed largely by a report from the National Research Council called “A New Biology for the 21st Century.” That document had also been an inspiration for the reorganization of what became the National Institute of Food and Agriculture, the grant-making and extension education arm of the four agencies I oversee.

That report – written by 16 leading scientists and engineers – begins:

“Imagine a world:

- where there is abundant, healthful food for everyone
- where the environment is resilient and flourishing
- where there is sustainable, clean energy
- where good health is the norm.”

That list sums up the vision for our research programs at USDA, and I hope for our work here this week.

So what is the new biology?

The New Biology draws on different fields of science to study life. It brings together inputs from a wide range of disciplines: from biological, physical and computational sciences to mathematics and engineering to establish a deeper understanding of scientific processes than our current, very silo-ed research regimes offer. Today's research lays the foundation for the New Biology, which promises biology-based solutions for the problems facing society, while at the same time, provides new insights to the separate disciplines involved. It weaves a strong tapestry for the science of the future and expands the universe of ideas from which we will discover tomorrow's solutions to today's problems. And, most importantly, this new biology is "purposefully organized around problem-solving."

So where is our starting place?

Worldwide, the amount of land for agricultural production is finite, so it is crucial to use that land wisely, sustainably and productively. Economists who study agricultural productivity, break it down into three components: growth in land area, which is unlikely to increase significantly; yield growth that stems from increasing inputs into production; and finally, a further contributor to yield growth they call Total Factor Productivity (TFP.) TFP measures the efficiency with which all inputs – land, labor, capital and materials – are combined to produce total outputs of crops and livestock. It's a good indicator of technological change and clearly displays the link between investments made in research and development to outcomes. I think of TFP as a combination of innovation and know-how, because TFP is strongly associated with adoption of new technology.

Growth in global ag output has remained steady from the 1960s til now, but the source of growth has shifted from resource-led to innovation-led.

There is a great disparity in investment around the globe in ag R&D. Countries like China and Brazil are increasing their ag R&D investments at much higher rates than the U.S. and most other countries. And countries where science could substantially improve their ability to feed themselves, such as Sub-Saharan Africa, are barely able to invest at all – spending only half of one percent per year of agricultural GDP on research, although there are some bright spots. In these countries, it will be important to harness the know-how of farmers on the ground and build upon it. Scientific innovation can magnify the benefits of their current knowledge, if we can develop it and if we can work with local farmers to use it effectively. Right now, when so much of the world is facing tough economic times, we need to identify where we think we'll get most out of our investment.

These differences in investment are evident in places where TFP growth is high – like Brazil and China. And even within countries like Australia and the U.S. Western Europe and North America fall in the middle.

So, let's set our sights high and think big. What are the blue sky ideas that would make the greatest difference if we combined our research efforts to advance them as fast as possible? What are the novel, game-changing – transformational – ideas?

One way to approach this effort involves cross cutting, fundamental science that can be applied in crop and livestock production, improving food safety and human nutrition. The ideas where I see the most promise include

Two issues that have been on blue sky lists for decades -- nitrogen fixation in non-legumes and perennialization of cereal crops.

- **Nitrogen fixation.** Sir John Beddington of the United Kingdom has proposed establishing a UK/USA program in nitrogen fixation and utilization, which would eventually be broadened out to include other key nations and NGOs, and potentially with private sector partners. His focus on this issue has ignited the interest of the UK's Department for International Development to seek a partnership with other international funders to develop and promote this project in a coordinated, collaborative way. Solving the problem of nitrogen fixation would also reduce demand for synthetic nitrogen fertilizer, reduce fossil energy use in agriculture, and reduce nutrient runoff into water bodies.
- **Perennialization.** Can crops be bred or engineered to be perennials, to get the benefits of not disturbing the soil on regular basis, saving energy, soil, water and seed? We are doing work on several basic crops to see if we can attain this goal.
- **RNAi technology.** In addition to the complete genome sequence of numerous plants and animals – and those sequences can be shared on the internet – we have greater ability to identify and manipulate genes and their expression. As we learn more about the genomic

basis for beneficial and harmful traits, RNA interference techniques to limit or encourage cell activity could provide new approaches to fight pests and diseases of crops and livestock.

- The Encyclopedia of DNA Elements (**ENCODE**) has recently released information about the role that so-called “**junk DNA**” plays in gene expression. Thirty-five research teams analyzed 44 regions of the genome - 30 million bases in all, about 1% of the total genome and found that 80 percent of the human genome serves a purpose, and is not wasted. The new information provided by this coordinated effort clarifies genetic risk factors for a variety of human diseases and offer a better understanding of gene regulation and function. As a result of ENCODE, some researchers argue that the fundamental unit of the genome and the basic unit of heredity should be the transcript - the piece of RNA decoded from DNA - and not the gene. This is exciting research that has changed our concept of the gene and shed new light on RNA works, and offers new pathways for plant and food animal improvement.
- **Synthetic and systems biology.** Synthetic biology includes both the synthesis of new organisms do novo, as well as the genetic manipulation of existing organisms to create new products. While this field is new, it is developing rapidly and it holds great promise for agriculture, including through the manipulation of food crops to produce essential nutrients, such as vitamins, by creating synthetic biosensor films which can detect soil health and food spoilage, by engineering photosynthetic algae to directly produce ethanol,

and by using agricultural waste, such as soybean hulls, to manufacture necessary chemicals such as surfactants.

- **The micro-biome.** Understanding the totality of microbe populations, their genomes and their interactions in particular environments will likely play a significant role in improving agricultural productivity. For example, we may be able to improve the efficiency with which ruminants extract nutrients from their food through an understanding of gut microbes, we may be able to improve plant-microbe interactions to find new ways for plants to live in new environments, and we may be able to improve plant growth processes by studying the rhizosphere microbiomes.
- **Water Security** – by which I mean preserving water supplies around the globe and using them wisely in agriculture is growing into a crisis. Eighty percent of the world's population faces the possibility of water shortages or water-related risks to biodiversity. Right now, research efforts aren't well integrated with the needs of policymakers and practitioners. Science magazine recently featured an article by British Columbia's Director for the Program of Water Governance, Karen Bakker on the topic. Water scarcity undermines food and energy security, and could be enhanced by both conservation and innovations that science could bring. Hydrological variability accompanies climate change, which will require more effective water management. Lower water tables can lead to more contamination of crops and drinking water. And there is the perpetual challenge of balancing human and environmental water needs while

safeguarding essential ecosystem services and biodiversity – never an easy trade-off to make.

- **Long-term sustainability of agricultural systems.** In the United States, we have just launched our Long-Term Agroecological Research (LTAR) network, giving researchers and policymakers a unique tool to address large-scale questions in the ag system of a geographically large country. Feed-the-Future – the government-wide ag R&D program – focuses on four agro-ecosystems in Africa. Agro-ecosystems are trans-border, so we are organizing our efforts to develop long-term sustainable ag systems with high productivity. This will call for a coordinated approach to research that ensures valid cross-site comparisons that can help policymakers and ag practitioners alike determine different, appropriate management responses to diverse challenges. Along these lines, the Foresight Report calls for a **global open-source database** encompassing ag, land-use, economic and environmental data – and an international forum for modeling the food system.

This list is by no means exhaustive, but I hope it can serve as a basis for our discussion today. I believe using the Global Research Collaboration platforms we're talking about this week can break down barriers of geography and politically drawn borders, and unite us in moving together towards some focused goals. More importantly – the GRCPs can facilitate current and future work and decrease the time from the idea of a project to its actualization.

Progress in science has always depended on communication and sharing of results, whether to replicate and validate new findings or to translate discoveries into applied outcomes. With the development of science in the Internet Age, opportunities for scientific collaboration and dissemination of research results have increased dramatically. And in fact we observe rising levels of international collaboration, not least in areas of agricultural science. The Global Research Collaboration Platforms that are on the agenda for this meeting provide an infrastructure to harness this collaboration for expanding the capacity of agricultural research systems and amplifying agricultural science results.

The Global Research Collaboration Platforms provide a set of general tools and practices that can accelerate specific research projects. As an example for how the Global Research Collaboration Platforms apply broadly, imagine how they would support research in the perennialization of cereals. Open access to genome sequences of target species and their relatives could help researchers identify loci for research, and open access to germplasm would allow breeders to identify useful traits and incorporate them into new cultivars. Open access to publications would allow other research teams to build on emerging results or try alternative approaches. Improved agricultural innovation systems can accelerate the commercialization and adoption of the first new products. Improved agricultural statistics help to trace the impact of the new varieties, measuring the benefits to producers in saved planting time and reduced input costs. And also allowing future MACS to gauge progress on sustainable intensification of productivity and to plan new projects.

There are several ways to find our way through this huge universe of possible research ideas and predicting the future is by definition an inexact science. As Dr. Lincoln Moses, the eminent statistician, said, “we cannot provide facts about the future.”

Do we choose a focus on certain set of crops and livestock issues which seem to us to be the most urgently needed food sources to shore up for the future? Do we begin in areas where research is mature enough that we can imagine a major international effort leading us to tangible results in five to 10 years? Or do we decide to focus on more fundamental topics that have implications across many different crops, such as nitrogen fixation, that could be transformational?

As a scientist, my inclination is to make those judgments by looking at a set of criteria that will help us make such choices:

- 1) The state/maturity of the science is such that a concerted international investment is likely to produce results in five years.
- 2) The project is appropriate for government investment, fitting under the categories of “precompetitive” and international “public goods.”
- 3) Scientific resources (i.e. scientific expertise, instrumentation) are widely distributed.
- 4) The project addresses a fundamental question with broad applicability to crops and/or livestock.
- 5) The project focuses on one crop or animal that is an important staple in many countries, one that poses a common problem or natural resources concern.

In his remarks opening this session, Dr. Jones set the context for agricultural research for development, making the case that the challenges for the developed and developing world are real, and that we cannot tolerate business as usual. We must find ways to accelerate innovation and adoption of new agricultural technologies as part of a new, forward-looking approach to the food and agricultural challenges we face.

We have a lot of work ahead of us, so I'll close and let us get to it. I sense that there is a tremendous will here to commit to this collaborative kind of work, and share a common goal of creating agricultural systems across the globe that are productive, sustainable and offer healthful foods for our citizens.