

Proceedings of the 2014 AAAS Charles Valentine Riley Memorial Lecture

A Food and Agricultural Research Agenda to Deal with the Asteroids of the Future

Organized in collaboration with the Charles Valentine Riley Memorial Foundation and the World Food Prize Foundation

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Foreword

There are nearly 840 million people around the world who are chronically hungry. To feed them and meet a rising food demand as a result of anticipated population growth and increase in standards of living, the world will need to more than double its food production in the next 35 years. At the same time, however, growers are facing the impacts of a changing climate, including increased drought, higher temperatures, and severe storms, and will have limited new land to put into agriculture.

“Given the challenges facing agriculture, it is far from assured that agricultural output can climb enough to keep pace with expected demand,” said the 2014 AAAS Charles Valentine Riley Memorial Lecturer Daniel Glickman, former U.S. Secretary of Agriculture.

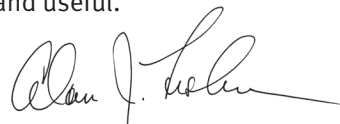
Secretary Glickman went on to provide a list of recommendations for addressing what he called the ‘asteroid-like problems’ facing our planet. Among the key points, he argued that only more basic and translational research can ultimately help food producers find solutions to challenges posed by population growth and climate change, since we need to entertain wholly new approaches for increasing agricultural productivity. But, the necessary public support for increased funding has not been forthcoming.

The issue of public support was a central theme of the lecture and the ensuing panel discussion. Panelists agreed that members of the agriculture community need to work together to improve public awareness of the critical issues confronting the global community and to speak in a more unified voice about the need for increased agricultural research funding.

On the pages that follow, you will find the text of the 2014 AAAS Charles Valentine Riley Memorial Lecture, selected highlights of the panel discussion, as well as information on federal funding for research in this area. The table and analysis included present updated figures from the chapter on “Food, Nutrition, Agriculture, and Natural Resource Sciences” in the *AAAS Report XXXIX: Research and Development FY 2015*. We thank the authors for their contributions to this section and to the overall report.

We also remain grateful to the Charles Valentine Riley Memorial Foundation and to the World Food Prize Foundation for their valuable input and to our sponsors for their continued support.

I hope you will find these proceedings interesting and useful.



Alan I. Leshner
Chief Executive Officer, AAAS and
Executive Publisher, *Science*

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A Food and Agricultural Research Agenda to Deal with the Asteroids of the Future

Daniel Glickman

Former U.S. Secretary of Agriculture

To date, our agricultural system has been largely a success story. In the 20th century, increased productivity due to cropland expansion and scientific breakthroughs made it possible to grow the global food supply exponentially and keep prices low for most of the world's consumers.

Our past investments are what allowed us to create the reliable, affordable, and safe food supply we have today.

However, our past success is being put at risk. There are significant challenges facing our global food system:

Globally, nearly 840 million people are chronically hungry.

There are growing constraints on water and land resources, which will make increasing production the way we have in the past impossible.

“Water is the driving force in nature.”

—Leonardo da Vinci

Irrigated agriculture currently uses 70 percent of the world's fresh water. Yet water resources are expected to become scarcer in the decades ahead.

We no longer have the luxury of expanding to new land in many places. There is at most 12 percent more arable land available worldwide that isn't presently forested or subject to erosion or desertification, and the loss and degradation of our soils continues. But we will need to double food production by 2050 to meet the huge needs of global demand and population growth. We need to produce enough

food in the next 40 years as the world produced in the previous several thousand years.

Dr. Norman Borlaug pioneered the Green Revolution of the 20th century, and now we need an ever-green revolution of the 21st century, based on using advanced science to meet food and natural resource challenges.

Childhood malnutrition still contributes to the deaths of 2.5 million children under the age of five each year. At the same time, diet-related non-communicable diseases are the leading cause of death in many high and middle-income countries, and these rates are expected to rise.

Commodity price volatility has made agriculture a high-risk business and is yet another challenge for global food security. New research suggests that food price spikes are highly correlated with social unrest.

In addition, it is clear that climate change and increased weather volatility will pose additional threats to our food supplies in the near future.

Science suggests that changing rainfall patterns, more frequent natural disasters, and higher temperatures are on the horizon.

In some places, droughts and heat, like those occurring now in California and Texas, will make it more difficult for the crops to grow and livestock to survive.

In others, heavy rainfall, similar to the storms that caused flooding in China and Pakistan in 2010, may wipe out harvests and healthy soils.

Weather in most places will become more volatile and unpredictable. The effects of climate change will

permeate our food supply across the value chain.

In total, these effects are expected to slow the growth of food production by two percent each decade for the rest of this century.

All of these challenges will be compounded in the years ahead as demand for food rises due to population growth and rising incomes. Adding two billion people to the planet by 2050, including those with much higher incomes, will increase food demand by 60 percent.

Without new strategies to make sure food production can meet demand, we will face food shortages and higher food prices. The number of those that aren't able to afford a nutritious supply of food will climb. Under-nourishment and chronic hunger will continue at current rates and over-nourishment will climb.

Given these challenges facing agriculture, it is far from assured that the agricultural output can climb enough to keep pace with expected demands, let alone be helpful to farmers and consumers in the developing world.

The food system is global. When Russia loses its wheat crop to fire, American consumers pay more for bread at the grocery store. And if we do not increase the productivity of small scale farmers in low-income nations, we can't meet the world's future food needs.

The state of global agricultural research:

Agricultural research is a necessary vehicle for equipping the agriculture and food sectors to overcome these challenges.

Despite our success in the past, the rate of agricultural productivity growth is slowing worldwide including a dramatic slowdown happening in the U.S. – growth has been cut in half from two percent in the decades before 1990 to one percent after 1990.

Despite these enormous challenges, U.S. public investment in agricultural research lags woefully behind other types of federally supported research. For example, for every federal dollar spent on agricultural research, \$14 is spent on medical research.

The decision making and management of federal agricultural research was established in the latter half of the 1800s at a time when most Americans understood and had a deep appreciation of agriculture. The National Institutes of Health (NIH) and the National Science

Foundation (NSF), on the other hand, came to be after World War II. There was a recognition at both of these institutions that it took experts in the fields of science and health to determine priorities and set the agenda. Agricultural research management and decision making has been slow to adapt to these modern challenges. To meet these challenges it will require not only more money, but also significant changes in how priorities are set and how agricultural research is awarded in the future.

Funding at NIH and NSF far outstrips funding for agricultural research at USDA. NIH at \$29 billion, NSF at \$8 billion and USDA at \$2.7 billion. While over 80 percent of NIH and NSF funding is competitively awarded, only 10 percent of USDA's research budget is competitively awarded.

In 1980, the U.S. was the world's leader in public funding of agriculture, but beginning in about 2000, China began dramatically increasing its investment and has now surpassed the U.S.

In 1960, high-income countries accounted for 56 percent of the world's total agricultural research spending. Spending by middle-income countries, including Brazil, India, and China, now surpasses high-income countries.

We need to revitalize investments in public food and agricultural R&D. The U.S. is uniquely positioned to lead a global call for action, but we've got to put our money where our mouth is.

We can meet our current challenges through agricultural research. We know that science has the ability to meet and triumph over food crises. Today, we need agricultural science once again to deliver innovations that will equip the global food system to meet the challenges it currently faces.

However, society is not valuing science the way that we have in the past.

There is a rising tide of concern in the U.S. and Europe as people have begun to question science and make value-based judgments about food rather than science-based judgments.

We need to mitigate these concerns. We know that science has the ability to meet and triumph over food crises. Today, we need agricultural science once again to deliver innovations that will equip the global food system to meet climate change and other challenges.

We need to broaden the focus of agriculture and food science.

While the Green Revolution of the 1950s and 1960s transformed agriculture through innovation and technology in much of the developing world, advances were largely focused on increasing production and did not account for environmental conservation or nutrition.

Today's challenges have become infinitely more complex, and we need a full range of expertise to address them. Today's growers and food producers need innovations and approaches that will not only increase productivity, but produce more nutritious food with less resources and inputs while adapting to climate change and weather variability. They also need innovations to reduce food waste along the value chain.

The only way this is possible is through investments in innovation and making sure tested innovations are shared with farmers everywhere. We need to broaden agriculture's mandate beyond simply increasing production and make sure it is done in a way that uses fewer resources and optimizes nutrition outcomes while also providing solid incomes to food producers.

We need to harness experts from all scientific disciplines to dedicate their talents and energies toward increasing nutritious food production sustainably.

We need to increase the transfer of proven approaches and innovations to farmers everywhere, but especially to women and under-producing farmers in Sub-Saharan Africa and South Asia.

Research priorities:

More research is needed on how agriculture and food can use water more efficiently.

Nearly half the world's population relies on groundwater for drinking water. In many places, groundwater is brackish and not suitable for humans, livestock, or crops. But, if we were able to use some of this brackish water for agriculture, it would relieve some of the pressure we are seeing on water resources.

We need to develop crops that can tolerate salt water or affordable desalinization technologies that can be used for irrigation.

Pests and diseases are another area where more research is needed.

Coffee leaf rust is one example of a fungus brought on

by climate change. It is sweeping through Central American coffee fields and is expected to cause crop losses of \$500 million and a loss of 374,000 jobs this year. We need new innovations and strategies to deal with the broader range of pests and diseases we are facing.

We desperately need innovations in reducing food waste.

One-third of all food produced is wasted globally. In developed countries, consumers throw too much food away. In developing countries, the food rots before it can even be processed or brought to market because of poor infrastructure, allowing pests and mold to run rampant.

Higher temperatures and humidity will cause even more food to be wasted without innovations in cold storage and transport.

If we can find ways to reduce this type of food waste and bring them to scale, we can increase food production some without necessarily growing more food. Innovation from the private sector can help address this challenge.

We also need better data. Food producers cannot prepare effectively and researchers and businesses cannot innovate without better data. We need data on weather, water resources, crop performance, land use, and consumer preferences if we're going to adequately prepare.

Better models and data are crucial for increasing productivity, enhancing nutrition, and increasing resilience to the effects of climate change.

Recommendations for moving forward on agricultural research:

A good example of where agricultural research stands within the broader research community occurred at the April 29, 2014 Senate Appropriations Committee hearing entitled, "Driving Innovation through Federal Investments." Five government witnesses were invited: Dr. Francis Collins, Director of NIH; Dr. France Cordova, Director of the NSF, and Dr. Arati Prabakar, Director of Research at the Department of Defense. The Secretary of Agriculture was not invited. This speaks volumes as to where agricultural research stands on the priority list of government supported research.

We need to focus the entire agricultural research

enterprise on solving today's challenges. We need a whole government transformation.

To help do this, Congress and the President could launch a National Science Commission on Global Food Security.

This National Science Commission should bring all necessary government resources and expertise to bear. This includes scientists working at USDA, the National Science Foundation, the National Institutes of Health, the Department of Energy, and other U.S. agencies.

Its mission should be to identify necessary steps to ensure that both domestic and global agricultural sciences and related disciplines are working toward the goal of sustainable global food security.

The U.S. should also double investments in agricultural and food research over the next ten years, and focus on sustainable intensification – producing more with less.

We know that science has the ability to meet and triumph over food crises. Today, we need agricultural science once again to deliver innovations that will equip the global food system to meet climate change and other challenges.

Research dollars should be focused on priorities that will be most important to meeting future demand: equipping agriculture in the U.S. and building capacity in low-income countries to be resilient to climate change and weather variability; aligning agricultural production and nutrition goals; and ensuring agricultural production builds, not harms, the natural resource base.

Because the challenges facing our food system will be both global and local, it will be important that we make developing university and research institutions in other countries a major priority.

The U.S. government has ramped up this type of training over the past five years, but it is nowhere near the level of support the U.S. provided in the 1970s and 1980s. These efforts should be expanded to develop local institutions in developing countries that can deal with the consequences of climate change.

This can be done through public-private partnerships, educational exchanges, and connecting universities around the world. The U.S. university system – which is one of the best in the world – is well positioned to contribute to this.

The challenges inherent in increasing food production while protecting and enhancing environments and habitat will require the expertise, creativity and commitment of researchers around the world. Strong support for the Consultative Group on International Agricultural Research (CGIAR) from our government and international financial institutions must continue. The CGIAR and its 15 research centers in close collaboration with hundreds of partner organizations work every day to combat rural poverty, increase food security, improve human health and nutrition, and ensure more sustainable management of natural resources.

Science and innovation are key to overcoming the challenges we face today. Today's growers and food producers need innovations and approaches that will not only increase productivity, but produce more nutritious food using less resources while adapting to climate change and weather variability. These efforts will help build a sustainable food system here in the U.S. as well as abroad.

Now, putting my political hat on, some truths about our system: we must increase the relevance of food and agricultural research and production in the national debate. It is us, in this room, that must make this happen and engage—get out of our silos and bring this to the national attention. As Napoleon once said: “War is too important to be left to the generals.” We must get out there and make the case for agricultural research and development.

Ralph Waldo Emerson said: “The first steps in agriculture and zoology teach that nature's dice are always loaded: that in her heaps and rubbish are concealed sure and useful results.”

We have the power, indeed the responsibility to discover these loaded dice and prepare for the future of a safer, thriving and healthy food and agriculture system.

To view Secretary Glickman's full presentation, go to www.aaas.org/page/riley-lecture.

Lecture and Panel Discussion Highlights

Secretary Glickman's address focused on the state of global agricultural research; research priorities; and recommendations for moving forward in these areas. His lecture was followed by a discussion with a panel of distinguished stakeholders in the agricultural community. Below are some highlights from the discussion.

The Challenges:

“Those major scientific discoveries of the 20th century, as profound and as useful as they have been, they may not be adequate to solve the emerging ‘asteroidic’ problems facing us now.”

–*Gebisa Ejeta*

“In the U.S. we've literally been running down our capacity—that is our stocks of knowledge—and therefore limiting our degrees of freedom and scope to address these problems... In the last 50 years, the U.S. has gone from conducting one-fifth of the world's entire public agriculture and food R&D spending to now barely 13 percent...”

–*Philip Pardey*

“Complacency has been the biggest problem. American agriculture has been so successful and the U.S. has provided global leadership to what science can do to advance agriculture and opportunities for livelihood change in so many societies. Yet, we seem to have forgotten here at home the value of what sustained investments in science based developments have made for a nation.”

–*Gebisa Ejeta*

“There's a burgeoning anti-technology movement that wants to take us back to local production, back to natural... to move us backward from the significant agricultural science advancements that we have made, which is quite ironic and challenging...”

–*Leon Bruner*

“The lags are very long, upwards of 50 years from when you invest a dollar in research today to realizing the productivity consequences of that dollar. It doesn't mean you have to wait 50 years for that impact to materialize but it takes a long period of time for that to play out in terms of the basic science, the pre-commercialization science, the developing—say— of new crop varieties, extending those crop varieties into the hands of farmers...”

–*Philip Pardey*

Lecture and Panel Discussion Highlights (continued)

Public Perception:

“People just aren’t aware that for the last 20 years agriculture research has been flat. It’s extraordinary... while the NIH and NSF and DOE have grown incredibly, funding for agriculture has been flat.”

–*Daniel Schrag*

“Farmers are probably the best intelligence officers in the world, in terms of what’s happening with the weather... I don’t think that most farmers are anti-science when it comes to climate change. I think most farmers believe that the weather is changeable, that it’s real, and that they have to adapt to it.... A lot of it is about language-ing... Our language-ing has to reflect respect for different people with different points of view and make our case on the merits where we think they are wrong.”

–*Daniel Glickman*

“If we want public support in terms of dollars for research to solve these vexing problems, we must help the public understand there is an urgent need. We need to help them recognize there’s a problem so that there is a clamor for doing the research and getting the job done.”

–*Leon Bruner*

“You can’t fight the consumer. The consumer likes farmers markets. Some consumers like organic food... We have to be careful not to paint people into this corner where if you’re into the local food movement—that if you want to buy food that’s produced locally—that there’s something wrong with you. This is different strokes for different folks.... This doesn’t mean they aren’t for good science.”

–*Daniel Glickman*

“The public has to let Congress know what our values are and what we want out of our agricultural systems. That will be very important in developing our political will.”

–*Catherine Woteki*

Looking Ahead:

“We need two things: a clear strategy that helps us focus our energies in the right direction; and we need to help society understand the need for advancement in agricultural science so that, in turn, they will provide the support for this research in the context of calls for research dollars in other areas and for spending on government programs in general... How do we bump the priority level up so that agricultural research will be supported?”

–Leon Bruner

“Any dollars we inject into U.S. agriculture today won’t start maximizing their impact on farm productivity in U.S. agriculture until 2035 or so... You need a lot of foresight and patience...”

–Philip Pardey

“[There needs to be a] coordination that should occur across disciplines because of the complexities of the issues that we’re dealing with.... You can’t speak about agriculture without talking about climate change. You can’t talk about agriculture without talking about the looming global water crisis and the energy issues and so on... So when we’re dealing with these major challenges, the deductive approach of science that we had done in the past is not likely to solve some of these complex problems. We need to bring people together for the more holistic trans-disciplinary engagement.”

–Gebisa Ejeta

“We need a more unified voice about the importance of the investment in agricultural science, about the public investment that’s going to address the fundamental long term research that needs to be done that’s going to prepare the next generation of researchers and is going to lead to those innovations. We don’t have that unified voice; we have a lot of voices...”

–Catherine Woteki

“We had a very effective public-private partnership model that served us well in the past, we now need a 21st century public-private partnership paradigm that is more relevant for today’s world. We don’t have one now.”

–Gebisa Ejeta

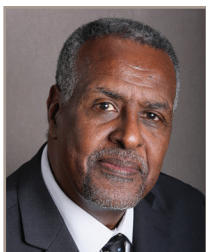
Participant Bios



Daniel Glickman is former U.S. Secretary of Agriculture, Vice President of the Aspen Institute and Executive Director of the Aspen Institute Congressional Program. He co-chairs the Chicago Council on Global Affairs Initiative on Global Food Security. Secretary Glickman is also a Senior Fellow at the Bipartisan Policy Center where he is co-chair of its Democracy Project. He is a member of the Board of Directors of the Chicago Mercantile Exchange and co-chair of AGree, an effort of the largest private Foundations of America to examine long term food and agricultural policy. Prior to joining the Aspen Institute, he served as U.S. Secretary of Agriculture in the Clinton Administration. He also represented the 4th Congressional district of Kansas for 18 years in the U.S. House of Representatives, where he was very involved in federal farm policy on the House Agriculture Committee and also served on the House Judiciary Committee and as Chairman of the House Permanent Select Committee on Intelligence. In addition, Secretary Glickman served as Chairman of the Motion Picture Association of America, Inc. and Director of the Institute of Politics at Harvard University's John F. Kennedy School of Government. He has served as President of the Wichita School Board; was a partner in the law firm of Sargent, Klenda and Glickman; and worked as a trial attorney at the U.S. Securities and Exchange Commission.



Leon H. Bruner is currently Executive Vice President for Scientific & Regulatory Affairs and Chief Science Officer at the Grocery Manufacturer's Association (GMA) in Washington, DC. The Science and Regulatory Affairs organization carries out a broad range of member services in areas including science policy, product safety, education and applied food safety research. Before joining GMA, Dr. Bruner served in a variety of positions at The Procter & Gamble Company and The Gillette Company. He served as Vice President and Director of the Corporate Environment, Health and Safety Organization in P&G's Gillette organization where he was responsible for product safety, regulatory compliance, workplace safety, environmental compliance, quality, sustainability and business continuity planning. Prior to joining The Gillette Company, Dr. Bruner worked for P&G's Health and Beauty Care organization based in London, England. In this position he was internationally recognized as an expert in the development, validation and regulatory acceptance of toxicity test methods. He has written numerous peer-reviewed scientific articles and several book chapters on these subjects.



Gebisa Ejeta is Distinguished Professor of Plant Breeding & Genetics and International Agriculture and serves as Executive Director of the Center for Global Food Security at Purdue University. He has been a member of the Purdue faculty since 1984. His career has been devoted to education, research, and international development with contributions in human and institutional capacity building as well as in advocacy for science-based global development. Professor Ejeta has served in advisory roles to several global development organizations including the USAID, the Rockefeller Foundation, the Bill & Melinda Gates Foundation, the Food & Agricultural Organization of the UN, and the International Agricultural Research Centers (CGIAR). He currently serves on the boards of the Chicago Council for Global Affairs' Global Agricultural Development Initiative (GADI), the National Academy of Sciences Board on Agriculture and Natural Resources (BANR), and the Global Crop Diversity Trust (GCDT). He is the 2009 World Food Prize Laureate and the recipient of a national medal of honor in science from the President of Ethiopia. He is a Fellow of the American Society of Agronomy; the Crop Science Society of America; AAAS; and the African Academy of Science. Professor Ejeta has served the United States government in several capacities, as Science Envoy of the U.S. State Department, as Special Advisor to the USAID Administrator Dr. Rajiv Shah before being appointed by President Obama as member of the Board for International Food and Agricultural Development (BIFAD) in 2010. More recently, he was appointed by Secretary General Ban Ki Moon to the first U.N. Scientific Advisory Board.



Philip G. Pardey is Professor of Science and Technology Policy in the Department of Applied Economics at the University of Minnesota where he also directs the University's International Science and Technology Practice and Policy (InSTePP) center. Previously he was a Senior Research Fellow at the International Food Policy Research Institute in Washington, DC, and prior to 1994 at the International Service for National Agricultural Research in The Hague, Netherlands. He is a Fellow of the American Agricultural Economics Association, Distinguished Fellow and Past President of the Australian Agricultural and Resource Economics Society, and winner of the Siehl Prize for Excellence in Agriculture. His research deals with productivity measurement and assessment, the finance and conduct of R&D globally, methods for assessing the economic impacts of research, and the economic and policy (especially intellectual property) aspects of genetic resources and the biosciences. He currently co-directs a Gates Foundation project, HarvestChoice (www.HarvestChoice.org), designed to inform and guide investments intended to stimulate productivity growth in African agriculture.



Daniel P. Schrag is the Sturgis Hooper Professor of Geology and Professor of Environmental Science and Engineering at Harvard University, and Director of the Harvard University Center for the Environment. He has taught at Harvard since 1997, after finishing his Ph.D. at U.C. Berkeley in 1993 and then teaching at Princeton. His interests cover a broad range of environmental issues, in particular climate change, energy technology, and energy policy. He has studied climate change over the broadest range of Earth's history, including how climate change and the chemical evolution of the atmosphere influenced the evolution of life in the past, and what steps might be taken to prepare for impacts of climate change in the future. He is also interested in how we can use climate events in the geologic past to understand our current climate challenges. Dr. Schrag has worked on a range of issues in energy technology and policy including advanced technologies for low-carbon transportation fuel, carbon capture and storage, and risks and opportunities of shale gas. He was named a MacArthur Fellow in 2000. He currently serves on President Obama's Council of Advisors for Science and Technology (PCAST), contributing to many reports to the President including energy technology and national energy policy, agricultural preparedness, climate change, and STEM education.



Catherine Woteki is Under Secretary for the USDA's Research, Education, and Economics (REE) mission area, as well as the Department's Chief Scientist. Her responsibilities include oversight of the four agencies that comprise REE – Agricultural Research Service, National Institute of Food and Agriculture, Economic Research Service, and National Agriculture Statistics Service. Since returning to USDA, Dr. Woteki has followed the direction established by Congress, developing the Office of the Chief Scientist, the USDA Science Council, and other coordinating programs. She has been called upon to lead scientific delegations to China and the first Meeting of Agricultural Chief Scientists held under the auspices of the G-20 leader, Mexico. Before joining USDA, Dr. Woteki served as Global Director of Scientific Affairs for Mars, Incorporated, where she managed the company's scientific policy and research on matters of health, nutrition, and food safety. Prior to this role, she was the Dean of the College of Agriculture and Life Sciences at Iowa State University, and she was the first Under Secretary for Food Safety at USDA from 1997 to 2001.

Federal Food, Nutrition, Agriculture and Natural Resource Sciences Funding Update

Matt Hourihan

Director, R&D Budget and Policy Program
American Association for the Advancement of Science

Whereas last year's appropriations cycle featured large gaps between the Senate and House, this year's outcomes show relatively more agreement. Following an Administration budget that sought to boost extramural research while cutting back intramural research, appropriators in both the House and Senate have shown restraint over National Institute of Food and Agriculture (NIFA) funding, though both chambers have matched the request for the Agriculture and Food Research Initiative (AFRI). Program funding for the Agricultural Research Service (ARS) would also increase above the request in both chambers, though neither would rise above the rate of inflation. The major ARS increase shown here in the House is due to the addition of \$155 million for construction of a replacement poultry science center, a priority for ARS. Elsewhere in USDA, the House declined the Administration's proposal to cut Forest Service research, a marked change for House appropriators from last year. The Senate has not yet released Forest Service funding figures.

Other related agencies show mixed funding outcomes so far. The National Science Foundation would receive a clear if modest boost in the House, but not in the Senate. Department of Energy Office of Science funding would see little change from FY 2014 in both chambers. Lastly, the Senate would grant an increase slightly ahead of inflation to the National Institutes of Health, though no NIH bill has emerged in the House. There is substantially less controversy

this year compared to last year, but limited legislative days before the election makes the likelihood of a continuing resolution very high.

This table and analysis present figures from the chapter on "Food, Nutrition, Agriculture, and Natural Resource Sciences" in the *AAAS Report XXXIX: Research and Development FY 2015*. Figures have been updated based on additional agency reporting and appropriations bills and reports from Congress. To read the entire analysis of the FY 2015 budget, go to www.aaas.org/report-FY2015.

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Jianrong (Janet) Zhang
Institute of Food Technologists

Lowell Randel
Federation of Animal Science Societies

Jim Gulliford
Soil and Water Conservation Society

Federal Food, Nutrition, Agriculture, and Natural Resource Science Investments

(budget authority in millions of dollars)

	FY 2013 Actual	FY 2014 Estimate	Change FY 13-14		FY 2015 Budget	FY 2015 House**	Change FY 14-15		FY 2015 Senate	Change FY 14-15	
			Amount	Percent			Amount	Percent		Amount	Percent
Selected USDA Program R&D											
Agricultural Research Service (ARS)	1,049	1,154	105	10.0%	1,136	1,307	153	13.2%	1,171	17	1.5%
Natl Inst of Food & Agri (NIFA)*	652	807	155	23.8%	876	823	16	2.0%	836	29	3.6%
Agri & Food Research Init (AFRI)	276	316	40	14.5%	325	325	9	2.8%	325	9	2.8%
Forest Service**	298	327	29	9.7%	301	324	-3	-0.8%	NA	--	--
Forest and Rangeland Research	322	307	-15	-4.6%	337	163	-144	-46.8%	337	30	9.7%
U.S. Dept of Agriculture R&D	2,116	2,418	302	14.3%	2,447	2,592	174	7.2%	2,145	-273	-11.3%
Other Related Agency R&D Budgets											
National Institutes of Health***	28,341	29,252	910	3.2%	30,490	NA	--	--	29,771	519	1.8%
National Science Foundation	5,329	5,552	223	4.2%	5,565	5,706	154	2.8%	5,593	41	0.7%
Dept of Energy - Office of Science	4,291	4,655	364	8.5%	4,714	4,677	22	0.5%	4,691	35	0.8%

Source: AAAS estimates based on OMB R&D data, agency budget documents, and Congressional reports. Legislation funding the Office of Science and NSF have been approved by the full House; otherwise, all figures refer to committee bills. Figures include mandatory and discretionary R&D.

*FY 2014 and FY 2015 each include \$3 million for Biomass R&D program; **FY 2012 includes \$40 million for Biomass R&D program.

** Forest Service is appropriated in the Interior and Environment bill, which has not been released in the Senate.

*** The Labor/HHS/Education bill has not been released in the House. Some NIH R&D is also contained in the Interior and Environment bill.

About Charles Valentine Riley

Charles Valentine Riley (1843-1895)

“Professor Riley,” as he was generally known, was born in Chelsea, London, England, on September 19, 1843. He attended boarding school at Dieppe, France; and Bonn, Germany. Passionately fond of natural history, drawing, and painting, he collected and studied insects and sketched them in pencil and in color. At both Dieppe and Bonn, he won prizes in drawing and was encouraged to pursue art as a career.

At the age of 17, he came to the United States and settled on an Illinois farm about 50 miles from Chicago. Soon his attention was drawn to insect injuries of crops, and he sent accounts of his observations to the *Prairie Farmer*. At the age of 21, Riley moved to Chicago and worked for this leading agricultural journal as a reporter, artist, and editor of its entomological department. His writings attracted the attention of Benjamin D. Walsh, the Illinois State entomologist.

It was through Walsh’s influence as well as the recommendation of N.J. Coleman of *Coleman’s Rural World* that Riley was appointed in the spring of 1868 to the newly created office of entomology of the State of Missouri. From 1868 to 1877, in collaboration with T. W. Harris, B. D. Walsh, and Asa Fitch, Riley published nine annual reports as State Entomologist of Missouri, which unequivocally established his reputation as an eminent

entomologist. Today, authorities agree that these nine reports constitute the foundation of modern entomology.

From 1873 to 1877, many Western States and territories were invaded by grasshoppers from the Northwest. In some states their destruction of crops was so serious that it caused starvation among pioneer families. Riley studied this plague and published results in his last three Missouri annual reports and worked to bring it to the attention of Congress. In

March 1877, he succeeded in securing passage of a bill creating the United States Entomological Commission, the Grasshopper Commission administered under the Director of the Geological Survey of the U. S. Department of the Interior. Riley was appointed chairman, A. S. Packard, Jr., secretary; and Cyrus Thomas, treasurer.

All this time, Riley, with the help of Otto Lugger, Theodore Pergrande, and others, was also making brilliant contributions to the knowledge of the biology of insects. Besides studying the life

cycles of the 13 and 17 year cicadas, he also studied the remarkable *Yucca* moth and its pollination of the *Yucca* flower, a matter of special evolutionary interest to Charles Darwin. In addition, he conducted intensive life history studies of blister beetles and their unusual triungulin larvae, and the caprifigation of the fig.

In the spring of 1878, Townend Glover retired as



Charles Valentine Riley Examining an Insect.

entomologist to the U. S. Department of Agriculture and Riley was appointed his successor. After a year in this position, Riley resigned owing to a disagreement with the Commissioner of Agriculture over Riley's practice of making independent political contacts; he then continued the work of the U. S. Entomological Commission with others, from his home. Two years later, after the inauguration of President James A. Garfield in 1881, Riley was reappointed and remained chief of the Federal Entomological Service until June 1894, when the Service was renamed the Division of Entomology of the U.S. Department of Agriculture. In 1882, Riley gave part of his insect collection to the U. S. National Museum, now The Smithsonian Institution, at which time he was made honorary curator of insects. In 1885, he was appointed assistant curator of the Museum, thus becoming the Museum's first curator of insects, whereupon he gave the Museum his entire insect collection consisting of 115,000 mounted specimens (representing 20,000 species), 2,800 vials, and 3,000 slides of specimens mounted in Canadian balsam.

One of Riley's greatest triumphs while Chief of the Federal Entomological Service was his initiation of efforts to collect parasites and predators of the cottony cushion scale, which was destroying the citrus industry in California. In 1888, he sent Albert Koebele to Australia to collect natural enemies of the scale. A beetle, *Vedalia cardinalis*, now *Rodolia cardinalis*, was introduced into California and significantly reduced populations of the cottony cushion scale. This effort gave great impetus to the study of biological control for the reduction of injurious pests and established Charles Valentine Riley as the "Father of the Biological Control." For a review of the cottony cushion scale project, see Douthett, 1958.

A prolific writer and artist, Riley authored over 2,400 publications. He also published two journals, the *American Entomologist* (1868-80) and *Insect Life* (1889-94). Riley received many honors during his lifetime. He was decorated by the French Government for his work on the grapevine *Phylloxera*. He received honorary degrees from Kansas State University and the University of Missouri. He was an honorary member of the Entomological Society of London and founder and first president of

the Entomological Society of Washington. He and Dr. L. O. Howard, Riley's assistant in the Federal Entomological Service, were among the founders of the American Association of Economic Entomologists, which became part of Entomological Society of America in 1953.

Tragically, on September 14, 1895 Riley's life was cut short by a fatal bicycle accident. As he was riding rapidly down a hill, the bicycle wheel struck a granite paving block dropped by a wagon. He catapulted to the pavement and fractured his skull. He was carried home on a wagon and never regained consciousness. He died at his home the same day at the age of 52, leaving his wife with six children.

ACKNOWLEDGEMENTS

We would like to thank the U.S. Department of Agriculture, National Agricultural Library (NAL) for providing Riley's biographical information and accompanying image. The Charles Valentine Riley Collection at NAL includes correspondence, unpublished lectures, photographs, news clippings, drawings, reprints, books, and artifacts covering the time period from 1868 to 1919.

About the Partner Organizations

In 2008, the Charles Valentine Riley Memorial Foundation (RMF) selected the American Association for the Advancement of Science (AAAS) to receive an endowment to establish the annual AAAS Charles Valentine Riley Memorial Lecture “to promote a broader and more complete understanding of agriculture as the most basic human endeavor and ... to enhance agriculture through increased scientific knowledge.”

Concurrently with establishment of the endowment, a collaborative agreement between RMF, AAAS, and the World Food Prize Foundation (WFPF) was signed to implement the annual lecture. Collaboration between AAAS, RMF, and WFPF provides a unique opportunity to build upon Charles Valentine Riley’s legacy as a “whole picture” person with a vision for enhancing agriculture through scientific knowledge. Professor Riley’s involvement with AAAS, beginning as a member in 1868, being elected a Fellow in 1874, and serving as Vice President for the biology section in 1888, brings into the perspective his broad view of how science impacts on agriculture when placed in the broadest context.



The American Association for the Advancement of Science (AAAS)

The American Association for the Advancement of Science (AAAS) is the world’s largest general scientific society and publisher of the journals *Science* (www.sciencemag.org), *Science Signaling* (www.sciencesignaling.org), and *Science Translational Medicine* (www.sciencetranslationalmedicine.org). AAAS was founded in 1848, and serves 262 affiliated societies and academies of science, reaching 10 million individuals. The non-profit is open to all and fulfills its mission to “advance science and serve society” through initiatives in science policy, international programs, science education, and more. More information on AAAS and its diverse portfolio of activities can be found at www.aaas.org.

building upon Charles Valentine Riley’s legacy as a “whole picture” person with a vision for enhancing agriculture through scientific knowledge. Founded in 1985, RMF recognizes that agriculture is the most basic human endeavor and that a vibrant, robust, food, agricultural, forestry, and environmental-resource system is essential for human progress and world peace. RMF conducts a wide range of program activities that include discussion groups, forums, round tables, workshops, briefing papers, and lectures on various parts of the food, agricultural, forestry, and environmental-resource system. RMF’s goal is to have all world citizens involved in creating a sustainable food and agriculture enterprise within a responsible rural landscape. More information is available at www.rileymemorial.org.



Charles Valentine Riley Memorial Foundation

The Charles Valentine Riley Memorial Foundation (RMF) is committed to promoting a broader and more complete understanding of agriculture and to



World Food Prize Foundation

Founded by Nobel laureate and “Father of the Green Revolution” Dr. Norman E. Borlaug, the World Food Prize is a \$250,000 award presented annually for breakthrough achievements in science, technology, and policy that have im-

proved the quality, quantity, and availability of food in the world. Termed “the Nobel Prize for Food and Agriculture” by several heads of state, it is presented each October in conjunction with a week of events that includes the international “Borlaug Dialogue” symposium and gathers pre-eminent global leaders and

experts representing over 65 countries. The 2014 World Food Prize events will take place October 15 to 17 in Des Moines, Iowa. Information about the World Food Prize events, highlights from past Borlaug Dialogue symposia, and nomination criteria are available at www.worldfoodprize.org.

Cover photo: Storm clouds over a wheat field in Kansas, USA. WLADIMIR BULGAR/Getty Images
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