EMBO *reports*

outlook

Sowing the seeds of the future

An interview with Roger Beachy, Director of the US National Institute of Food and Agriculture

In January 2010, Roger Beachy was named acting chief scientist of the US Department of Agriculture (USDA; Washington, DC) to lead its scientific activities. This came shortly after his appointment in October 2009 as the first Director of the US National Institute of Food and Agriculture (NIFA; Washington, DC), a new USDA agency to support scientific research to improve agriculture—in the USA and globally—in the face of climate change, to produce biomass to contribute to addressing US energy needs, and to fight childhood obesity and improve food safety.

Beachy, who holds a doctorate in plant pathology from Michigan State University (East Lansing, MI, USA), previously served as founding president of the non-profit Donald Danforth Plant Science Center (St Louis, MO, USA).

EMBO *reports*: Why was it necessary to create a dedicated federal institute for research on food and agriculture?

Roger Beachy: There has been a research arm of the USDA for many years that has included the Agriculture Research Service (ARS), the Economic Research Service and others. The new agency, NIFA, will refocus and redirect functions that were conducted under CSREES [Cooperative State Research, Education and Extension Service] and its predecessor agencies, which have supported research that impacts on agriculture. NIFA provides support for research and extension activities at land-grant institutions [In the late nineteenth century, the Morrill Acts funded educational institutions by granting federally controlled land to the states to develop or sell to raise funds to establish and endow so-called 'land grant' colleges] through grants on the basis of statutory formulas, which depend on factors such as the rural population or farm population, and through a competitive grants programme. However, there was a growing sense that USDA needed an agency to bring greater focus, impact and financial support to its research efforts. NIFA was formed by US Congress to address the concerns of the agriculture community.

> **"We face challenges that are far greater than can be met solely by researchers in land-grant universities. We need the best brains in the country, no matter their affiliation"**

The total amount of resources for all research on agriculture is far less than the budget of the National Institutes of Health (NIH). The proponents of NIFA recognized the need for greater alignment between intramural and extramural research goals to achieve greater impact. NIFA aligns the support for extramural research with some of the intramural efforts, so there is a greater synergy between the two. Intramurally, USDA's Agriculture Research Service employs about 1,000 PhD scientists and other research staff.

EMBO *reports*: What ideas from the NIH have you applied to NIFA?

Beachy: For many years, the NIH has provided project grants that bring together investigators from different backgrounds to solve a problem. We're using a similar approach at NIFA in this round of requests for applications to bring together teams of scientists, economists and engineers to work together in ways that have not been common in the past. The 'societal' challenges we face in agriculture are extremely complex. For example, we must deal with reducing agricultural greenhouse gas emissions while developing a more sustainable agriculture that meets the needs of a growing global population. We need interdisciplinary teams to solve this and other complex challenges.

EMBO *reports*: Has there been an accompanying increase in funding for research?

Beachy: There was a rather modest increase, in actual dollars, in funding for the 2010 competitive grants. One of the challenges that characterized research funding for the predecessor agency of NIFA is that a large percentage of the funding is earmarked for projects that are defined by individual constituents. We need a greater focus on competitive grants and less reliance on those earmarked funds.

In 2009, the total budget for competitive grants was slightly more than US$200 million out of a total budget of US$1.05 billion. In 2010, the total budget of the agency didn't change, but the amount for competitive grants went up to US$262 million. The proposed 2011 budget includes US$426 million dollars for competitive funds. It is through our competitive grants that we can address the changing needs in agriculture and have the flexibility to meet these needs.

EMBO *reports*: As you increase competitive grants, will this come at the expense of formulaic funds for universities?

Beachy: There is a recognized and important role for formulaic funds in agriculture. We didn't want to see those go down as others suggested they should, but we also want to increase funds for competitive grants. In fact, we're hopeful that those universities that received those formula funds will see greater opportunities for their faculty in the context of the structures of the competitive grants.

EMBO *reports*: Some scientists at land-grant universities have expressed concerns about opening your grants to all researchers from basic science.

Beachy: We face challenges that are far greater than can be met solely by researchers in land-grant universities. We need the best brains in the country, no matter their affiliation.

EMBO *reports*: Do you generally see a growing recognition of the importance of agriculture and plant science?

Beachy: Congress, as well as the public, has recognized the growing importance of agriculture, both plant and animal, and the need for research that supports the enterprise. However, there are some who hold less respect for the kind of research that is done at agricultural colleges than is warranted. This new agency should be organized to make clear to Congress that the science and technology for agriculture is of the same high quality and value as that conducted through funding by the National Science Foundation, the NIH and the Department of Energy.

The Department of Agriculture is a large and important component of the US government, providing food services to tens of millions of school children daily, overseeing the safety and quality of the food supply, and much more. And agriculture is an industry with an enormous impact on the environment. Given its role in the lives of people, it's imperative that we recognize the importance of science in addressing the issues we face.

> **"An enormous amount of genomic science has taken place in agriculture during the last 20 years, and we are now starting to see the impacts on plant and animal breeding"**

EMBO *reports*: How would you compare the role of NIFA and other federal agencies with the European Research Council, which combines all research under one umbrella?

Beachy: We are privileged to have multiple agencies that fund science in the United States. Combining all of them into a single agency would probably lead to more bureaucracy than we already have. That said, I think we need to look at holistic approaches to address questions across the life sciences. Thus, if one works in the biomedical field on human health without considering food-related issues that affect health, the potential for synergy is lost.

Donald Danforth Plant Science Center, St Louis, MO, USA.

EMBO *reports*: What is the long-term place within NIFA to increase basic research in plant science? Is more work needed in areas such as cell biology and developmental biology?

Beachy: These topics are part of NIFA's competitive grants programme, although the amount of money available for basic cellular and developmental biology is relatively modest. It's an area that needs to grow. We need the fundamental sciences to prepare for the next grand challenges that we face. The National Science Foundation has done a great job in contributing to the genome sequence of *Arabidopsis* and will continue to contribute to fundamental plant and animal science. We need to apply this knowledge to agriculture. NIFA will continue to focus on applications of fundamental science as well as the generation of new knowledge. Our larger grants include components of fundamental research that are embedded in larger, translational projects.

EMBO *reports*: Are there other areas to which NIFA can bring new attention?

Beachy: There are a number of areas that, if we had more resources, we would like to tackle. For example, food safety and human nutrition are of high importance to the public and policy-makers alike. As consumers hear reports about *E. coli* and other microbial contaminants in foods, of the increase in obesity in children, of poor nutrition in diets, and so on, they want and need guidance. Detecting and eliminating food contamination is an area where we need a marriage of fundamental science and applications. Similarly, addressing the complex issues surrounding human and animal nutrition and finding the linkage between the microbiome and genetics will be important to increase health in humans and feed-use efficiencies in animals. We need more fundamental science in cell biology, biochemistry, genomics, etc. to address these and other complex questions. There are many other areas—I'm not sure where to begin the prioritization. We would look at the needs and the fundamental knowledge that we need to meet them.

Climate change creates challenges for managing pests and diseases in agriculture, both in livestock and plant agriculture, and it is another area that demands greater research to ensure high productivity in agriculture. We need to understand the mechanisms for disease resistance in animals and plants in order to create durable resistance that ensures high productivity.

I wish we had sufficient funding to increase support for soil chemistry and

microbiology and to learn more about the linkage between microbial populations, carbon and nitrogen cycles and soil fertility as well as carbon capture and sequestration. I could go on and on: there are many important questions that should be addressed by research in support of agriculture sciences.

EMBO *reports*: What role does genomics play in agriculture, and how will NIFA facilitate this?

Beachy: An enormous amount of genomic science has taken place in agriculture during the last 20 years, and we are now starting to see the impacts on plant and animal breeding. The USDA, including NIFA and ARS, has funded some of the sequencing of the chicken, bovine and swine genomes and of corn and soybean genomes in partnership with the National Science Foundation, NIH and the Department of Energy. There's much more to do and as the technology becomes more and more affordable, NIFA will remain involved in genomics, but in the larger context of our goals for research and education and extension.

> "As we learn more about the human genome and the genomes of the microbes that live in our digestive tract […] there may be a greater role for functional foods"

EMBO *reports*: What is NIFA doing to support training of breeders and breeding in general?

Beachy: In this year's calls for proposals, we request applications for research in breeding of animals and plants to achieve specific goals. Many conventional breeders use marker-assisted selection in their research to develop new varieties, but the skill to use these markers more effectively requires continual updating. There is a growing concern that the number of breeders is critically low and will limit progress in crop production unless the number of scientists who know the biology as well as the genetics and molecular biology of breeding is increased significantly. Shortages are experienced in the public and private sectors. Some of the NIFA fellowship programmes and grant programmes will require the involvement of breeders, and I hope it also leads to training of additional students.

EMBO *reports*: There are still concerns over the lack of translation between basic research in genomics and its application in the public sector. What can NIFA do to close the gap?

Beachy: I agree that there is a gap between fundamental research, including in genomics sciences, and application to societal needs. For example, applying the knowledge of genome sequences to plant breeding requires correlating molecular information with genetic markers and phenotypes, followed by developing new varieties—a process that takes years. The private sector has made significant progress in linking sequences to breeding in the major crop species; it has been less rapid in the public sector breeding of crops and livestock. In part, this is because of the shortage of funds for such activities as well as a growing shortage of scientists who are trained in both molecular and classical breeding. This may come through greater investments in our universities along with stronger public–private partnerships that enrich the public sector; the latter may require funding the training of the next generation of plant breeders and agriculture scientists.

EMBO *reports*: Do you see a danger that the technology to generate GM crops becomes largely controlled by a few companies, with negative consequences for publicly funded research?

Beachy: There are some drawbacks to development, and perhaps adoption of genetically engineered crops, if certain technologies are controlled by a few companies. Researchers in the public sector have made many of the key discoveries in this technology, and the public sector still controls a lot of intellectual property. I think the consolidation among seed companies creates some challenges, but I'm also confident that for every desirable trait, for example disease resistance, there are many ways to accomplish the end result, and no single company has a monopoly on all traits or tools. It is far more difficult for public sector researchers to develop a transgenic crop than to make the fundamental discoveries of valuable traits.

EMBO *reports*: GM crops have met a lot of resistance in Europe, but not so much in the USA. What is your read on public opinion regarding GM and do you expect this to become an issue in the USA?

> "I remain convinced that the practices that lead to sustainability can be achieved so that neither environmental health nor profits are jeopardized"

Beachy: There are a number of reasons why Europe is opposing the application of genetic engineering in agriculture. These range from not having a trusted food safety review board, loss of public trust in the approval process, to more traditional ideas about agriculture. That said, the general response to genetic engineering was out of proportion to the actual risks of using such crops —perhaps exaggerated by the press and specific non-governmental organizations.

How long will it be before they become more proactive in using these technologies to help them solve their agricultural challenges? I'm not sure. Europe relies heavily on the use of chemicals to control weeds, insects and disease in its agricultural systems. While some of its sustainability practices are good, others can be improved, and biotechnology can play an important role. However, acceptance of GM crops in Europe is going to take more time than many of us had predicted or hoped.

Whether the US will drift in the direction of reducing the use of GM crops, or extension to other crops, depends on a lot of factors. There's always been a market for non-GM food. I don't know that this market is going to grow sufficiently to change the practices of farmers, but it may slow down our willingness to adopt genetic engineering in other crops. If biotechnology could be used to reduce the use of chemical fungicides on fruits and vegetables, or to increase the shelf life of vegetables, would there be a market for the new varieties? If the consumer saw the environmental and potential health benefits, they might accept genetic engineering over the use of chemicals? Or will they say, "no, we'll only take what we consider to be more natural, conventional or organic"? It's hard to tell how the public will respond to opportunities and choices.

EMBO *reports*: What role do you see for food in public health—that is, functional foods or fortified foods?

Beachy: I think that such foods will be an important component in the future if scientific research can validate that these improve health and well-being. As we learn more

about the human genome and the genomes of the microbes that live in our digestive tract and the role that each plays in nutrition and health, there may be a greater role for functional foods.

EMBO *reports*: What role will NIFA play in regard to sustainable agriculture?

Beachy: NIFA is very interested in sustainability of agricultural systems, of course. In fact, we consider that all forms of agriculture must include sustainable practices whether it's small or larger, organic, conventional or biotech in practice. We fund research on sustainability in agriculture and see sustainability as a goal rather than a set of practices *per se*. It's an outcome that can be defined scientifically.

> "…agricultural practices must also be economically sustainable"

EMBO *reports*: In this regard, how do you balance environmental health versus profits and equity issues?

Beachy: Sustainability must preserve and, if possible, enhance natural resources. There are different kinds of practices that can be employed to achieve that goal. For example, ensuring that organic matter is returned to the soil may be a goal, but success will be different in a clay soil compared to a sandy soil, or on a slope versus a flatland. I remain convinced that the practices that lead to sustainability can be achieved so that neither environmental health nor profits are jeopardized. The discussion about sustainability has gotten mixed up with other issues; agricultural practices must also be economically sustainable. As a science-based organization, we will define it based on science.

EMBO *reports*: What role will NIFA play in developing solutions for agriculture in developing countries versus solutions for US farmers?

Beachy: There is a great deal of awareness in this government about the issue of food security, both in this country and in a global context. This is the case at the White House, in the State Department, the Department of Agriculture and other units of the government.

When I was a graduate student, there were between 17,000 and 18,000 foreign graduate students working in agriculture in the USA; during the last 20 or so years, we have let that number dwindle to a fraction of that. Increasingly, we see this as a social responsibility and an inter-governmental responsibility to do more to provide training and support for greater food security through building local strength in agriculture.

In NIFA, we are establishing a Center for International Programmes. The goal is to increase opportunities for more fellowships and scholarships for students and faculty and to establish inter-institution collaborations. During the past 10 years, an increasing number of American scientists who care about international development became involved and established collaborations with researchers in developing countries, both in training and in specific research topics.

We're hopeful that President Barack Obama's initiative on global food security will create new opportunities for increasing these types of interactions. NIFA can help train agronomists, plant breeders, plant pathologists, hydrologists, extension agents and others.

> "…it will be a great start to more closely link researchers to the farmers and others they serve…"

EMBO *reports*: What are NIFA's greatest priorities?

Beachy: There are so many things that need to be done. What would I call number one? In my opinion it will be a great start to more closely link researchers to the farmers and others they serve and let them use their most relevant knowledge of science and technology to achieve a useful outcome.

EMBO *reports*: Dr Beachy, thank you for the interview.

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