Nina V. Fedoroff

Nina Fedoroff is a molecular biologist known for her work in the field of plant biotechnology. Her research interests include plant stress response, hormone signalling, transposable elements and epigenetic mechanisms. Fedoroff graduated from the Rockefeller University, USA in 1972. She then joined the faculty of University of California, Los Angeles, USA. She has served as a scientist of the Carnegie Institution for Science and held academic posts at the Johns Hopkins University, Penn State University, USA and King Abdullah University of Science and Technology, Saudi Arabia. She was Science and Technology Adviser to the US Secretary of State from 2007 to 2010. In 2007, she was awarded the National Medal of Science in the field of Biological Sciences, the highest award for lifetime achievement in scientific research in the US. She was President of the American Association for the Advancement of Science (AAAS) from 2011 to 2012. She is also a member of several academies and has lectured all over the world on plant science, science diplomacy and the future of food production.

During her tenure as the Janaki Ammal Chair Professor of the Indian Academy of Sciences for 2018, Fedoroff addressed the following questions in a one-on-one interview:

What have been the research interests important to you, spanning your overall career?

The most important part of my career is my work on transposable elements which has been built on the ground-breaking work of a famous woman geneticist by the name of Barbara McClintock. During one of my talks at Cold Spring Harbor, I had the opportunity to meet McClintock. When I returned to Baltimore, I read her work from end to end and found it to be phenomenally interesting. During that time, I was offered a job at Carnegie Institution at Washington, now called the Carnegie Institution for Science which provided the opportunity for innovative work while not having to teach. At that time there was no plant molecular biology and people were of the opinion that plant DNA could not be cloned. Those were some of the obstacles that had to be overcome. Apart from the work on transposons, my laboratory has worked on stress responses of plants and also worked on certain mutants, which has turned out to be interesting – especially with on-going work in New Delhi on certain mutants that we isolated 20 years ago that affect micro RNA processing. In late 2006, I got a call from the National Academy of Sciences (USA) asking if I would be interested in being a candidate for the job as science advisor to the US Secretary of State. I could not have asked for a better platform to talk about what we now call biotechnology. So I took the job and it gave me a new platform to talk to people around the world about genetic modification.

During your tenure as the science and technology advisor for the Secretary of State, on what initiatives did you mainly focus?

My office was host to a group of young scientists who came in as part of the AAAS fellowship programme. Another major initiative was the Jefferson Fellow's programme that has seen tenured professors coming into the State Department for a year. A major activity included interacting with them, placing them and at times supporting them.

I came into the State Department with the conviction that we don't use science in our diplomatic efforts efficiently enough. Hence I launched the science diplomacy initiative that involved travelling to places, reaching out to the scientific communities and politicians in a different way compared to my predecessors. The office that was concerned with biotechnology in the State Department largely talked about the economic impacts. To give it a more human face, I began to explain the advantages of biotechnology – environmental and economic – in the larger context.

One of the things that I did early on was to organize a conference that was sponsored by USAID, the State Department and the Department of Education. The conference brought together university chancellors and presidents from all over the world to address the topic of how science can be effectively used in diplomacy. One of the speakers at the conference, Sam Pitroda and I, together started a small organization called the Global Knowledge Initiative (GKI) that works with people on the ground to identify issues locally. At the GKI, we ran competitions for problems and then brought in expertise needed to address those problems, which was contrary to how the US system worked previously.

The responsibility also involved talking to people about improvements to be made to address problems in developing countries such as getting produce to the market where the cold chain is part of the issue, gaining attention of the top levels in the State Department of countries that had a bilateral science agreement with us, and so on.

Can agricultural biotechnology assist in meeting the food demands of the growing population?

The few genetic modifications that have been introduced in a few crops have made a huge difference. Insecticide use in particular has gone down. For the insect pests that affect corn, there is almost a 90% reduction in insecticides against those pests. For cotton, it is around 60%. In countries that have adopted GM technologies and sophisticated breeding like genome-based breeding, the yields are still going up. Will GMOs feed the world? Yes, but not in terms of doubling, tripling or quadrupling of crops; that has been done and cannot be done again. However, there are other innovations that can be brought about. For example, genes that allow some plants to flower and set seed at 45°C are not in species that are sexually compatible with food crops. Such genes can be identified and

introduced into existing food crops to handle change in climate. Thus, crops such as maize and soybeans which are major sources of calories for humans and animals can be moved out of their temperature optimum to handle changes in climate. So in my view being able to call on genes, whatever their source, requires molecular technology which is going to be essential in maintaining even our present level of food production. So, yes it will continue to feed the world, but not in the simple sense of doubling or tripling yields.

Are there safety assessments to GM foods and, if yes, what are they?

There is a report by the US Academy of Sciences that analysed almost 2000 studies assessing health issues associated with GM crops. The report concluded that there is zero credible evidence that GM food is harmful to humans or animals. There is also a 2010 overview of the 15 years of biosafety research from the EU that again concluded that modifying plants by molecular technology is no more dangerous than modifying plants by older technologies that include radiation and chemical mutagenesis. The GM crops on the market today are safe; that does not mean it is true for every crop that could ever be created. In the process of developing a GM crop, you have to test for the toxicity and allergenicity.

What is your take on the cost–benefit analysis of GM crops?

There are very few studies that have done a cost–benefit analysis on GM crops. A 2014 study evaluated the economic and environmental impacts from 1996 to 2014. The study concluded that there was almost 40% reduction in pesticide use and cost increase by a few percentage points. So the increased cost of seeds was offset by the reduced cost of pesticides, which again varies from crop to crop.

Also, there are 18 million farmers around the world growing GM crops, 90% of whom are resource-poor smallholder farmers. The average increase in income was almost 70%; however, if you start with a very low income, 70% is still not be a very big number. So much of the increase in income was in less developed countries.

Also, the increases in yield are a little difficult to determine because there is constant improvement in the developed world (US and Europe). There is improvement every year – the hybrids are improved and the entire yield improves by a small amount each year. Hence it is very hard to tease out the specific impact of GM traits on yield.

What role does regulation play in GMOs?

Early on it was scientists who raised concerns. When the first proposals to modify organisms for use outside of laboratories came out, regulatory agencies became interested in extending their jurisdiction to GM organisms. The US President's Office of the Science and Technology Policy (OSTP) brought together the Food and Drug Administration, the Environmental Protection Agency and US Department of Agriculture to come up with a framework for regulation. The OSTP advised the agencies regulate GM organisms based on their properties and environment into which they were to be introduced and not the methods by which they were modified. Instead, the regulatory agencies have regulated all organisms modified by molecular techniques. The regulatory process has been slow, cumbersome and expensive. Big biotechnology companies like Monsanto were quite successful with crops that had huge markets and approved of the regulation as it kept the competition down. But this has put a complete stop to research coming out of public sector research laboratories. Because of this, there is an extraordinary backlog of innovations that could have reached the farmers 20 years sooner. With 20 years of commercial production, 30 years of development and 40–50 years from the time the first transgenic plants were produced, people are still worried about the potential hazards despite the complete absence of actual hazards. Even as we have become much more specific, directed and targeted with our genetic modifications, the hysteria in society has continued to rise. This is paradoxical because chemical mutagenesis was never regulated and yet we have not had any disasters. Why would we think that as we get more precise in genetic modification, new hazards will emerge? USDA is now moving towards a trait-based regulation and they have already announced publicly that they are not going to regulate any modification that could have been made by an older unregulated technology. I believe that is a step in the right direction and the only way out of the impasse that the regulators are in.

Can you talk about some of the further developments that are expected in the areas of GMO?

I can tell you some that are in the pipeline. There is a company called Recombinetics in the US that has come up with hornless beef cattle using CRISPR/Cas technology. Some that are close to commercialization are apples, potatoes and mushrooms that do not turn brown because the polyphenol oxidase chain has been inactivated. There are also peanuts where the genes that code for allergens have been inactivated. However, there is no way of looking at the peanut and determining whether it has the allergen or not. So I am not sure if it can be commercialized. These are some examples.

S. Priya (S. Ramaseshan Fellow), Current Science Association, Benglauru 560 080, India.
e-mail: priya@ias.ac.in