Student Voice[1] *Report*

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The twenty-sixth NABC conference, held in 2014, *New DNA-Editing Approaches: Methods, Applications and Policy for Agriculture*, included presentations on developments, applications, and regulatory concerns for DNA-editing technologies, particularly targeted mutagenesis using zinc finger nucleases (ZFNs), transcription activator-like effector nucleases (TALENs), and clustered regularly interspaced short palindromic repeats (CRISPRs).

The *Student Voice* discussions were focused mainly on the following areas:

- Scientific advocacy,
- Consumer benefits, and
- Regulation.

[1]The Student Voice program was inaugurated at NABC 19 in 2007 to promote graduate-student participation in the annual conference. Student representatives from NABC-member institutions attend the keynote and plenary sessions and meet separately to develop what they see as the most significant points of interest that emerged.

[2]Co-presenter of the *Student Voice* report at the conference.

Scientific Advocacy

Western civilization has a long history of scientific mistrust and speculation, perhaps most famously the conflict which existed between Galileo and the Roman Catholic Church during the Renaissance. Today, there is still a large part of the public which remains skeptical and adverse to Darwin's theory of evolution. While public distrust of good science is always troubling, in the two examples mentioned above, it mainly threatens the scientists' well-being, and does not directly affect the general public that the science of today so often tries to help. Major issues that will affect the planet and the human population at large in the twenty-first century include feeding nine billion people by 2050 and reducing the harmful effects of climate change by reducing greenhouse-gas production. One avenue that may help the hunger crisis while reducing inputs to agriculture, thus reducing carbon dioxide and other greenhouse-gas emissions, is the use of genetically engineered organisms, more commonly known as genetically modified organisms (GMOs).

In the late 1980s it became possible to deliver foreign genes into an organism, and have that gene up taken by the organism with expression leading to a more desirable phenotype. Many in the plant biology community, especially from the industrial sector, quickly noted the merits of such technology and the potential to help farmers and the public. Shortly after that, in 1996, Roundup Ready soybean varieties were released to growers, who benefitted by simplifying their herbicide-application regimens to only requiring the use of glyphosate, the active ingredient in Roundup herbicide. Other traits which were released include *Bt* corn and cotton, which conferred resistance to insect predation. After release of these traits and learning about the technology used to generate them, the public began to grow restless and wanted to know about the risks related to consuming such foods and the effects on livestock that ate the affected seeds. Since then, hundreds of studies have been released which indicate that GMO consumption does no harm to livestock or humans. However, non-government organizations (NGOs) such as Greenpeace have raised the alarm about the "dangers" of genetic modification and the harm that would befall the environment. In the true spirit of the precautionary principle and due to public pressure, government regulators such as the USDA and FDA quickly issued stringent regulations controlling GMO releases, virtually shutting the technology down for use in modern agriculture and stifling real life-saving innovations such as Golden Rice.

The resulting outcry from the scientific community, especially the agricultural biotechnology sector, quickly followed, sparking a public showdown between scientists, regulators, the public, and NGOs. Scientists responded quickly with a flurry of studies that demonstrated that there are no discernible health effects from consuming GMOs, and demonstrating that environmental concerns, while an issue in some circumstances, were largely overblown. In spite of this, regulation continues to be excessive and the consumer response has been lackluster, and many are still quite wary of GMOs in spite of overwhelming evidence that they are safe. This combination has left the scientific community quite frustrated, and many will not live to see their discoveries reach a hungry public. It is quite evident that if we want to see things change, we will need to change tactics, while being aware of those who have fought the battle before us, learning from their mistakes, and capitalizing on their successes. The timing could not be more critical; we may have the

opportunity in the near future to re-cast the narrative, as the public begins to understand the applications of the new DNA-editing techniques to plant and animal improvement, some of which will soon be up for review and will undoubtedly gain attention.

One of the issues we can examine is that of climate change. Evidence continues to stack up supporting the theory of global warming, and that the rise in temperature is tightly associated with levels of carbon dioxide and other greenhouse gases in the atmosphere. In spite of these facts, it is a politically polarizing subject in the United States, resulting in delayed action on climate-change legislation and the regulation of greenhouse-gas production. Rarely, though, does one hear about climate change from climate experts, and most information is disseminated through media outlets and politicians, who may suffer from greater levels of mistrust even than scientists! As greenhouse-gas emissions continue to rise, little is being done due to partisan gridlock while other countries have long ago transitioned to green energy solutions such as solar, wind and nuclear sources. As we cast alliances with public figures such as celebrities and politicians, we need to be wary that we do not alienate half of the country and create a partisan rift.

The pharmaceutical industry has been much more successful at pushing its products to the public and they now benefit a vast majority of American consumers, in spite of recalls and settlements when some users exhibit extreme side-effects. Though the industry is (rightfully) tightly regulated, many new products are released every year, in stark contrast to the virtual moratorium placed on GM crops. While few consumers are enthused about paying for and taking prescription drugs in the face of side-effects, millions do. This begs the question, why do people trust big pharma enough to risk side-effects and mistrust ag-biotech advocates the same way they mistrust climate-change advocates? How can ag-biotech avoid the polarity that climate change has engendered?

The key difference is advocacy. Pharmaceutical industries have thousands of advocates scattered throughout the country. These advocates are physicians and other medical practitioners who possess the ability to not only understand how drugs work, but also to make sure their patients also understand. While we may never be able to emulate for ag-biotech exactly what physicians do, we certainly can learn a good deal about the way they operate. First, they are actively engaged with the public on a daily basis. Though some of them could have been promising researchers, they chose instead to work with the public. In the same spirit, some up-and-coming leaders in ag-biotech will have to turn down careers in research and pursue avenues where they can engage the public, including legislation, policy, scientific communication and teaching at the secondary and post-secondary level. However, this does not release researchers completely from responsibility, and they can play a special role being on the forefront of innovation and having the land-grant system in place. Land-grant universities often include extension agents who go out and speak to farmers and the public in general about crops. It would not be challenging to set aside one day a year for a lab, or at least one of the graduate students, to organize a talk about GMOs and explain it from the perspective of someone doing the research. Other avenues could include public high-school science demonstrations and botanical gardens. Together we could form a network of advocates by sacrificing as little as one day per year and become a positive voice for ag-biotech.

Consumer Benefits

A frustrating issue that was raised in our discussion was the question, "How can we appeal directly to consumers?" Clearly, we need to hear more of genetically engineered products that directly benefit members of the public at large. Currently, the benefits of genetic engineering are clear to growers, but are largely hidden from consumers. A good example of a consumer benefit from agricultural biotechnology is the potato—a specialty crop—that produces significantly less toxic acrylamide during frying.

Products that lead consumers to realize that the quality of their lives is being improved by genetic engineering will open doors to improved communication, which, in turn will open doors to acceptance of other products of genetic engineering beneficial not only to farmers but also to consumers.

Regulation

A large portion of the NABC 26 meeting focused on regulatory concerns, both within the United States and internationally. It is clear that existing regulatory terminology fosters confusion about gene-editing approaches, even among leading scientists. During our conversation, it was unanimously agreed that a universal, standardized set of definitions should be developed and utilized to mitigate confusion about the regulation, adoption, and legislation surrounding gene-editing technologies and their resulting products.

As mentioned by many speakers during the meeting, there is a tendency to regulate the process in *lieu* of the product. This method not only adds many years to the regulatory process, but reduces the amount of resources devoted to testing the safety and quality of the actual product. Additionally, the extensive regulatory process perpetuates consumer distrust of genetic engineering, *i.e.* "if the product is safe, why does it require so much testing and paperwork to release?" Although we recognize there is no easy solution to this issue, we propose reduction or elimination of regulation for gene-editing technologies in favor of increased regulation and testing of the final organism.

As graduate students, we are especially apprehensive about the impact of regulation on funding opportunities for recent graduates. Our greatest concern is the high barrier of entry created by the costs and restrictions imposed by existing regulations. The current system favors large corporations and narrows research and funding opportunities for entrepreneurs and public-sector scientists. This circumstance stifles innovation and limits the ability of scientists to address more crucial issues, such as climate change and food security.