STEWARDS, NOT "ABSOLUTE ARBITERS"

A Scientific and Catholic Perspective on Genetically Modified Crops

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"Their eyes tell their sad stories," remarked a rice farmer in Tamil Nadu, India, speaking in an interview with *Global Farmer Network* about the children he encounters. "[G]hostly white irises give way to vacant stares. We can look at them but they can't look back at us. They've gone blind because of malnutrition."

What he is describing is Vitamin A deficiency, a disorder which wreaks havoc on the physical development of children. "Upwards of half a million Indian children go blind each year," he explained, "and many of them die within months of losing their eyesight."

The statistics on malnutrition in children around the world are simply staggering. According to the World Health Organization, fifty-two million children under the age of five are wasted, meaning they experience a low weight-to-height ratio, and seventeen million of those young children are severely wasted. One hundred fifty-five million children—the equivalent of half the population of the United States—suffer from stunted growth as a result of malnutrition or undernutrition. What is more, nearly half of all deaths among children under five years of age are linked to undernutrition, a condition which makes children more vulnerable to various diseases.

A number of genetic discoveries over the past hundred years have inspired remarkable technological advances in agricultural biology—advances that can help to alleviate the suffering of our brothers and sisters in dire need. But various challenges need to be properly understood and overcome in order to do so. This essay

considers the subject of genetically modified (GM) crops from a scientific and Catholic perspective. It asks what gene editing is, where the technology comes from, and what it is capable of doing to aid mankind today. It also provides an overview of the Church's approach to this issue. It is becoming a pressing issue even for the Church in her sacramental life, as the final section makes clear. An informed and responsible approach to GM crops can help people of good will to promote solidarity and practice responsible stewardship of the earth.

Genetic Modification Then and Now

We have come a long way from Fr. Gregor Mendel's experiments on pea plants in the vast gardens of his nineteenth-century monastery. Yet those experiments, in which Mendel artificially bred crops to pass on desirable traits to future generations, laid the groundwork for modern genetic studies. By the 1960s, the West was experiencing its most fruitful period of agricultural innovation, thanks to the introduction of "dwarfing genes" into cereal crops. These genes increased the production of seeds in the plants while minimizing the amount of inedible parts of the plant. A decade later, a group of scientists showed that bacterial DNA could be introduced into the DNA of plant cells during infection by a bacterium. This was a significant discovery because it meant scientists were then able to insert any type of DNA molecule into a plant cell in order to change its genetic makeup.

Today, the term "genetically modified" is used to describe plants produced by the man-made manipulation of the plant's genes. Scientists have developed multiple technologies to edit the genes of organisms over recent decades. The gene-editing tool that might possess the greatest potential to promote scientific discovery and advancement, especially in plant biology, is what is known as the CRISPR system. The Clustered Regular Interspaced Short Palindromic Repeat (CRISPR)-Cas 9 system is a gene-editing technique that was borrowed from bacteria that naturally use it as

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a defense mechanism against viruses. The bacteria store memories of viral DNA and draw from this memory to identify invading viruses. This leads to the destruction of the virus by the DNA-cutting enzyme called Cas9.

So what's the big deal? This system is significant because it is cheap and accurate, and can edit the genetic material of any organism. Imagine taking a pencil and using it to change a single letter in a multi-volume encyclopedia, say from an "a" into a "g." This is what CRISPR allows scientists to do. They can now change a single chemical letter in the human genome, which is three billion letters long. And that one change can make a world of difference. Some claim that the development of the CRISPR system is more significant than the discovery of antibiotics. Such is its rich potential.

Since it was first described five years ago, the CRISPR technique has changed science and medicine. It is currently being

implemented for the eradication of mosquito populations, for example, in order to thwart the spread of the Zika virus here in the United States and malaria in other countries. It is also being used to handle complex gene-editing in plants. Providing resistance and tolerance for a crop often requires that multiple genes be mutated, and the CRISPR can do so in a single cell in the same experiment (Aimee Malzahn et al., "Plant Genome Editing with TALEN and CRISPR," *Cell Biosci* [2017] 7:21). The CRISPR system has also proven helpful in combating rice blast, a fungal infection that is one of the most destructive diseases in rice-growing countries and a blight on global rice production. The CRISPR system was used to offer enhanced resistance to rice blast fungal infections. Unlike other gene-modifying systems, with the CRISPR system multiple genes were able to be targeted simultaneously (Fujun Wang et al., "Enhanced Rice Blast Resistance by CRISPR," *PLOS ONE* [April 26, 2016]). In addition to rice, the CRISPR system has been utilized to make both low-gluten bread wheat and durum wheat, which is a hard wheat used to make pasta. Since there is a market for low-gluten bread products, scientists mutated the disease-causing α-gliadin genes to modify the gluten protein composition of wheat (Susana Sánchez-León et al., "Low-Gluten, Non-Transgenic Wheat Engineered with CRISPR/Cas 9," *Plant Biotechnology Journal* [2017]). Such are some of the benefits that the CRISPR system offers for global health and food production.

The Case For (and Against) Genetically Modified Crops

There are a number of compelling reasons to use this technology in order to create GM crops. First, according to a recent estimate by the UN Department of Economic and Social Affairs, the world population will increase from 7.6 to 9.8 billion people by 2050, which would increase the demand for food and require an even greater food supply. At the same time, each year we are losing about ten million hectares of cropland because of soil erosion (a space totaling the approximate size of the state of Kentucky).

These factors create the potential for a dire predicament. In the future, there will be many more mouths to feed with less cropland to produce food. With GM crops, however, food spoilage can be delayed and environmental stresses can be better resisted. Ripening can be delayed in order to improve post-harvest shelf life, and herbicide tolerance, insect resistance, drought tolerance, and bacterial/viral resistance can all be improved. One recent advancement in this field of biology is golden rice. Since there is a shortage of dietary Vitamin A in low-income countries leading to malnourishment, scientists inserted two genes into the rice plant to program it to produce beta-carotene, a precursor to Vitamin A (X. Ye et al., "Engineering the Provitamin A [beta-carotene] Biosynthetic Pathway into [Carotenoid-Free] Rice Endosperm," *Science* 287 (2000), 303–05). This modification, which gives the rice a golden color, represents a major step to prevent malnourishment in countries where rice is the staple crop.

GM crops have also contributed to food security, sustainability, and the protection of the environment. From 1996 to 2015, these crops increased food productivity by 574 million tons, an amount valued at $168 billion. Sixty hundred twenty million kilograms of pesticides did not need to be used. It was projected that carbon dioxide emissions were reduced in 2015 by 26.7 billion kilogram, equivalent to taking 11.9 million cars off the road for one year. In addition, eighteen million small farmers and their families were aided, possibly preventing them from becoming impoverished (*International Service for the Acquisition of Agri-Bioethics Applications*, 2016 Executive Summary).

Despite the promise that GM crops hold, they have received mixed reviews since their introduction into commercial markets approximately three decades ago. A meaningful portion of the current U.S. population thinks that GM crops are unsafe for consumption. Over half the individuals surveyed in a recent ABC News poll expressed precisely this opinion. In another poll taken by the Pew Research Center, 39 percent of people said that GM foods are worse for one's health than non-GM foods. And there

is more than just a fear of bodily harm from consumption of GM foods. The Pew Research Center poll also suggested that there is a public distrust of the scientists who conduct research on GM foods. A third of the people polled said that a desire to help their industries is what influences scientists' research findings.

In response to such public concerns over the safety of GM crops, a study committee of the National Academies of Science, Engineering, and Medicine stated that it found "no substantiated evidence of a difference in risks to human health between currently commercialized genetically engineered crops and conventionally bred crops." Additionally, the World Health Organization has stated that "GM foods currently available on the international market have passed safety assessments and are not likely to present risks for human health," and that "no effects on human health have been shown as a result of the consumption of such foods by the general population in the countries where they have been approved."

In addition to the opinion that GM crops may harm one's health, there are various concerns about the effect of genetic modification on the environment. Some critics have voiced concerns about transferring genes from GM crops, such as antibiotic resistance genes or other genes that might offer an advantage to microbes or wild plants. But there are currently procedures in place to remove antibiotic resistance genes before commercial introduction (Smita Rastogi Verma, "Genetically Modified Plants: Public and Scientific Perceptions," *ISRN Biotechnology*, vol. 2013 [2013]). Decades ago we would actually find commercial crops that were mutagenized in a less controlled way than new gene-editing technologies, leading to widespread and relatively indiscriminate mutations that were not necessarily desirable or even known to exist in the plants. These "conventional crops," as they were called, lacked a requirement for assessment before entering the food-chain (Halford et al., "Genetically Modified Crops: Methodology, Benefits, Regulation and Public Concerns," *British Medical Bulletin* [2000] 56.1: 62–67). Even though there is some breeding

between GM crops and wild plants, this has always been the case between conventional crops and wild plants. With GM crops, it is apparently difficult for breeding to occur, despite observation of it in the field.

In another criticism of GM crops, it is argued that these crops will only increase food supply at a very slow rate. One scientific reviewer concluded that the public's lack of a basic knowledge of GM crops is actually the prime factor for its slow progress rate (Verma, "Genetically Modified Plants"). Also, limited research funding is another significant factor, including staunch opposition from advocacy groups. Greenpeace, in particular, has a "robust global presence" that spearheaded opposition to golden rice, which could have its "greatest impact on the poorest people in Africa and Southeast Asia." In response, more than one hundred Nobel laureates signed a letter urging Greenpeace to "end its opposition to genetically modified organisms in general and Golden Rice in particular" for the sake of the malnourished. They also pressed Greenpeace to "recognize the findings of authoritative scientific bodies and regulatory agencies" (Joel Achenbach, "107 Nobel Laureates Sign Letter Blasting Greenpeace over GMOs," *Washington Post*, June 30, 2016). The public debate continues, however.

A Catholic Perspective on Genetically Modified Crops

How is a Catholic to evaluate the morality of GM crops? Overall, the Catholic Church views GM crops in a positive light, but she recommends prudence and caution concerning the proper implementation of this technology. The USCCB stresses this idea in Part 4 of the document, "For I Was Hungry & You Gave Me Food: A Catholic Agenda for Action—Pursuing a More Just Agricultural System" (2003). The Church, however, has not made definitive judgments on moral issues pertaining to the use of biotechnology in agriculture.

If we look to the Scriptures for guidance, we ought to recognize that God, in all His benevolence, entrusted the earth to man:

> God blessed them, saying to them, "Be fruitful, multiply, fill the earth and conquer it. Be masters of the fish of the sea, the birds of heaven and all living animals on the earth." God said, "See, I give you all the seed-bearing plants that are upon the whole earth, and all the trees with seed-bearing fruit; this shall be your food." (Gen 1:28–29)

Thus God calls us to be stewards of the earth. As Pope St. John Paul II stressed, these words from Genesis "entrust the earth to man's *use*, not *abuse*. They do not make man the absolute arbiter of the earth's governance, but the Creator's 'co-worker'" ("Jubilee of the Agricultural World" Address, 11 November 2000).

This stewardship begins with scientists. When proceeding with experimentation and gene-editing on plants, scientists must have a noble goal in mind: to help humanity, whether it be to reduce poverty and hunger or to aid farmers in their livelihood (USCCB, "For I Was Hungry," Part 4). The *Catechism* states that man may perform biomedical research on animals "if it remains within reasonable limits and contributes to caring for or saving human lives" (*CCC* 2417). This teaching would include experimentation on plants, since they are simpler organisms than animals. Similarly, the Pontifical Academy of Life states that

> there is a place for research, including cloning, in the vegetable and animal kingdoms, wherever it answers a need or provides a significant benefit for man or for other living beings, provided that the rules for protecting the animal itself and the obligation to respect the biodiversity of species are observed. ("Reflections on Cloning," Ch. 4)

The use of the word "cloning" here refers to gene manipulation. When writing on this subject, Pope Francis has affirmed that there are benefits from scientific and technological progress, but that parties should not perform "indiscriminate genetic manipulation" (*Laudato Si'* §131). To prevent such a misuse of technology—which could lead to serious consequences, especially upon the environment—both the USCCB document "For I Was Hungry & You Gave Me Food" and *Laudato Si'* stress that there needs to be an open scientific discussion and participation in the decision-making process. This allows all those affected to offer their concerns regarding the usage and introduction of GM crops. Pope Francis states that "a technology severed from ethics will not easily be able to limit its own power," which involves considerable risks (*Laudato Si'* §§136, 131). Pope Francis also pointed out that the "risks involved are not always due to the techniques used, but rather to their improper or excessive application" (§133). Socioeconomic problems arise when lands are exploited, leading to the destruction of complex ecosystems, and when productive land is held by a few farmers to the detriment of many small farmers. GM crops therefore represent but one element in a much broader effort to cultivate the earth responsibly and for the benefit of all mankind.

Genetic Modification: A Eucharistic Matter

With an increase in the usage of GM crops, including wheat, there is concern that the removal of gluten from crops may become more common. There ought to be increased concern and awareness, therefore, about the importance and sacramental significance of gluten in the hosts used for Communion at Mass.

Earlier this year, Pope Francis requested that Robert Cardinal Sarah, the prefect of the Congregation for Divine Worship and the Discipline of the Sacraments, remind local ordinaries that they need to "provide for all that is required for the celebration of the Lord's Supper" ("Circular letter to Bishops on the bread and

wine for the Eucharist," 15 June 2017). This includes providing guidance and "guaranteeing the Eucharistic matter through special certification." Ordinaries are required to remind priests "to verify those who provide the bread and wine for the celebration and the worthiness of the material."

In reference to gluten-free altar bread, the letter by Cardinal Sarah also reiterates a previous clarification by then-Cardinal Ratzinger that, "[h]osts that are completely gluten-free are invalid matter for the celebration of the Eucharist. Low-gluten hosts (partially gluten-free) are valid matter, provided they contain a sufficient amount of gluten to obtain the confection of bread without the addition of foreign materials and without the use of procedures that would alter the nature of bread" ("Circular Letter to All Presidents of the Episcopal Conferences Concerning the Use of Low-Gluten Altar Breads and Mustum as Matter for the Celebration of the Eucharist," section A, 1–2, 24 July 2003).

Cardinal Sarah's letter also addressed the fact that scientists are able to modify wheat to lower the gluten content. He reiterates a statement about GM organisms from a previous letter of the Congregation: "Eucharistic matter made with genetically modified organisms can be considered valid matter" (see "Letter to the prefect of the Congregation for Divine Worship and the Discipline of the Sacraments," 9 December 2013). But of course, altar bread made from GM organisms must contain gluten, since it is the specific difference that gives wheat its essence. Catholics with celiac disease and other gluten-related allergies should be treated with pastoral sensitivity, and at the same time all Catholics, both pastors and the faithful, must remain cognizant of the Church's sacramental teaching on the Eucharist. This is an issue that promises to come up more and more frequently.

Ethical Modification

In sum, in a world whose population is growing and is experiencing a number of environmental and societal concerns, recent advances in agricultural biotechnology offer the global community significant benefits in the fight against malnourishment, hunger, and poverty. Ethical principles grounded in the common good, as well as responsible stewardship, should guide decision-making and the implementation of agricultural advances for the protection and assistance of humanity and the environment. We are called to be stewards of the earth, not "absolute arbiters." We should not change or tamper with the very nature of organisms, but we are permitted to modify the genetic code of organisms in order to aid our neighbor and, in a spirit of charity and solidarity, feed the hungry. As the number of advances increases exponentially in this exciting technological age, it appears that very few aspects of life will be untouched. But may we never lose sight of God's benevolence and omnipotence in creation. May cooperation with the Creator be our guide.

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