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Genetically Engineered Organisms: Progress or Poison

Melina Sansi
Dominican University of California

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By

Melina M. Sansi

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Abstract

Genetically engineered organisms are a part of almost everything we put into our bodies. More than any other time in history, humans are manipulating plants and organisms on an advanced level. Scientists are able to genetically alter food so that it precisely fills a specific dietary need, or increase crop yields to feed the growing global population expected to reach 9 billion people by the year 2050. Currently 250 million acres worldwide are used to grow genetically modified organisms. Many consumers don't fully understand the use and impact of genetically engineered organisms for lack of accessible and straightforward information. Federal agencies and the media have contributed to a lot of the myths, misinformation, and confusion surrounding engineered organisms. This essay will analyze the differing opinions and evidence regarding the safety of genetically engineered organisms for humans and animals.

Introduction: Please Don't Modify My Food

The idea that food, which fuels the body and brain, is being altered or modified can be unsettling. We are bombarded with information which has had a polarizing effect on how we think about and view genetically engineered organisms. But for all of the research, data, and commentary, consumers have not been provided with a definitive answer to the question are genetically engineered organisms safe for human and animal consumption? Innovation Hub host and executive editor Kara Miller tackles this controversial subject in the pod cast, "A Genetically Modified Menu." She points out that consumers demand new and advanced technology from cars to watches, but should the food we eat be precise and designed in a laboratory? Some people believe they are saving lives, while others claim they are destroying the planet. The one certainty is that they are here and will continue to evolve.

According to a poll conducted by the Pew Research Center on the public's opinion about food, "57% [of U.S. Adults] say they believe it is unsafe" to eat genetically modified foods (Funk and Raine). Award winning New York Times journalist Amy Harmon contends that consumers have lost sight of the fact that the food we eat today is dramatically different from its original species. She adds that we would be shocked by the form of corn, tomatoes, and carrots before humans began domesticating and cultivating them for consumption. More importantly, as the world's population grows the need to meet dietary demands increases and so do the methods for increasing crop yields and plant nutrients. Dr. Pamela Ronald, a professor in the U.C. Davis Department of Plant Pathology and co-author of *Tomorrow's Table: Organic Farming, genetics, and the future of our food*, points out that "virtually everything we eat has been genetically altered somehow" (Ronald). She goes on to state that this includes organic produce as well.

Unless you are eating wild caught Pacific Salmon, or foraging for mushrooms, the food we consume has been altered by different methods.

It all began when I haphazardly landed upon an online news article discussing the critical issue concerning population growth and food insecurity. We are diminishing our resources at a rapid pace, and according to scientists the added pressure of supporting 9 billion people by the year 2050 is not viable (Diamond 15). Jonathan Foley directs the Institute on the Environment at the University of Minnesota. In his National Geographic magazine article, *A Five-Step Plan to Feed the World*, he claims that the problem isn't just population growth and ensuring that people have enough food to eat, but that increased wealth and upward mobility across the globe will be the main culprit. He writes, "The spread of prosperity across the world, especially in China and India, is driving an increased demand for meat, eggs, and dairy, boosting pressure to grow more corn and soybeans to feed more cattle, pigs, and chickens. If these trends continue, the double whammy of population growth and richer diets will require us to roughly double the amount of crops we grow by 2050" (Foley). Further investigation led me to genetically engineered organisms. According to the World Health Organization (WHO), "genetically modified (GM) foods are foods derived from organisms whose genetic material (DNA) has been modified in a way that does not occur naturally, e.g. through the introduction of a gene from a different organism" (World Health Organization). Scientists accomplish this by bringing together genes from plants from unrelated species through molecular or chemical techniques.

Many governmental and non-governmental organizations have been employing genetically engineered organisms, and will continue to do so in order to meet this demand by the year 2050. Biotechnology to the rescue; genetically engineered organisms will be able to help us meet this critical food need in the next thirty years, so why all the hysteria? Well that is only the

tip of the iceberg. The controversy over the use of genetically engineered organisms is fiercely debated. There are a lot of books, articles, podcasts, journals, and commentary about genetically engineered organisms but limited scientific research. Very few studies have been conducted by unbiased independent third-parties who are not directly affected by the results. Yes, some research has been completed within the biotechnology arena, and many universities. However, the results are drastically split; some scientists claim they are safe, while others state they are toxic. There are too many unknowns for a definitive conclusion and many experts stress the need for continued research with limited use. But that ship has sailed because genetically engineered organisms are incorporated into every part of our food supply. Accessibility to GMOs by consumers and animals is regulated, but those policies are predicated on many of the scientific research published by the companies who own the patents on GMOs. In an attempt to satisfy my own curiosity, and to answer the looming question of their safety, I embarked on a research project about genetically engineered organisms.

Food Evolution and Genetically Modified Organisms

Ancient cultures were the first to recognize and harness the sustaining capabilities within plants. An important food source and element of their religious ceremonies, quinoa was a major component in the Inca diet. They recognized the amazing qualities contained in this super seed and adapted it for human consumption. There is "evidence of domestication about 7000 years ago" (Murphy). Research reveals that the Incas cultivated quinoa in Chile by 2750, by dedicating large swaths of land for growing and harvesting the grain. When our ancestors developed the ability to domesticate and cultivate cereal grains and vegetables they were able to generate an abundant food supply that rotated with the changing seasons. A consistent and predictable food supply lead to population growth, and according to author Ann Gibbons in her

article “Evolution of Food” for *National Geographic Magazine*, a reliable food supply allowed our ancestors to give birth, “—one every 2.5 years instead of one every 3.5 years” (Gibbons). Grain and plant domestication helped our ancestors evolve and survive. Scientists and researchers agree that modern plant engineering will help current and future generations advance diet and agriculture.

Horticulturalists and botanists like Luther Burbank were motivated by Charles Darwin’s theories in *The Variation of Animals and Plants under Domestication*. Burbank believed that he could improve a plant’s attributes through natural selection and new varieties from cross-breeding and hybridization. Burbank’s years of scientific research produced “over 800 varieties of fruits, flowers, vegetables, and grains” (Wiesler). One of his main goals of studying and working with plants was to improve their quality and increase the world’s food supply. Burbank, like many of the first plant pioneers, developed methods for cross-breeding plants and several processes for growing plants from cultured tissues, such as root tips or leaves. These methods are still used today; however, they are labor intensive and take extended growing periods to analyze the desired result.

Before chemicals and x-rays botanists took naturally occurring plants and started combining species for several different reasons like flavor, color, and seasonal growing. Scientists have been researching and altering the genetic material of plants since the 1860s. And when in 1902 German botanist Julius von Sachs experimented with growing plants in water and not soil, a fellow “German Botanist Gottleib Haberlandt theorized that each and every plant cell contained all the necessary instructions to grow a complete plant” (Brown and Federoff 11). The last fifty years has seen an explosion of hybridization and genetic engineering with the goal to mass produce food to fulfill food insecurity needs. This technology began with a few botanists

in agricultural science who manually developed different strains and varieties of plants by horticultural techniques of cross-pollination and grafting. These men and women were searching for new methods to start and grow plants from parts, and not the traditional method from seed.

Fast forward to today, when researchers and scientists have isolated specific traits allowing them to breed plants that have the ability to be drought resistant or contain highly concentrated amounts of vitamin A. Traits are separated into two categories: those that affect production and those that affect quality. Production attributes include yield, resistance to disease, insects, and herbicides, and the ability to thrive under various adverse environmental conditions. Quality attributes include those affecting processing, preservation, nutrition, and flavor. New York Times reporter Amy Harmon claims that, "Scientists are taking specific genes that they know what they code for and put it in a plant in order to produce a particular desired trait" (Harmon). The end result is a plant that matures for a precisely desired attribute that benefits the growers and consumers.

There are concerns that genetically altering a plant, by removing or adding specific genes, poses serious risks to animal and human health, whereas traditional methods like cross-breeding and culturing tissue with proteins is more natural. Dr. Pamela Ronald insists that "[There is] no unique risk of genetic engineering compared to other methods of breeding" and she also acknowledges that growers have been planting genetically engineered crops for about twenty years now and there are no known records of harm to humans or animals (Ronald). The problems arise with the modified or altered plants and accidental outcomes.

Whether the plant is modified through conventional breeding practices or genetic engineering, researchers and scientists are growing thousands of plants in order to design a plant to meet the unique niche they are searching for. Dr. Ronald suggests "any type of breeding

whether it's conventional breeding or genetic engineering can lead to unintended consequences" (Ronald). The mutated plants are quickly identified and prevented from further growth or reproduction. Consumers needn't worry that they will ever see these plants in their grocery store or in their food. But good mutations, like Clearfield corn, a variety of maize resistant to Patriot, an imidazolinone herbicide, allow farmers to spray fields to kill weeds without killing off the young crop. These early successes with genetically modified organisms fueled the competition to develop more genetically engineered organisms that were resistant to pesticides and herbicides in order to reduce the amount of synthetic chemicals being used in our food and damaging the environment. Furthermore, it is necessary to grow plants in these processes in order to meet the goal of producing food to meet the growing populations' dietary needs.

In the same Pew Research study, it states that "67% of adults say scientists do not clearly understand the health effects of GM crops" and are concerned that genetically engineered organisms are not regulated like other foods or products they consume (Funk and Raine). Genetically engineered organisms are controlled and monitored by the United States Food and Drug Administration. Amy Harmon points out that engineered organisms have a "rigorous regulatory process that they have to pass through" to ensure that they are safe not only for humans and animals but insects and the environment (Harmon). But how do you manage a crop of engineered plants growing next to a crop of traditional or organic plants so that there is not any cross pollination? Consequently, the counties of Mendocino, Marin, Trinity, Humboldt, Santa Cruz, and more recently Sonoma have passed ordinances banning transgenic crops in order to protect organic crops from cross-pollination.

Trusting the Sources and How to Access the Information

Increasingly consumers' decisions are based upon a few expert opinions or what they see in the media. Robert Cialdini Regents' Professor of Psychology at Arizona State University reports there is compelling "evidence suggesting that the form and pace of modern life is not allowing us to make fully thoughtful decisions, even on many personally relevant topics" (Cialdini 9). Many consumers, including myself, are frustrated and trapped. We don't have the time to investigate all of the information available on genetically engineered organisms; therefore, we rely upon the findings published by many government and nongovernment agencies as to the safety of GMOs. Furthermore, the public should be able to trust the reporting and labeling mandated on the use and consumption of genetically engineered organisms. Unfortunately, there have been conflicts of interest between federal agencies and the industry which have made the information less reliable.

The issue is that research has been primarily funded and completed by the companies who develop and patent biotechnology, and federal agencies use those reports to help determine an organisms' non-regulated status. In 2012 a group of scientists recognized a need to separate fiction from fact and provide the public with access to independent, peer-reviewed research on genetically engineered organisms. More importantly they wanted to demonstrate that research is completed on a global scale outside of the biotechnology industry. They decided to create an easily accessible and simplified database called the GENetic Engineering Risk Atlas (GENERA) and it houses all peer-reviewed and published reports on GMOs.

The developers of GENERA only include peer-reviewed literature that has been published in credible scientific journals, in this way they know the information more trust-worthy. The peer-review process provides checks and balances for scientific research and

follows a standard protocol. First the report is reviewed by unidentified field experts who examine the study and determine if the processes, data, and conclusions of the paper were well researched. Additionally GENERA includes meta-analysis which delves into the extensive reporting in a particular subject area in order to combine the data into one easy to read report. More importantly the database prohibits "grey literature" that has not been through the rigorous process of peer-review, and this includes white papers, advocacy documents, claims made on websites, anecdotal claims, or republished versions of retracted studies (GENERA). They are considering inclusion of other scientific research like university reports, government reports, scientific perspectives, opinions, and regulatory documents. When they have completed their goal of inclusion of all of the peer-reviewed literature the creators may consider "non-peer-reviewed studies that are widely discussed on a case-by-case basis" and those will be clearly labeled (GENERA). The goal of GENERA is to provide the public, educators, scientists, and government agencies with access to comprehensive analysis on genetically engineered organisms.

GENERA is a searchable database providing a snapshot of the critical details of each study so the viewer can see and understand what it was about, what the scientists concluded, and who funded it, as well as a link to the full report. As of August 25, 2014 the database housed 400 research studies which included 197 on the safety of genetically engineered organisms for human consumption. Specifically 148 studies provide analysis and conclusion that there is no difference than conventional organisms. Of those studies 75 were funded by governments, independent non government organizations, and mixed sources. 35 of the studies were funded by companies that develop and patent biotechnology and 38 studies did not provide any funding information (Haro von Mogel and Lim). GENERA scientists made an attempt to contact the

authors of every study to confirm the funding sources. And in some cases the authors could not be reached for verification, or some were unable to locate information on the funding source, or they "were able to reach the study authors but they refused to disclose the source of funding" (GENERA). Thus, the accuracy of this resource may be questionable since the sponsors of 38 studies could not be substantiated.

The GENERA database provides a critical resource for the public, federal agencies, and non governmental agencies. Their credibility is built upon adherence to strict rules of engagement. The end product is a comprehensive database of reporting from various sources revealing that the research isn't only funded by the biotechnology industry. Interestingly, half of the studies available on GENERA are regarding the safety of GMO consumption for humans. This demonstrates that the public's concerns regarding GMO consumption is being studied and by agencies outside of the industry. However, we should question why a quarter of the studies concluding that GMOs are no different than conventional organisms refuse to identify the funding source. Why would the authors of those studies be apprehensive about disclosing the sources of their funding? Possibly the industry is employing a truncated method to fund studies with conclusions which favor the biotechnology industries goals and aim. For this reason among many others, transparent regulation by federal agencies is vital.

Biotechnology Regulation and Our Federal Agencies

Currently biotechnology is regulated in the United States by three federal agencies: U.S. Department of Agriculture's (USDA) Animal and Plant Health Inspection Service (APHIS), Food and Drug Administration (FDA), and the Environmental Protection Agency (EPA). APHISs ensures that genetically engineered products are not dangerous for agriculture and the

environment. The FDA enforces policies governing food and pharmaceuticals for human and animal consumption. The EPA regulates the use of herbicides and pesticides.

In order for biotechnology developers to grow genetically engineered organisms without limitations, and for profit, they must petition APHIS. The Plant Protection Act (PPA) delegates authority for APHIS to regulate and impose requirements on developers and growers to prevent plant pests from harming American agriculture. The agency monitors activity during field testing, importation, and interstate movement of certain genetically engineered organisms "APHIS regulates a genetically engineered organism until the science shows that it will not harm plants or the environment" (USDA). The permit process requires developers to report their compliance with required conditions, equipment and facility inspections, which prove they confined the genetically engineered organism during every stage of the growing process. They evaluate the data to determine that a particular regulated specimen does not present a plant pest risk and should no longer be regulated. Once they have determined that the organism does not present a risk, the petition is granted, thereby allowing unrestricted planting, importation, and interstate movement. The latest information available from APHIS indicates that genetically engineered corn and soybean comprise the majority of petitions for deregulation. An unregulated organism that will be further developed for human or animal consumption transitions to policies enforced by the FDA.

The FDA was established around the beginning of the 19th century in order to regulate and sanction food and pharmaceutical products developed and marketed for human and animal consumption. In 1938 Congress passed and president Franklin Delano Roosevelt signed the Food, Drug, and Cosmetic Act, which is the code that the FDA adheres to in order for systematic review of any new biotechnology (FDA). The Food, Drug, and Cosmetic Act aims to advance

the progress of many new products and biotechnology with a requirement to ensure the health and safety of consumers by stipulating that they have the scientific information necessary to make informed decisions. This principle helped Congress pass the Food Additives Amendment Act in 1958, which requires manufacturers of new food additives to establish safety guidelines, and prohibits the approval and use of any food additive shown to induce cancer in humans or animals.

The Food Additives Amendment Act was implemented to control substances that become a part of the food or alter the foods attributes in any way, including the packaging. Additives covered by this act include food coloring and preservatives. Any substance considered for adding is forced through a series of intense qualifying toxicology tests that range from twenty-eight days to two years. The research must conclude with "a reasonable certainty that the substance in the minds of competent scientists is not harmful under its intended conditions of use" (FDA). There are a few substances that fall outside of this amendment and avoid these stringent tests. Either they were used in food prior to January 1958, or scientific methods have demonstrated that they are not harmful to our health. The agency defines these substances as 'generally recognized as safe' or GRAS. Salt, pepper, and vinegar are a few of the substances which they have categorized as GRAS, including genetically engineered organisms.

In order to gain the public's confidence in genetically engineered organisms, representatives from the biotechnology industry communicated to the FDA the importance of their supervision. Consumers and industry representatives were seeking the FDA's interpretation of the current Food Additives Act as it pertained to food developed from genetically engineered organisms. The agency concluded that the original structure of the food and its intended use are the factors which determine health and safety regulations. Plant innovation, whether it is by

traditional breeding methods or genetic engineering is irrelevant. FDA guidelines, policies, and regulations are concerned with any alteration to the original characteristics, nutritional values, and intended use. The only exception is any genetic engineering that introduces a substance to the plant that is not generally recognized as safe (GRAS), which would fall under the food additive regulation.

The main tenant of the FDA's conclusion hinges upon a theory developed by several expert scientists at a food safety symposium held in Geneva, Switzerland in November of 1990. Their evaluation and final report concluded that genetically modified organisms do not pose any additional health risk to humans, based upon the 'Principle of Substantial Equivalence', which states "The DNA from all living organisms is structurally similar. For this reason, the presence of transferred DNA in produce in itself poses no health risk to consumers" (Robin 169). This theory states that material which will become a part of food from genetic alteration is consistent with, or considerably comparable to, substances ordinarily found in food. The FDA adopted this principle within their Policy Statement for Foods Derived from New Plant Varieties.

The directive the FDA incorporated into their policy statement contains more specific language, "The substances expected to become components of food as a result of genetic modification of a plant will be the same as or substantially similar to substances commonly found in food, such as proteins, fats and oils, and carbohydrates" (Robin 169). Furthermore, the agency asserted that they had not uncovered any research or evidence that revealed foods resulting from any new method or technology varied in any significant way or added harmful aspects than foods produced by conventional practices. Continued advancement in biotechnology forced the agency to release a formal statement in 1992 which stated "The agency is not aware of any information showing that foods derived by these new methods differ from

other foods in any meaningful or uniform way or that, as a class, foods developed by the new techniques present any different or greater safety concern than foods developed by traditional plant breeding" (Food and Drug Administration Statement of Policy: Foods Derived from New Plant Varieties 57 FR 22991). The policy includes provisions regarding interstate commerce, specific plant varieties, essential scientific research needed to comply with human and animal consumption regulations, mandatory petitions, and special labeling. Ultimately this policy is the standard for safety and the regulatory status of foods derived from plant varieties, including plants developed by the newer methods of genetic modification. Yet, we still have a major disconnect between The Environmental Protection Agency (EPA) and the use of synthetic chemicals in conjunction with genetically engineered organisms.

GMO Fallout; human and environmental damage

Currently the spotlight is on organisms that have been engineered to resist disease, insects, and pesticides. The scientific and medical communities have undeniable and concrete evidence that the chemicals in pesticides and herbicides are harmful to humans, animals and the environment. But this wasn't always the case. In 1947 *Time Magazine* ran an advertisement claiming Dichlorodiphenyltrichloreothane (DDT) was good for people, homes, and farms. DDT's effectiveness at fighting pests was so successful it spurred new developments of synthetic pesticides to control nature. Pesticides were being promoted by the chemical industry and eagerly endorsed by our federal government which was quick to employ their use without extensive studies to indicate future effects. Initially pesticides worked wonders and crop production exploded. In fact, the development and widespread use of pesticides was considered a advancement in human comfort. People were no longer concerned with mosquitoes spoiling a backyard barbeque, because systematic spraying was conducted in urban neighborhoods.

Housewives were able to prevent moth damage to garments by lining drawers and closets with DDT laced shelf-paper.

Then in 1962 Rachel Carson's book, *Silent Spring*, was published and revealed how this unchecked use decimated wildlife populations, contaminated soil and water resources, and caused unprecedented cases of unexplainable sickness and death in humans. She had an affinity for the natural world and pursued an education in biology and writing where she endeavored to prove that every living organism is interrelated. Carson's work and research in *Silent Spring* stemmed from what she witnessed while the Editor-in-Chief for the U.S. Fish and Wildlife Service (Rachel Carson Council). She helped people understand the impact of the unregulated use of chemicals and in the PBS American Experience documentary, *Rachel Carson,* she stated "If we are ever to solve the basic problems of environmental contamination we must begin to count the many hidden costs of what we are doing" (Rachel Carson). It took scientists twenty years to realize how dangerous it was, and in the interim unabated spraying ensued over cities, public and private lands. Her work and writing brought American's closer to the natural environment and our attention to the damage that chemicals were inflicting upon nature and the human race. She was not supported by any educational institution or governmental agency, and on May 15, 1963 President Kennedy's Science Advisory Committee released its report which validated her work and warnings.

Carson provided evidence that increased crop production, or what we now refer to as industrial agriculture, actually created the growing pest problem. Large farms growing single crops provide a perfect breeding ground for pests that thrive on that plant. Rachel Carson claimed devoting huge tracts of land towards one crop is irresponsible "Single-crop farming does not take advantage of the principles by which nature works; it is agriculture as an engineer might

conceive it to be" (Carson 10). Additionally, studies reveal that insects experience a "flareback," or resurgence after spraying pesticides in numbers greater than before. We have reached an apex; attempting to feed millions of people by devoting increased acreage to a single crop, using engineered seed to increase crop yield which in turn creates a perfect breeding ground for pests that forces the grower to spray additional synthetic chemicals to reduce their populations and save produce.

The same chemical companies that endorsed pesticides now are the largest developers and producers of genetically modified organisms, and our federal government has favorably endorsed them through the Food and Drug Administration, and the Food Additives Act. Sadly Carson's work and writings didn't have an extensive influence because we have not drastically reduced the use of synthetic pesticides as would be expected. In the article "Current Sounds from *Silent Spring*" from the Network on Humanitarian Action reports that "In 1960 the United States produced 638 million pounds of synthetic pesticides" (Carson) and "in 1985, 1.4 billion pounds" of chemical pesticides (Briggs). Our generation has made a little progress by reducing the use of synthetic pesticides back to 1960s levels. According to Consumer Reports Food Safety and Sustainability Centers' March 2015 *From Crop to Table Pesticide Report* "Farmers use nearly 700 million pounds of pesticides every year" (Consumer Reports 8). How would Rachel Carson appraise our efforts in the last fifty-five years? There is no scientific certainty and the safety of our natural world has been veiled by government bureaucracy, shareholder revenue, and fleeting luxuries.

In more recent years scientists have created organisms that are engineered to reduce the use of pesticides and simultaneously increase crop yields. Award winning journalist and *New York Times* reporter Amy Harmon has written about the benefits of these types of GMOs and in

the *Innovation Hub* podcast "A Genetically Modified Menu" hosted by Kara Miller she reveals how since 2005 growers in Florida were dealing with a critical situation when a bacterial disease carried by insects decimated the orange crop. In order to save their crops growers were forced to spray more pesticides. A biotechnology company began developing an engineered orange that would be resistant to the bacterial disease which would help farmers save future crops, as well as, consumers and the environment with reduced spraying of pesticides. She goes on to state that this new type of orange "would reduce the use of insecticides and make the crop viable" (Harmon). At the time of the podcast this new engineered orange was looking promising with greenhouse trials while going through the regulatory process for approval.

The long term effects of genetically engineered organisms on the human body have not been studied at length. The studies that have been completed were done so through private funding. And it is difficult to find scientists willing to do this type of research because it could jeopardize their careers and institutional opportunities. What has been discovered is alarming, most notably with genetically engineered organisms that have been developed to resist herbicides and pesticides. Research has revealed that even low dose exposure to chemicals cause birth defects, mental disabilities, and damage to human immune and reproductive systems. Most genetically engineered organisms are developed to resist synthetic pesticides which are endocrine disruptors.

Endocrine disruptors interfere with our reproductive systems by mimicking or blocking the effects of our own sex hormones. Gilles-Éric Séralini is a biochemist and professor at the University of Caen. He is a member of the French Biomolecular Engineering Commission, who along with the CRII-GEN, the Committee for Independent Research and Information on Genetic Engineering, has requested more extensive research on the health effects of genetically

engineered organisms. During an interview with Marie-Monique Robin for her groundbreaking book, *The World According to Monsanto,* Seralini discussed the results of studies completed on genetically engineered organisms that are herbicide tolerant, "with GMOs that have been modified to be able to resist it, it has become a food product, because residues are found in transgenic soybeans and corn kernels" (Robin 83). Seralini's work contradicts several claims from governmental agencies that have endorsed the use of genetically engineered organisms in agriculture.

Not only are traces of herbicides found in genetically engineered organisms that have been developed to resist those types of chemicals, but those same chemicals that are sprayed over fields to kill weeds and not harm the maturing crop, seep into the soil and ground water. Consequently, all living organisms within a radius of the herbicide deployment are killed off, including small mammals, insects, and worms. The only living thing not affected by the herbicide spraying is the young budding crop. In spite of that, GMO proponents claim that meeting the growing global food demand outweighs these drawbacks.

Meeting a Global Food Supply

Food security is not a new topic, in fact concern regarding food availability and research began in the mid 1970s by The Food and Agriculture Organization of the United Nations (FAO). At that time public policy was focused on food supply challenges, specifically the accessibility of basic food staples at a international and national level, as well as price stability. Challenges like famine, hunger, and food supply have forced international policy to transform its definition; additionally, they have identified social and cultural aspects of affected people, which are foundational to food security. The definition today encompasses all of these areas:

> Food security [is] a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. (2.2)

Globally, millions of people struggle to find enough food to meet their daily dietary needs. And access to food that satisfies a cultural tradition is considered a luxury, something that millions will never experience in their lifetime.

Different factors prevent people from accessing healthy and nutritious food. In certain areas of the world many environmental issues like drought, natural disasters, and climate change cause crop failures which many communities depend upon for food supplies throughout the year. Additionally, war and conflict prevent needed food aid from reaching that people that need it most (FAO). Determining which countries or areas within the globe are facing food insecurity is difficult because data collection methods vary from area to area and are inconsistent.

The most troubling aspect of food insecurity is that social programs don't consider food insecurity as an ethical human rights issue, but incorporate it in the category of chronic poverty. This is problematic when geographic areas are experiencing food shortages due to lack of supply or other environmental issues out of their control. Additionally, many food aid programs are only concerned with caloric intake and meeting minimal daily dietary needs, and in most instances are filled by staples like corn, soy, and wheat. The resources and technology are available to supplement, or even replace cheap fillers like corn, wheat, and soy with cultural food traditions like beans, legumes, and root vegetables. Sadly, policy makers' decisions are influenced by large multi-national corporations who own the patents to most genetically engineered food staples and fillers like corn, soy, and wheat (Trade Reforms and Food Security).

The World Health Organization (WHO), the Food and Agriculture Organization of the United Nations (FAO), and many religious organizations supply aid through feeding programs to various areas experiencing food shortages. For the past fifty years international aid and feeding programs have used a corn soy-based and wheat soy-based fortified blend with micronutrients added. The challenge with a corn soy-based and wheat soy-based blend is that this meal type does not fall within many cultural groups' food preferences. Rice is the principal dietary ingredient for almost half of the world's people. Nongovernmental Organizations and other non-profits utilize these blends because they can be gown and produced cheaply. Advancements in the field of biotechnology make genetically engineered organisms the most cost effective choice to meet the critical need of feeding 9 billion people in the next twenty years. On the other hand, this may not be the best option when people don't fully understand how they affect the human body or the environment.

For decades plants scientists had been asking and tinkering with methods to transfer genes into different plant species. Apart from the traditional recombination methods like pollination scientists were doubtful genes could be transferred into the cells of another plant. Swiss plant scientist and geneticist, Ingo Potrykus, had focused his work on transferring genes from one species to another. In 1984 he published a definitive report that stated, "plant cells could take up and incorporate foreign genes directly" (Brown and Federoff 5). He had successfully introduced genes from one species into the cell of a different plant species.

Potrykus chose to use his discovery to help developing countries grow more foods. "Potrykus decided the application he would pursue was to help developing countries grow more food" (Brown and Federoff 5). His work focused on improving crop yields for wheat, corn, barley and rye by making them more resistant to disease. Then a husband and wife scientific

team persuaded him to include rice in his studies, since "Rice is the staple food for nearly half the world's people", and look beyond crop yield and include micro nutrients (Brown and Federoff 2). Potrykus and his team worked to transfer the genes necessary to make beta carotene into rice. The task had additionally complexity since up to that point only or two genes had been added to the cell of a plant. To produce beta carotene four genes had to be added to the cell of the plant.

Finally after ten years of continuous work, including researchers and scientists from six different countries, they had success. Potrykus felt he had developed a special genetically engineered organism, one that could be publicly funded and distributed for free to subsistence farmers in developing countries. This rice would change public opinion about genetically modified organisms. Meanwhile the prominent scientific journals refused to publish his report and it wasn't until he was invited to speak at the 1999 International Botanical Congress held in St. Louis where the American Journal *Science* read and accepted his report. It was published in January 2000 with positive accolades.

This led to articles and headlines in major publications like *Time* magazine, the *New York Times*, and the *New Yorker* magazine. Their stories endorsed the amazing qualities of Potrykus' discovery, now called 'Golden Rice' from the hue imparted by the beta carotene nutrient. However, public backlash was fierce asserting that Potrykus had sold out to a global company, he had licensed it to Zeneca Agrochemicals, who merged with Novartis Agribusiness which became Syngenta, "The world's leading agribusiness" (Brown and Federoff 7). Opponents to his Golden Rice called him a traitor to the scientific community and a deterrent to serious research towards answers to the worlds' food insecurity needs.

The debate continues as to the merits and flaws of Golden Rice. What is real is that millions of children are at risk of going blind from Vitamin A deficiency and The World Health Organization estimates that more than a million children die a year because of Vitamin A deficiency. Ingo Potrykus' research and discovery provided a way for non governmental agencies to utilize and employ micro nutrients into their health and food aid programs. Unfortunately the timing of his discovery provided vitriol for proponents and opponents alike. Is Potrykus collateral damage for the advancement of genetically engineered organisms? Were his good intentions exploited by the large multinational agribusinesses? He had to suspect that possibility when he agreed to license his invention and willing to take that chance in order for his discovery to make it to the global stage for the good of all.

Non Governmental Organizations: Protecting People and the Environment

We have an ethical responsibility to protect our environment and ensure equality and that all people have enough food to live a happy and productive life. A few nongovernmental organizations have structured advocacy projects connected with the ethical impact that the use of genetically engineered organisms will have now and into the future. The Nature Conservancy (TNC) is one such organization that has developed research to achieve a balance between agricultural approaches to meeting food security needs globally and at the same time using modern technology to encourage environmental preservation endeavors. The Nature Conservancy asserts that human expansion and environmental protection can be accomplished simultaneously.

Twenty years ago The Nature Conservancy articulated their vision for extensive collaboration between citizens, governments, and nongovernment organizations that would promote environmental protection. In their 2011 article *TNC, Food Security and Sustainability:*

Clarifying the Debate, Iman Meliane, Director of Marine Policy, and Andrew Deutz, Director of International Government Relations state, "This strategy looks at ways to partner primarily with industrial-scale agribusinesses to help these corporations and their suppliers improve yields to feed a hungry and growing world while simultaneously maintaining or improving key environmental variables" (Deutz and Meliane). Their theory is that meeting basic human needs of food, shelter, and clean water should guide conservation efforts not hinder them. TNC is collaborating with existing agencies, corporations, and universities who have already begun work in different geographic areas and environmental concerns. The work they are doing demonstrates that humans can progress while protecting the environment. "Conservation by Design" encompasses The Conservancy's goal and vision for this initiative, and through research and education they are demonstrating how we can actively participate and enhance the natural cycle where we work to protect and conserve nature which will enhance our lives and improve communities.

The Conservancy admitted to promoting an image that their work was helping to meet food security needs while simultaneously preserving the environment; however internal feedback within TNC revealed that additional work could be done. Since then The Nature Conservancy has undertaken additional initiates towards sustainable agriculture that will address critical food security issues while promoting environmental protection. TNC believes that we are all part of a continuous cycle where the natural environment enhances humanity and provides for our survival as long as mankind protects and preserves nature.

The Expert Opinions

The expert opinions and arguments regarding genetically engineered organisms are intensely divided. This could be attributed to the fact that many expert dedicate their life's work

to the research of one area. In most cases their research and studies support their arguments and theories. It would benefit the public who relies upon these opinions and arguments for them to be able to review and study other expert opinions to ensure that they have conducted their research well by following strict rules of conduct for research including processes, data collection, and conclusions are well researched.

Amy Myers, M.D., autoimmune specialist and medical director at UltraHealth functional medicine center in Austin, Texas, focuses her work and research on autoimmune disorders by eliminating toxic foods and healing autoimmune-related infections. One of the critical components to her medical program includes eliminating gluten from the patient's diet. She states that "Hybridization has created new forms of gluten---that is, brand-new proteins that our bodies do not recognize" (Myers 102). Human bodies have not evolved as quickly as the engineered organisms that are prevalent in the food the is consumed and consequently leads to many of the detrimental health problems that people struggle with today.

Dr. Myer's documented cases of autoimmune disorders and their direct connection to dietary causes is revealing and scary with the primary contributing factor being gluten. She highlights how hybridization has created new forms of gluten and "manufacturers can now use gluten as a preservative and a thickener in all sorts of products in which gluten never used to appear" (Myers 103). Her recommendation is to completely remove gluten and genetically modified organisms from an individual's diet.

According to Dr. Myers genetically modified organisms are the most significant health issue to face humans in modern times. She urges consumers to learn as much as they can about engineered organisms and their effect on the food supply. She does acknowledge that not enough studies have been completed in order to determine their long term effects. But she does

highlight a recent study completed in France where over a two year period of time rats consumed a diet which consisted of 30% GMO corn. The results are alarming: 70% of the female rats who consumed GMO corn prematurely died from cancer compared to 20% in the control group that did not consume GMO corn. Dr. Myers encourages consumers to examine food labels, avoid packaged foods, and whenever possible consume 100% organic which includes grass-fed beef and free-range poultry because most of the feed used for the animals we consume has been genetically modified. She says to support local growers who adhere to 100% organic, sustainable farming practices. And if you plan to grow your own food make sure the seeds are non-GMO.

Dr. Alison Van Eenennaam is an Animal Genomics and Biotechnology Cooperative Extension Specialist in the Department of Animal Science at the University of California, Davis. She explains that many studies have been conducted on the digestion process of genetically engineered crops compared to conventional crops. The research concluded that GMO feed is digested the same as conventional feed and that the resulting animal products did not contain any traces of genetically engineered plant proteins. Dr. Van Eenennaam claims that, "The nutrients in meat, milk, and eggs from livestock fed genetically engineered feeds have been found to be the same as the nutrients from livestock fed conventional feeds" (Van Eenennaam). This is encouraging since the majority of genetically engineered corn and alfalfa are used to feed livestock.

Many scientists and researchers do agree that more work needs to be done in order to educate the public, so that consumers can be confident in the recommendations from trusted government agencies. Alison points out, "As a community, we need to push for sensible regulatory reform" (Van Eenennaam). But why is there so little educational information?

Insufficient funding from several public and private sources sidelined a lot of progressive research. Organizations can't afford to allocate funds for programs that may be halted for extended periods of time because of directives from the USDA. This government agency has a reputation for encouraging scientific research and testing, then swiftly altering its policies consequently forcing many successful research projects into hibernation as they await new directives.

The ability of the USDA and FDA to freeze advanced research in this area leaves researchers, scientists, and consumers at a severe disadvantage. It is understandable that many corporations and businesses can't outlay resources and funding for experimental research that could be terminated at any time by a directive from these federal agencies. Developing policies and regulations that aid in comprehensive and cohesive work between scientists, farmers, and consumers is a logical approach. This tactic may be difficult to accomplish as all parties involved have their own agendas, and asking each group to consider another motivation and application; however, beneficial could derail all progress. Many times we aren't able to get out of our own way in order to move ahead.

Genetically engineered organisms are saturating every aspect of our food supply. And many experts agree that prolonged and unabated use will contribute to mankind's potential downfall. They cite several interrelated factors that begin with the removal and destruction of natural resources for industrial farming. This type of farming typically includes genetically engineered organisms for increased yield and pesticide tolerance. Sizable tracts of land dedicated to a single crop are the perfect breeding ground for pests which require more synthetic chemicals. The pesticides are absorbed into the plants, soil, and underground aquifers. Modern technology that aided in the development of genetically engineered organisms has benefits but

has caused many of the problems we currently face. Archeologists have begun to compare the modern era to a few ancient super societies which experienced periods of sustained power, followed by rapid decline and eventual collapse. Experts report how they exhausted natural resources despite being advanced and inventive for their time.

Jared Diamond, professor of geography at the University of California, Los Angeles, provide clues to our outcome in his book, *Collapse: How Societies Choose to Fail or Succeed.* Based upon findings from ruins from ancient civilizations located in the Polynesian Islands, Maya cities in the Yucatan Peninsula, and the Vikings in the North Atlantic, he writes that the global use of toxic chemicals and rapid depletion of natural resources is our modern day road to destruction similar to those past societies. Diamond admits that it wasn't just environmental factors which led to a societies' failure but, more importantly, how the society dealt with their dwindling natural resources "the society's responses to its environmental problems—always proves significant" (Diamond 11). Though most ancient civilizations lacked equipment and technology they maximized man power and crude tools to extract natural resources. Diamond provides practical points that all failed societies encountered and how we can avoid a similar fate, when he states "how could a society fail to have seen the dangers that seem so clear to us in retrospect?" (Diamond 23). In spite of these findings we haven't done anything to alter the current methods employed in industrial agriculture and animal production facilities. We need to acknowledge and accept responsibility for how we consume resources as well as our attitudes and influence on corporations and elected officials.

Conclusion: Progress or Poison

Genetically engineered organisms are a relatively new technology, only developed about fifty years ago (Brown and Federoff 16). Consequently, they have only been actively researched

and studied for the last twenty years, which seems brief compared to the two-hundred years since scientists started studying the unique properties of plants. Perhaps a more accurate comparison can be made after another twenty years of research and data gathering but in the meantime let's not trade our health and resources for convenience and technology. Additionally, you can't discuss genetically engineered organisms without including synthetic chemicals in the conversation. The two are inextricably connected and that is the unfortunate reality of this technology. The biotechnology industry should be prohibited from developing and selling pesticide tolerant GMOs. I support opponents who are requesting further evidence which proves GMOs do not harm conventional crops, and implementing more stringent regulations for containing and isolating growing and production of them.

The increasing population has placed pressure for increased crop yields not only on conventional farmers, but organic farmers as well. Finding new methods to increase crop yields or engineer plants that are able to shorten the growing time in order to help fulfill critical needs for food aid programs is an important aspect of biotechnology. Everything we do impacts the environment and that includes organic farming. Human dietary needs for a growing population, especially 9 billion people, can be met but it will require a conscious effort to eat less meat and processed food because those industries consume and use the majority of genetically engineered organisms. Sustainable farming, the combination of growing fruits and vegetables without the use of chemical fertilizers and pesticides and using natures own methods for rejuvenation and preservation is the most beneficial for the environment.

Scientists and researchers agree with consumers; we need more information and research in order to determine if GMOs are actually safe for humans and animals and the environment. Clear and transparent consumer education about genetically engineered organisms must be

established. Currently television commercials and print advertisement about engineered organisms are funded by the individual companies who created and own the patents and, as a result they present GMOs in a favorable light. Public service announcements explaining the methods involved in creating and researching GMOs, as well as, the regulatory processes for approval, would help consumers understand how this technology is integrated into food sources. Moreover, if the experts are correct, then additional education concerning alternative food options is essential in anticipation of the coming global prosperity.

As of a result of this research project I am cautious and try to avoid food with genetically engineered organisms. I make an effort to purchase organic food and look for the "Non GMO Project Verified" label. This seal informs consumers that the product they are buying has been verified non-GMO following strict protocol by an independent organization. Yet, their work encompasses many different areas to encourage organic growing traditions and environmental protection.

This non-profit group works to protect the varied genetic reliability of seeds and plants, and they believe that food can be improved without the use of genetic engineering. They support independent growers and farmers to choose the types of plants they reproduce. They work to improve public education so that consumers can make informed choices about genetically engineered organisms. More importantly Non GMO Project Verified believes that it is everyone's right to know where their food came from and be able to access non-GMO foods (nongmoproject.org).

In our constant struggle to control and simplify our lives we have lost sight of that fact that nature provides us with the most complete organisms to feed our bodies. The needs of our global community require that we make thoughtful decisions about our food. We have a

responsibility to improve food aid programs by selecting the healthiest options. Finally, we have an obligation to ensure that future generations have a safe and reliable food supply.

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