Deciphering Anti-GMO Rhetoric from Scientific Fact

Is the Anti-GMO Movement Spurred by the Lack of Understanding of and Discrimination Between Genetic Modification and Treatment to Seed?

Tag words: GMOs, Seed Treatments, Genetically Modified Crops, RoundUp, herbicides, Monsanto, golden rice, Bt toxin, DroughtGuard

Authors: Lori Sepkowski, Victor Paulino and Julie M. Fagan, Ph.D.

Summary

Genetically modified organisms are a hot-button issue lately with two prevailing fields of thought. On the one side, GMO advocates tout the countless benefits of genetically altered crops, such as improved crop yields and nutrient content, while opponents of GMOs have blamed genetically modified food for everything from allergies to learning disabilities. GM crops have an overwhelmingly bad reputation amongst the general public. By gathering data from the public we have determined what the primary concerns are and what misinformation is being proliferated. By understanding why and where the public falls short of accepting GMO technology, we can begin to correct the problem.

Video link: https://youtu.be/MdlaG6UFvS8

GMOs: A Two Sided Debate?

It is no secret that genetically modified (GM) crops have a bad reputation amongst the general public. Despite having the potential to be very beneficial to mankind, there are a variety of misconceptions. The public perceives risks to producing and consuming these GM foods. While some of these risks are legitimate concerns, many are false claims generated by a misunderstanding of what GMOs (genetically modified organisms) really are and how they are developed. Furthermore, crops that have been genetically modified are often confused with the chemical treatments applied to some seeds, which are what people should really worry about consuming. The field of genetic engineering has not only rapidly expanded, but has also vastly improved in recent years. Thus, genetically modified crops are developed more efficiently and are safer than ever, while offering a number of benefits. In this paper, we hope to correctly define GMOs, separate false claims from scientific facts, distinguish between genetically modified crops and seed treatments, and analyze the public perception of GM crops vs seed treatments.

History of Genetic Modification (LS)

There is evidence of genetic modification found as far back as the Bronze Age, around 3200 BC. The discovery of domesticated crops in the ancient Middle East illustrates that people have been tinkering with food since the switch from a hunter-gatherer to an agrarian society. This form of genetic modification is known as selective breeding (1). Selective breeding takes advantage of the mutations, or “change to the DNA sequence” of an organism. The mutated organism is then bred only with other organisms with the same phenotypic mutation until a new species is
produced all together. Some examples of such genetically modified foods are almonds, kale, broccoli, cauliflower, and tomatoes.

**Almonds (LS)**
People living in the ancient world had to live much more closely with nature, and understood through their own trials and errors, just because something grows from the ground doesn’t make it good for you. Almonds, often thought of as a “natural food”, were originally too toxic for humans to eat. Wild bitter almond seeds contained naturally occurring cyanide in the plant as a defense mechanism in such a high dose that eating just a handful would be fatal to a human (2). Through selective breeding by humans, the sweet almond was produced with a low level of cyanide which is it safe for consumption (3).

**Kale, Broccoli, and Cauliflower (LS)**
Another crop that is considered the ultimate all-natural health food by organic consumers is kale. Kale, along with other vegetables like cauliflower and broccoli, all originated from a single species of plant called Brassica Oleracea. The Greeks and Romans 2000 years ago selectively bred this wild cabbage. Plants that had curlier leaves were bred with other curly-leaved cabbages to produce kale. Plants with larger flowers buds were bred with one another to produce broccoli or cauliflower. From one plant came a whole subspecies of vegetables with drastically altered genes from the original source plant (2).

**Tomatoes (LS)**
Tomatoes have come a long way from their ancestors - perhaps even more than kale from wild cabbage. Tomatoes were tiny and sweet, more closely related to berries than to the larger variety of fruit they are today. For about 70 years farmers have been breeding tomatoes so that it’s easier to spot when the fruits are at the correct ripeness to be picked. Wild tomatoes contain a gene that is responsible for the production of chloroplasts. This gives the fruit its dark green color, but makes it more challenging for farmers to tell when it’s ripe for picking. The “genetically modified” tomatoes have that same gene, but it is inactivated and so the plants do not produce as many chloroplasts. Now farmers use this to their advantage so they can pick the freshest tomatoes and ship them out to consumers (4).

These new crops demonstrate that people have been altering their foods’ DNA for thousands of years. The results are crops that are not only safer for human consumption, but also offer more variety in texture, taste, and nutrient content. Genes are constantly mutating, sometimes for better and sometimes for worse. Humans, through selective breeding, make these mutations work to our advantage to get a more desirable product. Genetic modification merely takes selective breeding one step further with the ability to incorporate DNA in a more precise manner between members of different species, not just the same crops. A change to the genome is a change to the genome, regardless of the technique used to get there.

**Techniques for Genetically Modifying Crops (VP)**
The genetic engineering of crops in laboratories has been practiced since the early 1980s. Since then, the practice has drastically improved and rapidly advanced to produce transgenic crops more efficiently. Today, there are two main methods used to add or remove genes from crop species: *Agrobacterium*-mediated gene transfer and microparticle bombardment of plant cells via
a biolistic particle delivery system, or gene gun.

**Agrobacterium-mediated Gene Transfer (VP)**

*Agrobacterium* is a genus of soil bacterium, which has the ability to introduce new genetic material into plant cells in order to create a desirable environment. This is physically seen by the formation of a crown gall in plants. This material is often called tDNA (transfer DNA) and formed the foundation of the most popular technique in plant transformation because of its relatively high efficiency. To transform a plant using *Agrobacterium*, one must first isolate the gene of interest from the source organism and insert it into a plasmid, a circular sequence of DNA that can independently replicate. The plasmid is used as a transport vector for the gene of interest and replaces the tDNA in bacteria, so that the bacterial DNA sequence now includes the sequence of the gene. Also included in the plasmid is a marker gene in order to track the new gene in the host plant. The bacterial cells then act as a vector and are mixed with the target plant cells in order to allow the transfer of the gene of interest into the plant cells. Finally, the transformed cells are regenerated in the host plant and significant testing is done in the laboratory, greenhouse, and field in order to confirm the use and safety of the new genetically modified crop. If the procedure is successful, the gene sequence has been incorporated into the plant’s genome, and the plant will be able to activate the new gene. This method works especially well for dicotyledonous crops, such as tobacco, tomatoes and potatoes, but can also work for monocotyledonous crops, such as rice, wheat, and maize.

**Microparticle Bombardment (VP)**

Microparticle bombardment of plant cells is the other popular method for plant transformation and is similar to the *Agrobacterium*-mediated gene transfer method. Of course, one must still isolate the gene of interest and insert it into a plasmid in order to transfect the plant cells. Unlike the *Agrobacterium* method, this method makes use of a biolistic particle delivery system, more commonly referred to as a gene gun, to literally “shoot” plant tissue with microparticles that are coated with the plasmid DNA. Some of the plant cells will take up the plasmid DNA and the gene of interest will be inserted into the crop’s genome. Again, a marker gene is also included with the plasmid in order to identify the cells that were successfully transformed. Finally, the transformed plant cells are regenerated in the host plant, which is then tested first in a laboratory, then in a greenhouse, and finally outside on a field. This method has a lower transformation efficiency than *Agrobacterium*-mediated gene transfer, but is capable of transforming a wider variety of plants successfully.

**Emerging Techniques (VP)**

There are also new and emerging techniques that can be even more efficient at plant transformation than the above methods. One of these new methods make use of transcription activator-like effector nucleases (TALENs) to bind to specific sequences of DNA and induce double-stranded breaks, which is then repaired by non-homologous end joining or homology directed repair. Another method uses the clustered regularly interspaced short palindromic repeats (CRISPR) found in bacteria to similarly attach to a specific sequence and induce double-stranded breaks which is again repaired via non-homologous end joining or homology directed repair. With both of these methods, the breaks that are created can be used to specifically add or disrupt a gene of interest. Both of these methods can also be customized to target any desirable
sequence in a genome, specifically. As a result, these methods are highly efficient and have already been used to induce transformations in a variety of organisms.

The field of biotechnology has been around for a while and is still rapidly advancing. Because of heavy research and progress, it is easily possible to transform crops in an efficient and safe manner in order to make use of the advantages that genetically modified crops provide. The current techniques for plant transformation have been extensively tested and can develop crops that are very useful to mankind. Furthermore, there are newer techniques that are being improved, which can develop these crops even more efficiently.

### Advantages to GM Crops (VP)

When the public debates over GM foods vs. organic foods, the significant advantages that GM foods have are often not taken into consideration. With an increasing global population and apparent world problems, such as hunger and malnutrition, there is great potential to use this genetic modification technology to better mankind.

#### Increased Yields (VP)

One major advantage that GM crops hold over traditionally-grown crops is the promise of higher yields. This can be accomplished by various means, depending on the crop. One way to increase the yields of a crop is for the crop to produce its own insecticide. This is done by inserting a gene that codes for a toxin into the plant’s genome, which is only harmful to the insects that ingest the crop. With this ability, the crop will be able to resist its common pests, minimizing the amount of food lost to these insects, and thus increasing the amount that can be harvested. This idea has already been accomplished and is currently being applied in the U.S in major crops, such as maize and cotton. Furthermore, crops with this ability can be especially beneficial in developing countries, where farmers are more economically limited. This was demonstrated in a study that tested the yield effects of Bt cotton in India (5). Bt cotton is a genetically modified cotton crop that produces the toxin from *Bacillus thuringiensis*, a bacterium. The study showed that with no insecticide added, regular cotton lost up to about 80% of its yield, while Bt cotton only lost up to about 25% (5). Another way to increase the yields of a crop is to modify its ability to tolerate stress, such as drought conditions. Obviously, plants that are under some sort of stress will have reduced yields when compared to plants in a desirable environment. By growing crops that have a higher degree of stress tolerance than their natural counterparts, farmers can maximize annual yields, especially in areas with harsher environments. Another study showed that maize transfected with a bacterial stress tolerance gene, CspB, had more yields than non-transgenic maize under water-deficit conditions (6). The study concluded that expression of these bacterial stress genes can increase yields not only in maize, but also in Arabidopsis and rice under environmental stress (6). In summary, farmers are capable of maximizing yields by growing genetically modified crops that are able to resist pests and endure stressful conditions.

#### Improved Nutrition (VP)

Another advantage that genetically modified crops might have is improved nutrition. It is possible to develop transgenic crops that have more nutritional value than their natural counterpart. Consequently, producing these crops can help reduce the number of deaths due to malnutrition. Macronutrients and micronutrients are important for the human body to function
correctly, but they might not be as available as everyone would like, especially in developing countries. Successful examples of transgenic crops with improved nutrition include high-lysine corn, high-fructan sugar beets, and insulin-synthesizing potatoes (7). Golden rice is an example that can potentially save hundreds of thousands of lives. It is able to synthesize beta-carotene, a precursor of Vitamin A, and can therefore be used to treat children with Vitamin A deficiency. It is estimated that 250,000-500,000 children go blind every year due to vitamin A deficiency (8). Most of these cases occur in developing countries, a significant amount of which is reported in the Philippines. A Philippine case study reported that 270,103 disability-adjusted life years are lost annually due to vitamin A deficiency (8). If golden rice becomes available to them, it will not only extend malnourished individuals’ lives but will save them as well. It is clear that there is a serious, global malnutrition problem and improving the nutrition of crops via genetic modification can help alleviate that problem.

Resistance to Pathogens (VP)
Pathogens can pose a serious threat to some of the most important crops in the world. This is best portrayed by the papaya ringspot virus, which devastated the Hawaiian papaya market in 1992 (9). Pathogens are capable of destroying whole fields of crops if caution in maintaining these crops is not taken. Fortunately, resistance to pathogens is another feature that can be added to plants by genetic engineering. In fact, the solution to the papaya ringspot virus in Hawaii was the development of the Rainbow and SunUp Papaya, transgenic cultivars of the fruit that were resistant to the virus (9). Today, Rainbow Papaya makes up most of the papaya production in Hawaii, and has even been approved for export to Japan, despite the current controversies on GMOs. This is a good example of how genetically modified crops are not only advantageous, but sometimes necessary for farmers to be able to grow food. Furthermore, many important crops, including tomatoes, maize, and onions, are also affected by pathogens. By modifying these crops to be resistant to its pathogens, farmers won’t have to be worried about losing entire fields.

Risks and Concerns of GM Crops (VP)
When analyzing a new product, it is equally important to consider both advantages and risks of that product. As detailed above, there are great benefits to developing and growing GMOs, but there are also potential risks that have to be evaluated. Some of these risks are legitimate concerns, while others arise from the public’s misunderstanding on GMOs. In the field of GMOs, the risks and concerns can be divided into two areas: environmental risks and risks to human health.

Environmental Risks (VP)
Environmental risks are those risks that can possibly alter the area in which GM crops are grown. Specifically, there are concerns for the organisms that live or grow in the same area that the GM crop is grown. One such concern is the possibility of outcrossing. Outcrossing is the breeding of a crop with a related plant, thereby creating plants with a higher degree of adaptability. The fear is that weeds will acquire the transgenic traits of a genetically modified crop, and thus will be harder to handle. Obviously, weeds are undesirable plants on farms and so the problem with having weeds that are able to produce their own insecticide, resist pathogens, or tolerate stressful condition is evident. No one wants a “super-weed” abusing their farm. This is a justifiable concern, as outcrossing happens often in nature. The fact is, though, that the
probability for a Gm crop to outcross is tested before growing it and is even monitored after planting the crop (10). Furthermore, a ten-year study concluded that there are no increased risk of invasiveness for GM crops in wild habitats (10). In addition, genetic engineering can prevent cross-pollination, and induce sterility, should there be any concern of the outcrossing potential of a GM crop (11). One other environmental concern is the effect that GM crops will have on insects. One popular example of this is controversy between Bt corn and the monarch butterfly. In 1999, Losey et al discovered that pollen from a Bt corn variation can kill monarch butterfly larvae, due to the pollen carrying the Bt toxin (12). Fortunately, these results were found in a lab, and so did not arise from observations from real monarch populations in the field. Since then, Bt corn that produces pollen with no toxin has been developed, and field work has demonstrated that there is no significant impact on the butterflies (10). Another effect on insects that may be a concern is the ability of the insect to adapt to the crops that produce insecticides. The fear here is that the insects that the insecticide from a GM crop kills will eventually adapt to be resistant to the insecticide, resulting in a bigger problem for farmers. This has not been seen so far, but plans to reduce this possibility have been developed (10). This includes a requirement that fields with GM crops must have a portion of non-GM crops so that the insects can develop without gaining resistance to the insecticide (10). In summary, there are concerns that have to be addressed when developing a GM crop, but negative environmental effects have yet to be seen in fields with these modified crops.

**Health Risks (VP)**

Risks on human health is another concern that has to be analyzed. One concern is the possibility of increasing the allergenic properties of these crops. It can be a problem if GM crops induce allergic reactions due to the foreign gene that was inserted into them. Again, significant testing is done to make sure that a modified crop that is about to be commercialized does not cause allergic reactions to individuals. So far, there has been no evidence that genetically modified foods are more allergenic than conventional ones (13). Another concern to human health is the chance that antibiotic resistance genes may be transferred to pathogenic bacteria in a stomach. Antibiotic resistance genes are often used as markers in the development of GM crops, so this concern is justified. If a harmful bacteria were to gain resistance to antibiotics, it can be difficult to kill the bacteria and may end up sickening more people. However, only a small amount of DNA can survive digestion and there is no evidence that dietary DNA can be integrated into a bacteria’s genome (14). We eat DNA with every meal and there is also no evidence that DNA from GM crops is more dangerous than DNA from traditional crops (13). Health is a major issue with anything that humans ingest and that is why GMOs should be evaluated individually. As of yet, there have been no GM crops that cause negative health effects on humans.

**Treatments to Seeds (VP)**

The alternative to growing genetically modified crops is to treat natural seeds with various chemicals and compounds, such as pesticides and herbicides. Like GM crops, the idea for this is to increase yield and profit of crops by killing the organisms that injure these crops. Unlike Gm crops, though, is the fact that this practice can and is proven to be very harmful to people and the environment.

**Insecticides (VP)**
Insecticides are one of the most popular seed treatments, as they are effective at what they are meant to do. They are chemicals that kill insects, thereby protecting crops from harmful insects when used to treat seeds. What people don’t know is how harmful they can be. According to the U.S. Environmental Protection Agency (EPA), “lab studies show that pesticides can cause health problems, such as birth defects, nerve damage, cancer, and other effects that might occur over a long period of time” (15). As detailed above, GM crops do not have any risks that even come close to how serious these effects are. In fact, a study done by Carl Pray et al showed that the growing of Bt cotton, a cotton crop genetically engineered to produce its own harmless insecticide, had significantly reduced the number of farmers poisoned by pesticides each year in China (16). Do we really want seeds treated with such harmful chemicals? Other risks include those to the environment. Bt cotton and similar GM crops are specific only affect insects that actually ingest the crop. Insecticides used on seeds tend to be general, and can kill a wide variety of insects, even harmless ones. Furthermore, many birds feed on seeds and are therefore at risk from seeds that have been treated by these compounds (17). Why use this harmful practice, when there is a safer alternative capable of producing the same amount, if not more, yield: GM crops?

**Herbicides (VP)**

Another harmful treatment to seeds is the use of herbicides. Herbicides are substances that kill plants, often by interfering with the growth of the plant. In the field, they are used selectively: they are meant to target unwanted plants, such as weeds, and leave the desired crop unharmed. Herbicides are also very poisonous and include the same health risks that insecticides pose (15). Farmers are always at risk when using these chemicals. Specifically, it has been shown that the ingredients in glyphosate, a popular broad-spectrum herbicide, are deadly to human embryonic, placental, and umbilical cord cells (18). Furthermore, there may also be serious environmental consequences from using herbicides. A lot of the herbicides commonly used today are broad-spectrum; they are not specific and are capable of affecting a large variety of different plants. If the herbicide spreads, it may end up killing desirable crops or even affect neighboring fields. Today, most herbicides are used on crops that have been genetically modified to resist the herbicide. Monsanto, for example, develops a number of different crops, including maize and soybeans, which are modified to resist its RoundUp herbicide, glyphosate. Genetic modification of these crops is what makes them safe from these plant killers, but there are still risks involved, like the killing of unmodified crops and potential human health risks. Furthermore, these dangerous substances may prove to be hazardous to any animals that may have access to the seeds.

**Public Perception of Genetically Modified Food (LS)**

Between all the confusion with chemically treated seeds and genetically modified crops, the perception of genetically modified foods is at an all-time low. Many people who avoid eating “GMO food” don’t even fully understand what a GMO is. Through various media outlets and word of mouth, the public awareness of GMO food is high, but many lack a basic understanding of biology to understand how macromolecules, such as DNA, are processed after entering the body. One of the most detrimental things holding back GMO progress are big agriculture companies such as Monsanto using the technology for their own profits, at the expense of the consumer. Most of the bad press surrounding GMO crops is the result of just a few companies who are using the technology not to improve the food, or to help the world, but to improve the
sales of their other products, such as herbicides.

**Monsanto - GMOs, Chemicals, and Profits** (LS)

Perhaps the most notorious “biotechnology” company, Monsanto, has done a lot of damage to the overall public opinion of GMOs. Long before the company got into genetically modifying seeds, Monsanto was a chemical company responsible for the production of DDT and Agent Orange. Both of these chemicals are well known and documented for the harm they have caused to the environment, animals, and humans (19).

**DDT** (LS)

DDT was a pesticide commonly used for agriculture and controlling diseases spread by insects, such as malaria. It was banned in 1972 once it was discovered to be a carcinogen, and cause a host other problems like liver damage and reproductive issues in humans. Due to the nature of the pesticide, it is deposited into the atmosphere and continues to circulate today, contaminating plants and animals (20).

**Agent Orange** (LS)

Agent Orange is another one of Monsanto’s chemical constructions, an herbicide that was sprayed during Vietnam to wipe out vegetation as an aid to US soldiers. The Veterans Association has recognized many diseases related to those veterans that have been exposed to Agent Orange. Chronic B-cell Leukemia, Hodgkin’s Disease, Non-Hodgkin’s Lymphoma, Parkinson’s Disease, prostate cancer, and lung cancer are just a few of the illnesses directly linked to exposure to Agent Orange during the Vietnam War (21).

**Roundup Ready Crops** (LS)

Monsanto is in the business of selling chemicals, not improving food. The majority of genetic modifications Monsanto makes to their seeds are in the interest of selling a complimentary herbicide the crop has been modified to be resistant to. It has been documented (18) that the chemicals produced by Monsanto have health impacts to humans and the environment. It comes as no surprise that Monsanto’s “roundup ready” line of seeds have also been linked to human health issues.

Initial reports on Roundup’s active ingredient, glyphosate showed it to be generally safe (22) and with the major side effect being gastrointestinal stress (23). However, more recent studies that have looked at the chemical mixture of Roundup as a whole have resulted in a very different conclusion. When the inert ingredients are taken into account, they can actually intensify the toxicity of glyphosate and cause death to human cells (18). At the “Monsanto Makes Us Sick” protest held by The Organic Consumers Association, many people were outspoken about the health problems they experienced due to consuming Monsanto’s “Frankenfood.” The focus of the protest was against Monsanto and it’s use of Roundup, specifically glyphosate, but somehow as usual, GMOs were lumped together with the roundup, to be blamed for the deteriorating health of the protesters and their families. People shared personal accounts of the effects of Roundup ready crops. One such speaker, Zen Honeycutt of MAA (Mothers Against) had this to say about her own experience with Roundup ready crops.

“I want to share with you why I personally am here. I have three sons, 12, 9 and 6, and they all have food allergies and my husband and I never did. Two have life-threatening nut allergies and
one son we almost lost twice; I held his hand in the hospital and prayed to God for his life. But when we went organic, his allergies went from a 19 to a 0.2; he no longer has life-threatening allergies. And, my other son, at 8 years old, had a rash around his mouth, and a sudden onset of autism symptoms. His grades dropped from As to Ds. He was hitting and had erratic behavior. I got him tested and he had Clostridium difficile, fungus, clostridia, leaky gut, 19 different food intolerances and gut dysbiosis. These are all things farm animals have when they are exposed to glyphosate [the main ingredient in Monsanto’s Roundup herbicide]. I got him tested for glyphosate and he had 8.7 ppb in his urine, eight times higher than was found in anyone in Europe. So we all went organic to avoid glyphosate and within 6 weeks, we tested him again and his levels of glyphosate were undetectable. His autism symptoms were also gone and he has not had a single autism symptom since. And, I am not the only one; we have hundreds of testimonials. We see our kids get better from autism, allergies, asthma and autoimmune disorders (24).”

“OCA will continue to highlight the growing body of evidence that GMO foods and Roundup are harmful to human health, and remind consumers that while Monsanto may no longer be officially engaged in chemical warfare, its body count continues (24).”

While a growing body of evidence suggests that Roundup’s active ingredient, glyphosate, could cause an array of health problem, there is no evidence suggesting that the genetic modification of the crop has any part in these issues. The roundup ready corn contains a gene that codes for an enzyme, CP4 EPSP synthetase, which is a glyphosate-tolerant. This means it can break down the glyphosate and metabolize the chemical so that it does not harm to the plant. No studies to date have linked any human health issues to the ingestion of CP4 EPSP synthetase, the reason being that the enzyme would not be able to survive the digestive process. At this point, there is very compelling evidence that the chemicals cause side effects, but the genetic modification does not (25).

**Online Health Blogs (LS)**
The sudden popularity of social media has largely impacted the spreading of GMO awareness and misinformation about how GMOs impact human health. People who claim to be health experts start blogs and share their own opinions about GMO foods, whether or not they have the credentials to make such claims. On the Internet, anyone can claim to be an expert, and with using pseudoscience and half-truths, can make an argument against GMOs that may sound compelling, but in fact has no scientific basis at all. The “underground health movement” has become so popular, that it can hardly be considered alternative anymore.

**Food Babe Blog (LS)**
“Food Babe” is one blog that has gained a lot of attention in the last few years. The writer, Vani Hari, herself is claiming to make a stand against all things that are threatening our health. If one skims her blog for just a few minutes it becomes very apparent that she has ‘natural bias,’ which means if something doesn’t come from nature, then it’s bad. She is one of the many misinformed individuals that lumps GMOs with pesticides. She is not a scientist, but an “investigator” who is exposing all the horrible corporations that are trying to ruin the public’s health with their “Franken foods.” With nearly one million likes on facebook, 36,000 instagram followers, and 82,500 followers on twitter, Vani Hari, the blog writer, has gathered herself quite an army of
anti-GMO activists. She considers herself a martyr to the anti-GMO movement and anyone who challenges her stance is being paid off by big agro. The biggest problem is that her truth is far from it, and she uses a combination of pseudoscience and fear mongering to scare people away from intellectual reasoning into a more emotional response. Her statements border on conspiracy, and when she reaches impressionable people who are having their entire view of reality called into question, it is hard to undo the damage. It doesn’t matter how much scientific evidence is presented to these conspiracy theorists, they won’t buy it. Everything is under the manipulation of corporate America and therefore cannot be trusted. Anything that doesn’t grow from the ground is “ruining your health.”

To exemplify Vani’s line of reasoning One of Food Babe’s blog posts, “Is Butter Secretly Ruining Your Health,” Vani claims that because cows are fed conventional crops that are GMO, the quality of the milk suffers, making it toxic to your body. She wants everyone to buy grassfed butter so that the cow butter is not GMO. She then proposes a hierarchy of butter brands based on their organic-ness and the food source given to the cows. She recommends organic butter that comes from grass-fed cows as the best options, and then goes down the just grass-fed, not organic, and then lastly organic butter that is non-grass fed (26).

Problem is, that the organic crops are still being sprayed with pesticides, which makes that butter more “toxic” then conventional butter. In fact, some of the same chemical used in conventional farming herbicides appear in organic sprays. POEA, or polyethoxylated tallowamine, is a certified organic ingredient used in organic farming practices. It’s also the main inert ingredient in roundup. When POEA is used in conjunction with other chemicals, such as glyphosate which is found in roundup, it actually causes the toxic effects of the chemical to multiply. POEA is a byproduct of animal fat, and the role it plays in herbicides is that it uses its surfactant properties to help chemicals penetrate the plant more efficiently. So whichever chemical is used in conjunction with POEA will be able to penetrate cells more, making it more toxic (23).

There is also no scientific basis say that a cow that eats GMO crops becomes a GMO cow. Anyone with a basic understanding of biology knows that the DNA of the food is destroyed during the digestive process and is broken down into it monomeric components. The body will then utilize whatever monomers are produced to create energy. There aren’t any enzymatic byproducts due to eating GMO food because the DNA is destroyed before any of it can be translated into protein. GMO DNA is not being absorbed into cells and causing all sorts of mutations. The nucleotides are being broken down and then used to synthesize whatever the cells happens to need at that time. Therefore, there is no basis for calling the butter GMO because the cows are fed GMO grains.

The type of logic that Vani Hari uses is frightening, because it sounds completely reasonable to the average person. She’s gained so much popularity that she recently published her first book, titled “The Food Babe Way” which has landed itself on the New York Times bestseller list. It’s a frightening thought that people are willing to seek advice from someone who has no qualifications to be speaking about GMOs and herbicides. Ignorance about GMOs has been spreading like wildfire, and the Vani Hari’s of the world are responsible for the damaging the reputation of a technology that, if given the chance, can offer help to so many.

Why GMO Technology Has Not Lived Up to its promises (LS)
Many anti-GMO activists say that there is no reason to genetically modify crops because despite the technology being around for a while, it has not lived up to the promises many scientists claimed. Some of these promises include ending world hunger, making the food healthier, and making a strain of more resistant crops (27). The thing that many people fail to realize is that all this technology is available, and the reason it’s not being further implemented is because there is such a strong pushback against GMOs. Ironically, the people who are arguing that GMOs have not lived up to their promises are the very same individuals who are inhibiting its progress.

**DroughtGuard (LS)**

Drought resistant corn is a real thing, and it has a promising future as a weather resistant crop that will prevent mass starvation in areas of the world that don’t get enough rainfall for regular corn. Since 2006, Monsanto has been studying climate change and in this time frame have produced one corn crop, DroughtGuard, which is promising to farmers who have farms in regions with dry seasons. This crop doesn’t come with any corresponding pesticide, but relies solely on its genetic modification for survival. In this case the GM is the insertion of bacterial DNA into the corn’s genome. Although the risks to the consumer from DroughtGuard pale in comparison to Roundup Ready crops, Monsanto has been so vilified at this point, that the pushback from consumers will likely prevent this crop from making its way into American agriculture (5). Even if the consumers are justified to not trust Monsanto, they are now blind to any positive GM technology breakthroughs, and thus a cycle begins. A company is not going to work on GM products if they receive too much pushback from the consumer, simply due to its lack of profitability. Therefore, no real problems will be solved until people become more accepting of genetic engineering which will require individuals to become more familiar with the foundations of the technology and basic biological processes.

**Golden Rice (LS)**

Golden rice has lived up to its promises as a more nutritious grain that produces Vitamin A, which is not naturally found in white rice. Vitamin A deficiency is a problem that plagues many developing countries, and to combat this problem the gene that produces beta-carotene in carrots has been put into white rice. This give those individuals that have limited access to vitamin rich foods the ability to satisfy their Vitamin A requirements which, if not met, can cause blindness and also increases the individual’s chance of catching infectious diseases such as pneumonia and the measles (28).

The rice has been around since 2000, and has the potential to solve this problem, yet it has not taken off. Rather than being marketed to farmers by big agriculture companies for monetary gain, golden rice is actually being produced by International Rice Research Institute, a non-profit company. IRRI’s goal is to provide the crop to areas that mainly rely on rice for their food source, which makes it hard to get all the essential nutrients due to the lack of dietary variety. Golden rice is a perfect example of a GMO that is not financially motivated, but genuinely a product meant to improve the quality of life for many. Despite IRRI’s good intentions, fields growing golden rice in the Philippines were trespassed by local activists that uprooted and destroyed the plants (29).

The issue of the lack of acceptance due to the spread of misinformation is reaching far beyond herbicide resistant corn. It’s preventing those who really need the genetically beneficial crops from accessing them, and it is discouraging scientists who are genuinely trying their best to put
an end to serious problems such as malnutrition. Many people can benefit from GMOs and when the choice to implement this technology is taken away by a handful of the population, everyone loses. The individuals who are overly concerned with the health effects of eating GMOs don’t take into account others who don’t have the option of eating a well balanced diet due to socioeconomic issues along with ecological constraints. Children are suffering from vitamin deficiencies or go through the pain of starvation when the technology to save them is already in existence. Where is the justice for them? How are these anti-gmo parents any better than Monsanto for protesting, and thus denying children access to nutritious food? Since 2002 in India alone, the delaying of bringing golden rice to market has cost “1,424,000 life years,” and the people who should be held accountable are the same individuals who think that they are doing a great service to the world. What the issue boils down to is that the problem isn’t a matter of GMOs not living up to their promise, but activists preventing the technology to be used for its purpose (30).

Community Action: Analyzing The Public’s Ability to Differentiate Between A GMO Product vs Seeds That Are Treated But Not Genetically Modified

Getting the Public Onboard with GMO Technology (LS)
To better serve the public, we need to inform people about the benefits that GMOs offer, while also helping correct the misinformation spread about modified foods. If we can inform individuals about the truths of GMOs, we will stop the spread of misinformation to the public who, being properly informed, can educate others. This will allow for a healthy debate between the proponents and opponents of GMOs, while also helping those who don’t have a strong grasp of GMOs to better understand them. The best way to accomplish this is to: 1) investigate the companies that are leaders in the GMO production and sales, 2) identify the different GMOs on the market, 3) determine why the products are not trusted by GMO skeptics, and 4) refute the GMO opposing opinions with scientific studies and fact.

GMO Crops Available Commercially to Consumers (VP)
Below is a list of the current most popular genetically modified crops, the function and type of the modification induced, and the biotechnology companies that develop, as well as market, these crops. As seen in the chart below, the most popular GM crops are the crops that are most grown in the US. Also seen is that multiple different biotechnology companies often develop their own versions of the same GM crop. Practically all of these crops have been criticized at one point or another for various reasons by opponents of GMOs, most of which hold no scientific background or credibility. In particular, The Internet is an easy place to spread misinformation, and so it is full of false claims on GMOs.

<table>
<thead>
<tr>
<th>Product</th>
<th>Function(s)</th>
<th>Modification</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>Herbicide resistant, Insecticide production, Drought tolerance, facilitated ethanol production</td>
<td>Genes added via microparticle bombardment of plant cells and Agrobacterium-mediated plant transformation</td>
<td>Monsanto, Bayer CropScience, Syngenta, Pioneer Hi-Bred, Dow agroscience</td>
</tr>
<tr>
<td>Crop</td>
<td>Trait</td>
<td>Genetic Modification Method</td>
<td>Company/Institution</td>
</tr>
<tr>
<td>----------</td>
<td>-------------------------------</td>
<td>---------------------------------------------------------------------------------</td>
<td>--------------------------------------------</td>
</tr>
<tr>
<td>Cotton</td>
<td>Insecticide production, Herbicide resistant</td>
<td>Genes added via Agrobacterium-mediated gene transfer</td>
<td>Monsanto, Dow agrosciences, Bayer CropScience</td>
</tr>
<tr>
<td>Rapeseed</td>
<td>Faster Growth, Herbicide resistant</td>
<td>Genes added via Agrobacterium-mediated gene transfer</td>
<td>Monsanto, Bayer CropScience</td>
</tr>
<tr>
<td>Papaya</td>
<td>Resistant to papaya ringspot virus</td>
<td>Genes added via microparticle bombardment of plant cells</td>
<td>University of Hawaii</td>
</tr>
<tr>
<td>Sugar Beet</td>
<td>Herbicide resistant</td>
<td>Gene added via Agrobacterium-mediated gene transfer</td>
<td>Monsanto</td>
</tr>
<tr>
<td>Tomato</td>
<td>Longer Shelf life, Stress tolerance, pest resistance, improved nutrition &amp; taste</td>
<td>Suppression of polygalacturonase enzyme (softening)</td>
<td>Monsanto, Agritope</td>
</tr>
<tr>
<td>Soybean</td>
<td>Herbicide Resistant, Insecticide production, Less saturated fat production, More unsaturated fat production</td>
<td>Genes added via microparticle bombardment of plant cells and Agrobacterium-mediated plant transformation. Gene knockout via agrobacterium-mediated gene transfer</td>
<td>Monsanto, Dow agrosciences, Bayer CropScinace, Pioneer Hi-Bred, BASF Plant Science</td>
</tr>
<tr>
<td>Wheat</td>
<td>Herbicide resistant</td>
<td>Gene added via Agrobacterium-mediated gene transfer</td>
<td>Monsanto</td>
</tr>
</tbody>
</table>

The Internet (LS)
Getting public support for GMOs is the biggest challenge facing the technology. There are many people out there who are misled about the facts surrounding genetic modification. A lot of this misinformation is being spread on the Internet through various blogs and websites. On the Internet anyone can have a blog to share their opinions with the world. The problem lies, however, when people confuse opinions for facts. Having an objective opinion on a fashion blog is reasonable. Facts cannot be brought into the equations because taste in clothing is a matter of opinion. However, when someone creates a blog and gives their opinion on GMOs it creates a dangerous environment where the lines between opinions and facts are blurred.

When it comes to topics involving science, opinions are second to facts. Facts are what are tangible and observable in the natural world. There isn’t room for debate when a fact is founded. One can form an opinion on how they believe GMOs are harmful to the environment, but if research disproves this, then the facts need to be put in front of personal opinions. Say an individual has the credentials, has read the literature, and performed the experiments regarding GMO safety. These individuals have the basis to formulate an opinion on whether GMOs are safe for the public. On the other hand, a blogger who has no credentials, and therefore cannot read the literature intelligently, should not be giving their own opinions on the safety of GMO technology. They can certainly have opinions, but if they are going against scientific facts, then they have no credibility.

The problem is that there are many bloggers online who may not have the scientific background
or desire to objectively study the issue in detail to form opinions, yet they do anyway. Often, these opinions go against all scientific fact that has been established. This is especially true of GMO technology. These bloggers have thousands of followers. The followers will parrot whatever they read on these blogs to others, and then the blog gains new followers. Here lies the cycle of the spreading misinformation. The only way to put out this wildfire is to first establish what misinformation is being spread. Once we establish what the biggest misconceptions are, we can move forward to educate the public.

We have searched the Internet’s most popular blogs in order to determine the major internet arguments against GMOs. We have examined the public “backlash” against a few select GMO products. These products we included were 1) roundup ready crops 2) BT crops 3) Golden Rice and 4) Arctic Apple. We surveyed four popular GMOs, through various articles, blogs and social media accounts and out of 100 comments these are the most commonly held beliefs about the following GMO products:

<table>
<thead>
<tr>
<th>Popular Comments found in Social Media about the Arctic Apple, Golden Rice, Bt Crops, and Roundup Ready Crops.</th>
<th>Arctic Apple</th>
<th>Golden Rice</th>
<th>BT Crops</th>
<th>Roundup Ready Crops</th>
</tr>
</thead>
<tbody>
<tr>
<td>GMOS cause allergies</td>
<td>15</td>
<td>12,16</td>
<td>1</td>
<td>1,3</td>
</tr>
<tr>
<td>GMOS cause cancer</td>
<td>15</td>
<td>1</td>
<td>8</td>
<td>1,8</td>
</tr>
<tr>
<td>GMOS cause birth defects</td>
<td>19</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GMOS have not been tested thoroughly</td>
<td>2,19,19</td>
<td>17</td>
<td>16,16,16</td>
<td></td>
</tr>
<tr>
<td>GMOS are less nutritious than conventional food</td>
<td>2</td>
<td>9</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>
GMOs have unintended environmental hazards

Biotech companies put profits over public health

GMO research is biased and the data is altered

GMOs are cross contaminating natural crops, ruining biodiversity

GMOs are not helping to end starvation

Overuse of pesticides are causing pesticide resistance

GMOs cause higher use of pesticides

GMOs are harmful to humans (Not Specified)

Gene Modification is Not Specific, Precise, or Predictable

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 Sources

<table>
<thead>
<tr>
<th>Blog</th>
<th>Website</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><a href="http://gmo-awareness.com/all-about-gmos/gmo-risks/">http://gmo-awareness.com/all-about-gmos/gmo-risks/</a></td>
</tr>
<tr>
<td>2</td>
<td><a href="https://www.organicconsumers.org/essays/frankenapple-bad-news-no-matter-how-you-slice-it">https://www.organicconsumers.org/essays/frankenapple-bad-news-no-matter-how-you-slice-it</a></td>
</tr>
<tr>
<td>3</td>
<td><a href="http://foodbabe.com/2015/02/26/difference-between-organic-non-gmo-labels/#more-20384">http://foodbabe.com/2015/02/26/difference-between-organic-non-gmo-labels/#more-20384</a></td>
</tr>
<tr>
<td>4</td>
<td><a href="http://foodbabe.com/2014/01/20/is-butter-secretly-ruining-your-health/">http://foodbabe.com/2014/01/20/is-butter-secretly-ruining-your-health/</a></td>
</tr>
<tr>
<td>5</td>
<td><a href="http://foodbabe.com/2013/09/19/100-all-natural-products-can-be-chock-full-of-gmos/">http://foodbabe.com/2013/09/19/100-all-natural-products-can-be-chock-full-of-gmos/</a></td>
</tr>
<tr>
<td>6</td>
<td><a href="https://www.facebook.com/organicconsumers">https://www.facebook.com/organicconsumers</a></td>
</tr>
<tr>
<td>7</td>
<td><a href="https://attempter.wordpress.com/2015/02/17/by-their-own-standard-credentialist-pro-gmo-activists-are-ignorant-yahoos/">https://attempter.wordpress.com/2015/02/17/by-their-own-standard-credentialist-pro-gmo-activists-are-ignorant-yahoos/</a></td>
</tr>
<tr>
<td>8</td>
<td><a href="http://www.non-gmoreport.com/whatisnon-gmo.php">http://www.non-gmoreport.com/whatisnon-gmo.php</a></td>
</tr>
<tr>
<td>9</td>
<td><a href="http://www.foodrenegade.com/gmo-golden-rice-panacea-or-hoax/">http://www.foodrenegade.com/gmo-golden-rice-panacea-or-hoax/</a></td>
</tr>
<tr>
<td>13</td>
<td><a href="http://www.realfarmacy.com/monsanto-scientist-lets-massive-secret-slip/">http://www.realfarmacy.com/monsanto-scientist-lets-massive-secret-slip/</a></td>
</tr>
<tr>
<td>14</td>
<td><a href="http://www.realfarmacy.com/study-organic-honey-found-contain-monsantos-roundup-herbicide-glyphosate-avoid/">http://www.realfarmacy.com/study-organic-honey-found-contain-monsantos-roundup-herbicide-glyphosate-avoid/</a></td>
</tr>
<tr>
<td>16</td>
<td><a href="http://listverse.com/2013/06/22/10-problems-genetically-modified-foods-are-already-causing/">http://listverse.com/2013/06/22/10-problems-genetically-modified-foods-are-already-causing/</a></td>
</tr>
<tr>
<td>19</td>
<td><a href="http://blogs.discovermagazine.com/d-brief/2015/02/18/genetically-modified-non-browning-apples-approved-us/#VSqHAEzC6h">http://blogs.discovermagazine.com/d-brief/2015/02/18/genetically-modified-non-browning-apples-approved-us/#VSqHAEzC6h</a></td>
</tr>
</tbody>
</table>

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Analysis of Data (VP & LS)
The three most common beliefs were: 1) Biotech companies cared more about profit than effects of GMOs on the public; 2) the research regarding GMOs is biased since it is performed by the companies who produce the product, and 3) GMOs are harmful to humans (not specified how).
In response to the data collected, we researched both sides of the argument in order to verify or refute these claims with scientific research and facts. Using the same GMO products as in the above chart, we compiled a list of common arguments and a response to the arguments based on our research.

<table>
<thead>
<tr>
<th>GMO</th>
<th>Argument</th>
<th>True or False</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Golden Rice</td>
<td>GMOs have not lived up to their promises to end world hunger.</td>
<td>False - The technology is ready to help people, but opposition has held back the use and release of the products. Misplaced fears about GMOs are hurting developed and undeveloped countries.</td>
<td>30</td>
</tr>
<tr>
<td>Golden Rice</td>
<td>GMOs have not been tested extensively to know adverse effects. Don't want to risk</td>
<td>Has been tested, when information is presented it is ignored. Risk is a feeling determined more by emotions than by the actual facts presented.</td>
<td>30</td>
</tr>
<tr>
<td>Golden Rice</td>
<td>Biotech companies are using the technology for profit and don't care about the risks it poses to the consumer</td>
<td>False - Golden Rice was handed over to a nonprofit company to prevent profits from getting in the way of saving lives</td>
<td>29</td>
</tr>
<tr>
<td>Golden Rice</td>
<td>We don't know what new DNA or proteins might be produced by inserting new genes. These products can be harmful to humans.</td>
<td>False - Any added DNA and proteins produced by the rice break down in gastric fluids.</td>
<td>29</td>
</tr>
<tr>
<td>Golden Rice</td>
<td>GMO crops can cross pollinate wild type crops, wiping out non GMO species.</td>
<td>Somewhat true - limited because rice is self pollinating.</td>
<td>29</td>
</tr>
<tr>
<td>Golden Rice</td>
<td>Doesn't deliver enough vitamin A to be nutritious enough</td>
<td>False - After much research and development, the more recently produced rice has been shown to give effective amounts of vitamin A. 100-150 grams of it provides 60% of the daily requirement of Vitamin A in children.</td>
<td>29/31</td>
</tr>
<tr>
<td>Roundup Ready Crops</td>
<td>RR Crops are risky to the environment</td>
<td>False - The pesticides used on the crops are risky to the environment, there is no evidence of the genetic modification causing harm to humans or the environment.</td>
<td>35</td>
</tr>
<tr>
<td>Roundup Ready Crops</td>
<td>You can't control where the gene is being inserted, and therefore the product could have unintended products</td>
<td>False - GM is actually safer than conventional breeding because you know exactly where the gene is being inserted, rather than having random genes from other species cross pollinate where the genes could appear anywhere in the genome</td>
<td>36</td>
</tr>
<tr>
<td>Roundup Ready Crops</td>
<td>The overuse of these pesticides and insecticides are causing weeds and pests to become immune to these products.</td>
<td>False - The resistance may be showing up, but it doesn't mean that the pesticides being developed have to be more toxic, it just means there needs to be a new formula developed, which will still have to meet EPA standards. The key to preventing resistance is using a &quot;cocktail&quot; of herbicides in the same way that someone with AIDS would take a cocktail of a medications to fight the disease</td>
<td>38</td>
</tr>
<tr>
<td>Roundup Ready Crops</td>
<td>People who eat GMO treated crops develop an array of health issues from allergies, cancer, and fetal development problems</td>
<td>True/false - There is new evidence coming out that the inactive ingredients when combined with glyphosate actually enhance the toxicity of the herbicide. However, the side effects are from the pesticide and not the genetic alteration</td>
<td>24/22</td>
</tr>
<tr>
<td>Roundup Ready Crops</td>
<td>People who were live in areas that areas roundup is sprayed in have higher levels of glyphosate in their bodies, are found to be sick.</td>
<td>Correlation doesn’t not lead to causation. However, evidence does indicated that the inactive ingredients could increase absorption of glyphosate in the body. Glyphosate is a pesticide and is not produced by the genetic modification</td>
<td>39/22</td>
</tr>
<tr>
<td><strong>Arctic Apple</strong></td>
<td>The arctic apple didn't have to be approved for sale in the United States.</td>
<td>False - The company petitioned for the deregulation of the apple, because the company was able to demonstrate the safety of their product to the USDA. The company also voluntarily consulted with the FDA to prove that the apple is not toxin or allergy producing, even though FDA approval is not required for the apple to go to market.</td>
<td>32</td>
</tr>
<tr>
<td><strong>Arctic Apple</strong></td>
<td>The genetic modification of the apple isn't predictable.</td>
<td>False - The non browning apple is the result of downregulating the genes that produce one specific protein, polyphenol oxidase, which is solely responsible for the browning of the apple. If the modification were not predictable, than many of the apples would still be browning.</td>
<td>33</td>
</tr>
<tr>
<td><strong>Arctic Apple</strong></td>
<td>The arctic apple can cross pollinate with other non-GMO apples and ruin diversity of the crops.</td>
<td>False - Apple trees don’t cross pollinate on their own. Bees need to carry pollen to the stigma in order for the plants to reproduce. The chances of the bees traveling from one orchard to another are unlikely. They tend to stay in one orchard.</td>
<td>34</td>
</tr>
<tr>
<td><strong>Arctic Apple</strong></td>
<td>The arctic apple has not gone through rigorous enough testing to know the health effects on consumers.</td>
<td>False - The arctic apple has been in development since 1997 and is one of the most well tested biotechnology foods on the market.</td>
<td>35</td>
</tr>
<tr>
<td><strong>Bt Crops</strong></td>
<td>Bt crops kill monarch butterflies, honey bees, rats, and show up in the blood of pregnant women</td>
<td>False - The studies that make these claims have been scientifically refuted due to the validity and soundness of the experiments being disproved.</td>
<td>36</td>
</tr>
<tr>
<td><strong>Bt Crops</strong></td>
<td>Bt crops do not reduce the amount of pesticides used on crops</td>
<td>False - The EPA has concluded that there is a significant reduction in the amount of pesticides being applied to Bt crops when compared to conventional crops.</td>
<td>37</td>
</tr>
<tr>
<td><strong>Bt Crops</strong></td>
<td>The bt toxin found in Bt crops can be harmful to humans, and therefore Bt crops are harmful to humans</td>
<td>False - The EPA has concluded that there is no increased risk in consuming Bt crops, as the bt toxin found in Bt crops are the same as those sprayed onto conventional crops.</td>
<td>38</td>
</tr>
<tr>
<td><strong>Bt Crops</strong></td>
<td>Bt crops can cause allergies in individuals</td>
<td>True/False - Theoretically, it can, but is known not to since the bt toxin is still used as a conventional pesticide on natural crops. Multiple studies have concluded that there are no additional allergenic risks to Bt crops.</td>
<td>38/39/40</td>
</tr>
<tr>
<td><strong>Bt Crops</strong></td>
<td>Bt crops reduce biodiversity</td>
<td>False - Gene flow, which is also found in nature, by Bt crops has been labeled as an extremely rare event by the EPA, and there are no reductions in the number of non-target insects.</td>
<td>38/41</td>
</tr>
</tbody>
</table>

**Discussion (LS)**

What’s interesting about the data we collected is that the public is more concerned about the aspects of GMOs that have been proven to be false, then the actual issues that pose a possible threat. This shows just how little people understand science and scientific literature. Our results show that most of the concerns about GMOs are based on emotions rather than logic. Our hope is that our research on GMOs will reach people who don’t have a strong bias one way or another. The first step to getting the majority of people on board is to reach the individuals that take a middle ground stance on the issue. Once public opinion leans towards scientific reasoning and not emotional reasoning, then other people who might have a more opposing view may decide to reevaluate their own beliefs. Since GMOs are such a heavily divided issue, it is hard to get the mainstream opinion on board with the technology.

Once mainstream opinion is in favor of GMOs others will follow suit. It’s a domino effect that is set into motion by getting enough scientific literature out there to educate the public, but the...
scientific literature needs to be simple enough so the average person can understand it. That is why the anti GMO movement has been so successful. They take stuff that seems complicated and simplify it for the average person, although they usually are incorrect about a lot of their “science” used. The fact remains that their way of reaching out to people works because it doesn’t come off as pretentious. They make it inclusive so everyone can understand. That is the whole point of writing this paper. We are simplifying the science behind GMOs so people to make it easier for people to understand the science behind GMOs, and why this technology isn’t evil. If we are able to get our message out, then we will have set our plan into action, informing the public one reader at a time.

**Take-Home Message (JF, VP, LS)**
We prepared the following statements to post on various anti-GMO social media outlets in hopes of clearing up the stigma attached to GMO crops:

I. Genetically Modified Organisms (GMOs) are one of the products of modern science that has vastly expanded over the years, and continue to improve. Overall it seems that GM crops have a bad reputation among the general public. A lot of this “dislike” for GMOs stems from a lack of understanding of what a GMO really is, and overall confusion on GMOs. GMOs are proven to be as safe as conventionally-grown crops. The real problem is the pesticide use on GMO crops which have been linked to health and environmental issues. We should not dismiss the good that GMO technology can provide in the future because of the ethically-gray use of GMOs by companies like Monsanto. If you want to learn more about genetically modified crops, check out our video https://youtu.be/MdlaG6UFvS8

We posted the above to the Facebook page of the following organizations:
- Food Babe
- Organic Consumers Association
- GMO Free USA
- March Against Monsanto
- GMO Awareness

We also posted on the Facebook pages of the products (below) from the Hanes Celestial group, a strong company specializing in “good for you” products, that, in their advertising campaigns, taut that their products are GMO-free.

“The fact that the corn chips and corn meal containing food products manufactured by run of the mill companies originates from row corn seeds that have been pretreated with the class of insecticides called neonicotinoids (thought to be responsible for killing off bees; a main pollinators of our food crops), it is no wonder why someone in the know would purchase your products over theirs.

Just saying though, what’s not important or really relevant is that you taut that your products are GMO-free. The questionable/irresponsible agricultural practices revolve around the TREATMENT of seed crops with harmful chemicals, and are distinguishable/different from and not a result of genetic engineering. There is nothing despicable about GMOs like golden rice; rice that has been genetically engineered to contain high levels of Vitamin A, that when
consumed in areas of the world where Vitamin A deficiency is prevalent, it can both improve the quality of life and feed the planet. So one should not demonize GMOs, and instead, stop the over application/chemical treatment of our land that produces the food that feeds us.

The fact that Monsanto overstepped its boundaries by genetically engineering plant seed to withstand the pesticide glyphosate (Roundup) (which is not produced by the genetic modification) so that farmers could douse their fields with Roundup (that they manufacture and has recently been shown to negatively impact human health) in an effort to control noxious weeds that may not even pose a problem to that particular crop.

So the real problem is the pesticide use on GMO crops which have been linked to health and environmental issues. We should not dismiss the good that GMO technology can provide in the future because of the ethically-gray use of GMOs by companies like Monsanto."

Below is copied from their website http://ir.hain-celestial.com/phoenix.zhtml?c=87078&p=irol-newsArticle&ID=2011260

“The Hain Celestial Group offers many wholesome snacking alternatives that are sure to lead to a touchdown of taste and flavor during The Big Game:

- **Garden of Eatin'®**: The #1 natural and organic corn tortilla chip brand made with organic corn and other non-GMO ingredients. Show your support for either Seattle or New England by filling your bowl with our Blue Corn Tortilla Chips. Popular varieties include Garden of Eatin'® Blue Corn Tortilla Chips, Garden of Eatin'® Red Hot Blue Corn Tortilla Chips and Garden of Eatin'® Sweet Potato Corn Tortilla Chips. For more information, visit [www.facebook.com/GardenOfEatin](http://www.facebook.com/GardenOfEatin).
- **Sensible Portions®**: A leading natural snack brand delivering a wholesome snacking experience through its Garden Veggie Straws® and Sensible Portions® Pita Bites®. For more information, visit [www.facebook.com/SensiblePortions](http://www.facebook.com/SensiblePortions).
- **TERRA®**: Real Vegetable Chips that combine the beautiful colors and delicious flavors of the earth's vegetables into a perfect crunchy snack. For more information visit [www.facebook.com/TerraChips](http://www.facebook.com/TerraChips).
- **Bearitos®**: A leading natural foods brand offering a wide variety of non-GMO snacks, sauces, refried beans and taco shells. For more information on the brand's product offerings or conservation efforts, visit [www.Bearitos.com](http://www.Bearitos.com).
- **Rudi's Organic Bakery®**: Organic Soft Pretzels have everything you want in a quick bite. These dippable twists come in two varieties with no artificial flavors, colors, or preservatives, no GMO ingredients, and no high-fructose corn syrup. For more information, visit [www.RudisBakery.com/Organic/](http://www.RudisBakery.com/Organic/).”

The posting below was sent to the on-line publications shown in the links below this posting that discussed Chipotle’s Apr 27 2015 announcement that they were the first national restaurant chain going GMO-free

What has come of modern agriculture? Worrisome trends…
The fact that most of the corn chips and corn meal containing food products purchased in grocery stores originates from row corn seeds that have been pretreated with the class of insecticides called neonicotinoids (thought to be responsible for killing off bees; a main pollinators of our food crops), is majorly bothersome.

The fact that Monsanto overstepped its boundaries by genetically engineering plant seed to withstand the pesticide glycophosphate (Roundup) (which is not produced by the genetic modification) so that farmers could douse their fields with Roundup (that they manufacture and has recently been shown to negatively impact human health) in an effort to control noxious weeds that may not even pose a problem to that particular crop, is “ethically-gray”.

The above questionable, perhaps irresponsible practices revolve around the treatment of seed crops with harmful chemicals, but are distinguishable from and not a result of genetic engineering. These treatments are completely different from genetically modified crops. There is nothing despicable about GMOs like golden rice; rice that has been genetically engineered to contain high levels of Vitamin A, that when consumed in areas of the world where Vitamin A deficiency is prevalent, it can both improve the quality of life and feed the planet. So one should not demonize GMOs, and instead, stop the over application/chemical treatment of our land that produces the food that feeds us.

The real problem is the pesticide use on GMO crops which have been linked to health and environmental issues. We should not dismiss the good that GMO technology can provide in the future because of the ethically-gray use of GMOs by companies like Monsanto.”


USA Today  http://www.usatoday.com/story/opinion/2015/05/04/chipotle-gmos-restaurants-your-say/26900555/

Chipotle’s Facebook page https://www.facebook.com/chipotle/posts/10150599437289253


We also sent the above posting to the sites below but because of their exclusivity, they did not allow our posting to their site.

Our messages should reach out to those that are GMO-free proponents. We expect that most readers will outright reject our message just because it is not of their strong (perhaps lopsided/uninformed) opinion. Hopefully though, our message will strike a chord with some of the readers and enable them to differentiate the rhetoric about GMOs from scientific fact.

References


Philippine case study. Food Policy, 29(2), 147-168.


Letters to the Editor:

March 19, 2015
Courier News
92 E Main St #202
Somerville, NJ

To the Editor:

Over the last decade there have been many advances in the field of biology, which continue to improve the quality of life in our country. It’s hard to deny the benefits of modern medicine such as
surgery, pharmaceuticals, prosthetics, etc. All of these improvements go against the natural order of things. Opening up a person to remove and replace a kidney, or putting chemicals in peoples bodies to fix a genetic disease all are not natural processes. They work against the natural order of our world, which is survival of the fittest. Regardless of that they are still widely accepted in our society because of the ability to save people’s lives or heighten the quality of life. So why when we insert a gene into our food to make improvement does everyone feel like a line is being crossed?

There is a huge breakdown between the ability to discriminate GMO technology with the use of pesticides. In the paper that I co-authored, we distinguish the difference between GMO technologies with pesticide use. These are two completely different and unrelated processes. GMO’s have not shown evidence of harm to the humans who consume them. Pesticides on the other hand, have been linked to a variety of human health issues. Sometimes the GMO and pesticides are used together, and this is where things become gray for most people. They assume that because they were consuming GMO foods that the GMO’s are responsible for their deteriorating health, when all it simply comes down to is they are ingesting chemical that are toxic to their bodies.

Genetic modification, to me, is just another technological step in the ever-growing advancement of our species. GMO’s appears to have gained more negative criticism then positive approval, but its biggest critics are often individuals with little scientific education. It is my mission, not to change people’s minds with emotional persuasion, but to simply present the facts about GMOs and pesticides. I leave it up to the reader to draw their own conclusions, but at least they can now do this objectively with all the facts in hand.

We have collected data about public perception of GMO’s and categorized them as true or false. If this is of interest to you then please contact me.

Sincerely,
Lori Sepkowski

Sent to “The Daily Record”

Dear Editor,

Please consider publishing the letter below to The Daily Record. I am writing to spread knowledge on how genetically modified crops offers a variety of benefits, and are as safe to consume as traditional organic crops. If you have any questions, comments, or concerns, please do not hesitate to contact me.

It is no secret that GMOs (genetically modified organisms) tend to receive a bad reputation from the general public. This is especially true for genetically modified (GM) crops, despite the considerable benefits that they may provide. Then why are so many people so against genetically modified crops, despite the fact that they have been proven to be as safe as traditional organic foods? The answer to question that can be summarized in one word: fear. GM crops suffer from the fear factor that exists with every emerging scientific product, which is caused by a lack of understanding and overall confusion on the product. This in turn causes people to reject these advances in science. This fear also stems from the mistrust that the public has for the entities
that produce and distribute GM crops. Big agro-chemical companies solely concerned with profit, such as Monsanto, are one of many companies who cause the public to mistrust GMO technology. This mistrust leads to a large number of people to rejecting GM crops, regardless of the scientific evidence out there that defines GMOs as safe as organic foods. Furthermore, false information that is spread by people with no credentials further support the anti-GMO movement.

The lack of understanding has caused GM crops to be lumped with seed treatments. These are two completely different processes, in that seed treatments are known to be harmful. Therefore, pesticides are what people should really worry about consuming, not GMOs. When debating on GMOs, it is imperative that people understand the difference between seed treatments and GM crops. With the help of Dr. Fagan, an associate professor of animal science at Rutgers University, a partner of mine and I intend to analyze this issue in hopes of changing the opinions that some of the public has for GM crops.

We have collected the negative claims about some of the popular GM crops from a number of articles, blogs, and forums. We have organized these claims as data and have labeled them as either true or false with an explanation. We hope to open the eyes of people that have been guided by misinformation by telling the truth, the whole truth, and nothing but the truth behind GM crops. Our intent is to spread knowledge about the issue at hand, so that people can formulate their opinions, ideas, and arguments based on the facts, not on the false claims that have tainted the reputation of GM crops.

Sincerely,

Victor Paulino