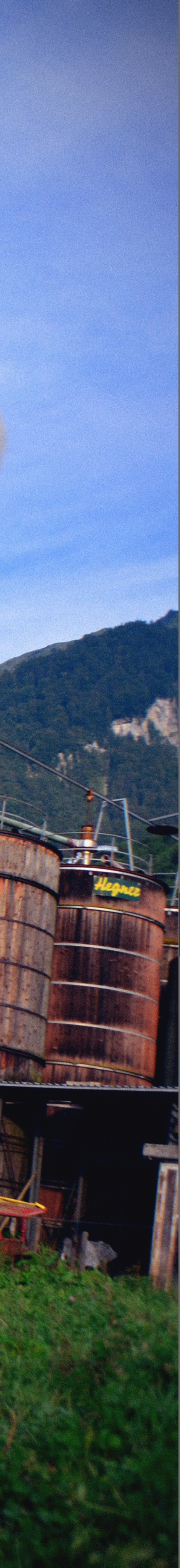

DISCUSSIONS

Undergraduate Research Journal of CWRU

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Photo Courtesy of United Soybean Board

Photo Courtesy of Geraint Rowland

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Letter from the Editor

Dear readers,

Since 2006, Discussions has celebrated and promoted undergraduate research at Case Western Reserve University and other universities all over the world. As a continuance of our tradition and mission, it is my pleasure to introduce to you a special issue of Discussions.

For the first time, Discussions has turned its sights away from general submissions and toward a specific research niche – American environmental concerns – thanks to a partnership with Mary Holmes' SAGES capstone course offered at CWRU. Her students spent the spring semester researching environmentally-conscious topics, and submitted their research papers to Discussions. Though not all of the papers made it through our rigorous peer-review process, the class' work matched up to the outstanding quality expected from our publication.

This special issue is the first one to be published in the summer, but if you would like to see your research published in Discussions, our next submission deadline, reopened to general submissions, is September 26, 2014. Visit our website at case.edu/discussions or our Facebook page for submission guidelines and more details. Feel free to contact us on our website with any questions.

As we continue to grow in size and prestige, I encourage anyone interested in research or the publication process to find ways to get involved with our publication. We accept submissions from around the world and distribute around the country, now to five top universities; our group's size has grown exponentially; and our submissions have tripled in the past two years. As our organization's success increases, we look to new, top students to continue our success. Reach out to me personally at jmb345@case.edu or email askdiscussions@case.edu to learn how to get involved.

For our first-ever summer publication, we will be without a few stalwart members of the editorial board. Vik Bhatnagar, who was integral in our journal's return to prominence during his time at CWRU, graduated this past spring. We will also be without key contributors Jeniece Montellano, Robert Minkebige, Kelly Peterson, Joseph Lin, and Katie Rose. I dearly thank them for all of their hard work, and their innumerable contributions will surely be missed. I would also like to thank Sheila Pedigo and the entire SOURCE office for their continued support.

Thank you for taking the time to read our journal, and I hope you enjoy the fantastic articles within.

Sincerely,

Jack Behrend

Jack Behrend
Editor-in-Chief, Discussions Research Journal

Faculty Spotlight

An Interview with MARY HOLMES

Conducted by Emily Malec

Photo Courtesy ofMary Holmes

INTRODUCTION

When Mary Holmes came to Cleveland in 1990 and discovered that there were few options to buy local foods, she started a mission to make buying fresh product from local farmers possible. That mission resulted in the creation of a Farmer's Market and grew into a more widespread effort to educate the community about the benefits of local and fresh foods. Professor Holmes has since produced a report about the economic and social benefits of local foods, contributed to *Edible Cleveland* and *The Plain Dealer*, and supported The Innovative Farmers of Ohio as president. In 2006, she started a SAGES course at Case Western Reserve University called "The Future of Food," which focuses on the political, economic, and public drivers that have influenced the evolution of the industrial food model.

1. What initially made you so interested in food, particularly fresh and local foods?

My mother was raised on a farm in Michigan and so I was very much in tune with seasonal foods. There was no fast food when I was growing up, and I was finding it more and more difficult to find the fresh food that I grew up eating. That's what led me to start the Farmer's Market in Shaker Square, where the biggest challenge was finding farmers. All of them were just growing soybeans! We knew there was a demand for local, fresh food when people came rushing into the market and everything was gone by 10 a.m.

2. What would you like to see CWRU do to promote the production and consumption of local, sustainable food?

I would like to bring together the group of teachers on campus who teach food-related courses in order to elevate the topic a bit more. I think food is one of those topics that are so important and so ubiquitous, yet so unseen. I would like to see Bon Appetite continue to look for local sources and help students understand what that means and why it's important. I think CWRU can distinguish itself through its use of local foods and its education of students about local food sources because, especially for undergraduates, this is very much a growing issue.

3. How would you like to see Cleveland support the movement toward local food?

I would love to see Cleveland consumers promote more educational programs about the benefits of eating healthy, whether it be through buying fresh vegetables and supporting local farmers or by cutting industrial meat out of their diet. The meat industry is a major issue on every level, from ethics to health to antibiotic resistance. There is nothing good to say about it except that it's cheap. When people say to me, "I can't afford to eat good food," I tell them to listen to what they're saying! We get this sense that all food is the same – that an apple grown with pesticides, packed with preservatives, and shipped from California is just as healthy as an apple grown locally and without the use of chemicals. This is a very explicit strategy that industrial food companies use in order to get consumers to buy the cheap, industrial produce. When people think "an apple is an apple

> *I would love to see Cleveland consumers promote more educational programs about the benefits of eating healthy*

no matter what," they'll buy whatever is cheapest and the industrial food is cheap. I think that Cleveland should initiate some programs that can teach consumers the reality about the food that they're eating and why cheap food isn't really the best option. If people get the chance to try the healthy and local foods, they will love it, and it will be very hard to go back. The idea of eating well really starts with kids, and research has shown that if children are given the chance to grow plants and fruits in the garden, they are enthusiastic about what they grow and they'll eat it and they'll love it. All Cleveland schools had gardens at one point, and I think that is definitely a good starting point for educating the kids in this field and getting them excited about healthy food.

4. Which organizations on the CWRU campus can students who are interested in this topic become a part of?

A year ago, in spring, a 300-level Italian course that I helped set up with Denise Caterinacci on the Slow Food movement decided to go to Terra Madre, a week-long celebration of local food in Turin. After coming back from that, the group of students who went decided to form a Slow Food chapter on campus. I would really like to see that chapter get some energy behind it. They have already had a few events on campus – one at Mitchell's Ice Cream where Mike Mitchell talked about the local sourcing of his cream and other ingredients – and they've even made a film. I'd like to see them get together and cook more while they talk about these issues because a big part of the movement is the sense of comradery. I would also like to see more people on campus, particularly students, embrace and understand the movement of local and sustainable food. We talk about what we can do to move away from the industrial model, such as going to farmers markets and participating in Community Supported Agriculture (CSA), but I would love to have more students take part in these opportunities instead of just talking about them.

5. What are some misconceptions about local food that you hear and would like to clear up?

I hear all the time that local food is more expensive. We're all on a budget, but people should be thinking in terms of nutritional value per dollar instead of calories per dollar. You can go to the grocery store and buy orange pop and fruity cereal and call it breakfast, but you're not getting nutrition from that meal and for around the same price, you could have eaten a healthy meal. That's a really hard sell: telling people to cut the sugary and cheap food out of their diets, but the satisfaction you feel when you eat right is worth the price. People also say that they don't know where to find local food, which was much more of a problem a few years ago, but now there are farmers markets all around the area, grocery stores that carry local produce, and even restaurants that take pride in serving local food. Good food is more accessible than most people think.

> *People should be thinking in terms of nutritional value per dollar instead of calories per dollar*

6. What are a few key ideas from your SAGES course that you would want everyone to take away from it?

The fundamental idea in the course is understanding the choices we have. Yes, there is public policy that puts us where we are, but ultimately what is changing is the fact that individuals have made a decision to back away from industrial, to criticize industrial. I try to help students see that they are very powerful in the decisions they make. Students can vote on University issues of food, educational issues of food, economic issues of food. I would tell students to share what you know and be curious about what you don't know.

Research

Is the Switch to Organic Soybeans Possible?

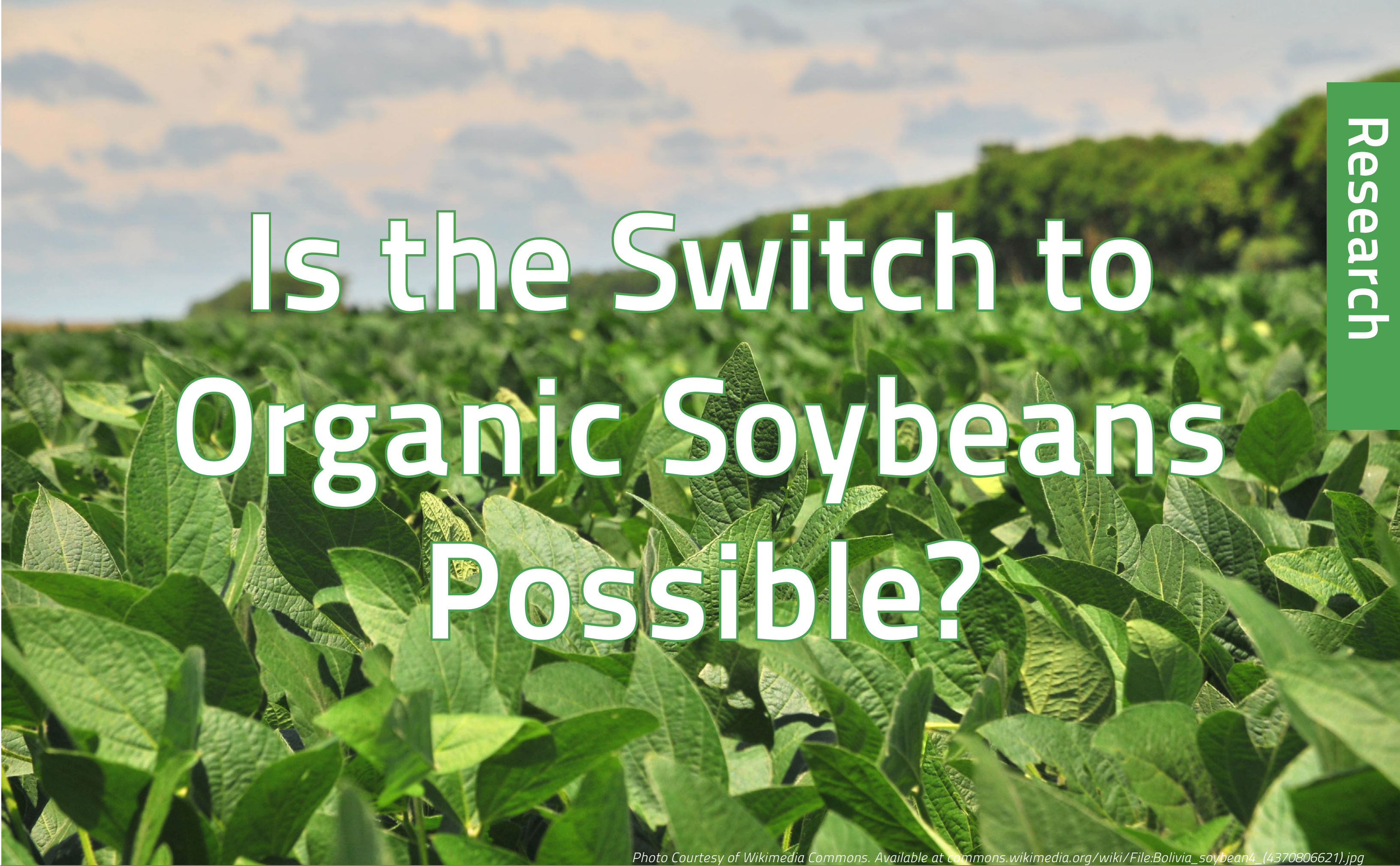

Photo Courtesy of Wikimedia Commons. Available at commons.wikimedia.org/wiki/File:Bolivia_soybean4_(4370806621).jpg

Chris Everett

Soybeans first appeared on the world stage when Chinese farmers began cultivating them around 1100 B.C. (North Carolina Soybean Producers Association, Inc.). The plant quickly spread to the rest of Southeast Asia and became an integral part of the regional diet. In the 1700s, the soybean debuted in Europe, occurring only after the success and subsequent demand for soy sauce. Soybean cultivation in the United States began in the late 1700s, but it wasn't until the late 1800s that soybeans were planted on a large scale and, even then, they were usually used as forage for livestock (North Carolina Soybean Producers Association, Inc). The current inundation of soybeans within the industrial food system can be traced back to the growth of the military industrial complex, which was facilitated by World War II. With the war came an increased demand for lubricants, plastics, and other oil-derived products. Soybeans had traditionally been imported from other countries, but the steep demand within the United States necessitated domestic growth. Currently, the United States grows more than one-third of the world's soybeans, which have become "… products of very large agribusiness operations." (Kimbrell, Fatal Harvest pg. 134).

In 2013 the United States Department of Agriculture (USDA) estimated that 76.5 million acres of soybeans were planted in the United States and, of that acreage, 93% was genetically modified to make the plant herbicide tolerant and/or insect resistant (Fernandez-Cornejo). Monsanto introduced herbicide tolerant soybeans in 1996 with the creation of Roundup Ready soybeans and has since applied similar principles to many other crops such as corn and cotton. Roundup Ready soybeans are resistant to the chemical glyphosate, a herbicide that allows farmers to spray for weeds without hurting their crop yields (Hauter). Following this invention, only 7% of the soybean crop in the United States, or some 5 million acres, are planted with non-genetically modified soybeans. While GMO soybean production did not get its start until 1996, soybeans have long been valued as a source of protein.

In a collection of essays titled, "Give Us This Day," compiled by the New York Times in the early 1970s, soy protein was recognized as a "better" solution to solve the nutritional needs of a growing world population. The industrial food system has since derived many products from soybeans that are now used in an increasingly large number of food applications. Nearly all soybeans produced in the United States are genetically modified organisms (GMOs) and increasing concern over the dangers of GMO soybeans has inflamed the debate over the benefits and consequences of GMO products. Evidence suggests a move away from

GMO soybeans will benefit the environment and the consumer by decreasing the use of chemicals and increasing the nutritional quality of food products. However, current policies and economic conditions such as government subsidies and monetary incentives inhibit a large-scale shift from GMO soybean production to organic soybean production, so focus must be put on small steps that can be taken toward more sustainable agricultural practices .

To better appreciate the importance of soybeans in the industrial food system, it is important to understand the methods of soybean production. Soybean varieties are grouped into 13 maturity groups depending on the climate and latitude for which they are adapted (McWilliams et al.). The large variety of soybean cultivars allows farmers to choose plant types that are better suited for growth in certain geographical regions and climates. Soybean seeds can be planted as early as April or as late as July in the United States. To ensure high crop yields, farmers may plant 6 to 10 different varieties of soybeans each growing season. Indeterminate varieties are often grown at northerly latitudes, where season length is shorter, since these varieties mature faster due the to simultaneous growth of vegetative and reproductive characteristics. In the south, longer growing seasons allow for the cultivation of determinate soybean varieties. Soybeans reach maturity once the pods and seeds have dried and changed in color from green to yellow to brown. Harvesting, usually done with a combine, is appropriate when the moisture content of the seeds is less than fifteen percent (McWilliams et al.). If the seeds are more than fifteen percent water, they must be dried before they can be distributed and processed .

The soybean is one of the most important protein crops in the world due to its high protein content of around thirty percent, the highest of any legume (Pimentel). In addition to their high protein content, the energy output to input ratio of soybeans also makes them a desirable food source. As calculated by David and Marcia Pimentel in *Food, Energy, and Society*, soybeans have one of the highest energy output to input ratios of 3.19 to 1. This calculation takes into account the large variety of energy inputs needed for soybean processing such as herbicides, nitrogen fertilizer, diesel used in transportation, and the energy needed to run the necessary machinery. Thus, it makes sense both from a nutrition and economic perspective to use soybeans as part of the industrial food system.

The rise of soybeans as a source of protein within the industrialized food system parallels the rise of corn as a source of carbohydrates (Pollan, pg. 91). Together, these two crops have dramatically changed the production and distribution of food. Much like corn, every part of the soybean is utilized throughout the production process. Processing enables soybeans to be consumed in the form of whole soybeans, soy protein, soybean oil and soy lecithin. During the first stage of processing, soybeans are cracked to remove the hull. The hulls can be used as animal food or processed into fiber additive that are included in everyday food items such as bread and cereal. Processing the remaining part of the soybeans yields full-fat flakes that are used in a variety of commercial applications (U.S. Soybean Export Council). Next, crude soybean oil is removed from the full-fat flakes with a solvent and further refinement of the oil separates out the lecithin. Lecithin is used in many food items from baked goods to instant foods. Once the oil is extracted, defatted soy flakes remain and are used as protein products in soy flour, soy concentrates, and soy isolates. Soy flour is especially valued for its ability to increase the shelf life of baked goods, soy concentrates are often used in protein drinks and soup bases while soy isolates are used as emulsifiers in dairy products (U.S. Soybean Export Council). Soybeans have become such an integral part of our diet that any dramatic change in soybean production would lead to major shifts in how food is processed and distributed to consumers.

Since their development and implementation, genetically modified organisms (GMOs) have been both lauded for their potential to provide enough food for an ever-increasing population and decried for their negative effects on the environment and their unknown effects on human health. As Pinstrup-Anderon and Ebbe Shiøler claim in "Seeds of Contention," the public debate within the United States often seems one-sided, in favor of non-GMO products. They further argue that the concerns surrounding GMOs in developed countries focus on the consequences of "tampering" with nature. These concerns draw attention away the potential benefits of GMO crops and limit questions about how GMOs can increase crop productivity or improve the quality of food that is consumed (Pinstrup-Anderson, pg. 11). Despite this apparent negative consensus, consumers have taken little action to limit the use of GMOs in the industrial food system. Instead, change is occurring in the form of a popular push for the production of more "organic" food that parallels the increasing prevalence of GMOS. More and more consumers can be found roaming the aisles of "organic" grocery stores like Whole Foods and avoiding GMO products sold in Wal-Mart size supermarkets. However, organic and GMO are not mutually exclusive. The term "organic" is a subjective measure of product quality that is not fully understood by consumers. There are many rules and regulations set for by government agencies and policies guide the production of "certified organic" and GMO products. In light of the increasing prevalence of GMOs, an analysis of the difference between certified organic products and GMO products must occur. This analysis can be accomplished by examining the methods of organic and GMO production in addition to an explanation of the current laws that set standards for organic products.

However, this does not mean that those acres produced USDA certified organic soybeans or that less herbicides or pesticides were used on the soil. These fields may be non-GMO but they are not organic. Often, GMO fields and non-GMO fields of the same crop receive the same treatment in terms of amount of herbicide and pesticide but with different chemicals (Charles). In addition, standard commercial fertilizer is used to keep the soil fertile on both GMO and non-GMO fields. With essentially the same inputs, it can be said that GMO and non-GMO fields are both farmed conventionally. Production in organic fields is vastly different from conventional fields. Natural fertilizers, such as chicken litter, are used on organic fields and crop rotation is implemented as a means to control pests. Weeds must be removed by hand as herbicides are prohibited. Organic farming offers a more environmentally friendly form than conventional farming and should be considered as an alternative to conventional farming.

Fears and concerns over the consequences of the industrial agricultural system have led organic farming to be labeled as "… a crucial alternative to industrial agriculture" by many ecological thinkers (Kimbrell, The Fatal Harvest Reader pg. 279). Individuals have responded to these fears and a growing number of consumers can be found searching grocery store shelves for organic labeled food. However, "organic" does not mean that the resultant food product is completely GMO free. The production of organic crops requires stringent farming practices that are regulated by the USDA and "demonstrat[ion] that they are protecting natural resources, conserving biodiversity, and using only approved substances" (Agricultural Marketing Service). The Organic Foods Production Act (OFPA) of 1990 (Title 21 of P.L. 101-624, the Food, Agriculture, Conservation, and Trade Act of 1990) authorized the National Organic Program (NOP) to be administered by USDA's Agricultural Marketing Service (AMS). The program is operated based on federal regulations that define standard organic farming practices and on a National List of acceptable organic production inputs in order to use the USDA Organic label. These regulations are set forth in the Code of Federal Regulations at 7 C.F.R. Section 205. To be able to use the Certified or USDA Organic labels, the producer must apply to a USDA accredited certifying agent providing a detailed description of the operation and a history of the substances applied to the land during the previous three years. To be labeled as 100% Organic the product must contain by weight 100% organically produced ingredients (7 C.F.R. 205.301(a)). To be labeled as USDA Organic "a raw or processed agricultural product sold, labeled, or represented as "organic" must contain (by weight or fluid volume, excluding water and salt) not less than 95 percent organically produced raw or processed agricultural products" (7 C.F.R. 205.301(b)). The remaining ingredients must "be organically produced, unless not commercially available in organic form, or must be nonagricultural substances or non-organically produced agricultural products produced consistent with the National List" that is provided in subpart G of the regulations (7 C.F.R. 205.301(b)). The regulation also sets forth long lists of both non-organic produced agricultural products; such as casings from intestines, celery powder, chia, and colors, that are allowed as ingredients in processed organic-labeled consumer items (7 C.F.R. 205.606) and non-agriculture/non-organic substances; such as acids, calcium, dairy cultures, egg whites, gum, waxes, and yeast, that are allowed as ingredients in organic products (7 C.F.R. 205.605). Therefore, Certified or USDA Organic labels that require at least 95% of the content is organic by weight are usually GMO free. However, the remaining 5% of the content may not be "organic" and this and other loopholes exist that allow for some conventional food products to be incorporated into organic food (Agricultural marketing Service). In addition, GMOs can become incorporated into organic food products through cross-pollination between GMO and non-GMO crops, trace amounts of GMO in animal feed, or contamination when ingredients from different suppliers are combined .

Many problems stand in the way of a shift from conventional soybean production to organic soybean production. Perhaps the most glaring is the change in production techniques that would need to occur. As mentioned before, organic fields must follow strict USDA guidelines in order to be labeled as certified organic. These guidelines enforce the use of natural fertilizers and prohibit the use of pesticides and herbicides among many other rules. This requires farmers to rotate crops in an effort to control pests and hand pick unwanted weeds. These two requirements alone make a change from conventional food production to large-scale organic production difficult, at best, and possibly infeasible. Crop rotation is an agricultural practice used to maintain the health of soil. For example, organic soybean farmers may cultivate "…soybeans, corn, oats, and alfalfa in successive growing seasons" to insure necessary nutrients are replenished in the soil (Kimbrell, Fatal Harvest, pg. 135). Rotating crops does maintain soil viability over periods of time but decreases the production of lucrative crops such as soybeans, as they cannot be grown on in the same soil every season. Without herbicides, large-scale organic operations must hire laborers to pick weeds by hand increasing the cost of production .

In a detailed study, published by the Economic Research Service on the U.S. Department of Agriculture, researchers collected data on the production costs and returns of conventional and organic soybean operations in the Midwest in 2006. The study found that the total economic cost of conventional soybean production was \$5.87 per bushel while the total economic cost of organic soybean production was \$10.97 per bushel (McBride). Higher fuel prices are the main reason for difference in economic cost as more mechanical systems are need to weed and till organic farms. The study also found that the yield of conventional soybeans was much higher, 47.06 bushels per acre, than that of organic soybeans, 31.04 bushels per acre. Unsurprisingly, the price at which the bushels were sold was dramatically higher for organic soybeans, \$14.64 per bushel, than for conventional soybeans, \$5.48 per bushel. While organic soybeans do sell more on the market and thus may seem more favorable to farmers, higher conventional soybean prices and fuel costs limit the expansion of organic soybean acreage (McBride). Thus, lower yields, higher cost of production, and high fuel prices, currently inhibit a permanent shift to organic soybean production.

In addition, switching from large scale GMO production to large scale organic production may be impossible to implement because of the proliferation of GMO seeds. Currently, ninety-three percent of the soybean crop in the United States is genetically modified. Despite the already high statistic,, the percentage of soybean crops that are genetically modified to be both herbicide-tolerant and pesticide resistant is growing. (Fernandez-Cornejo). This unprecedented percentage allows for little variation in growing techniques and promotes the use of monoculture and other conventional agricultural techniques. High demand for soybeans as animal feed and for industrial food inputs requires large crop yields that could not be supported without the use of GMO soybeans in conjunction with herbicides and pesticides. Furthermore, it is impossible to mediate the natural spread of GMO crops as they proliferate the same ways as non-GMO or organic crops. Pollen carried by wind, rain, and insects can easily travel from a field of GMO soybeans to a nearby field of organic soybeans. This "biological pollution" has caused many organic farms to become contaminated with genetically modified crops. Farmers are often unaware of this cross-pollination and continue to grow crops that may be contaminated. Many small farmers who depend on organic soybeans and other crops as a source of income have had to sell contaminated fields at a lower price, hurting their profits and destabilizing their primary source of income (Lilliston). Controlling the spread of GMO crops becomes increasingly problematic as small farmers in Mexico have reportedly found evidence of genetically modified corn typically grown in the United States spreading to their land (Knudson et. al). While these plants may be unwanted, it is difficult to stop them from spreading and there is often little to no federal or state regulation. Farmers who are not interested in growing GMO crops are often left on their own to deal with contamination that may occur in their fields (Lee et al.). In order to curb the prevalence of GMO soybeans and consider a move to the production of organic soybeans, increased oversight on the state and federal level must work to provide support to farmers who are serious about a maintain the organic integrity of their crops.

While many problems need to be solved before a change to organic soybeans can be considered, there is clear evidence that organic soybeans are not only more environmentally friendly than GMO soybeans, but they have also been shown to be healthier for human consumption. An article published in 2013 by Bøhn et al. analyzed and described the nutrient and element composition of 31 batches of soybeans from Iowa. The study included residues from herbicides and pesticides in the report and compared Roundup Ready soybeans to non-GMO soybeans and certified organic soybeans. It is of particular interest that herbicide and pesticide residues were included in the report, as the prevalence of these residues in processed food is often unknown to the consumer. Roundup Ready soybeans are glyphosate tolerant. Glyphosate is the most widely used herbicide in the world and approximately 6200,000 tons were produced in 2008 (Bøhn et al.). The study concluded that organic soybeans showed the best nutritional profile and contained no glyphosate. Organic soybeans had more sugar, proteins, and zinc than both the non-GMO soybeans the Roundup

Ready soybeans. Non-GMO soybeans also contained no traces of glyphosate but were deemed less nutritious than the organic soybeans, which directly refutes earlier claims that non-GMO soybeans actually contained more glyphosate than Roundup Ready soybeans. Many Roundup Ready plants were also found to contain levels of glyphosate that were considered “extreme” and “far higher than those typically found” (Bøhn et al.). This is particularly disturbing as the effects of glyphosate on human health are not fully understood or researched. It will be important to continue investigating the presence of glyphosate in industrial food products in an effort to understand and eventually mitigate the potential negative effects of this widely used herbicide.

From a consumer’s perspective, the study provides great support for the claim that the nutritional quality of GMO soybeans is worse than that of organic or non-GMO soybeans. Not only was glyphosate found as a residue on the Roundup Ready soybeans, but the herbicide had also been absorbed by the plant and could be found in the leaves and the beans. The “microbial community” within soil is important in balancing the growth and health of crops (Bøhn et al.). When glyphosate is added to the soil and absorbed by the plant, the microenvironment is upset, which disrupts the natural growth process and decreases the formation of nutrients for which the crop is valued.

The switch from Roundup Ready soybeans and other GMO varieties to organic soybeans is clearly a good choice to make in terms of environmental sustainability and nutritional benefit. Organic soybeans would eliminate the use of glyphosate reducing the pollution of streams and rivers caused by runoff. Other benefits would be improved nutritional value and lower risk to human health. Despite the numerous benefits, however, large-scale production of organic soybeans may be an unrealistic vision considering the current reality of the industrial food system. The infrastructure exists to enable large organic operations but the inputs that are required for organic cultivation are much more labor-intensive and increase the cost of production, which, in turn, raises prices for the consumer. The costly element of organic production is exemplified in the procedures of crop rotation and pulling weeds by hand. These procedures decrease production and increase labor costs, but are essential in order to avoid depleting the soil and removing unwanted weeds from the fields. Organic operations may also have difficulty keeping up with high demand for large crop yields. While it may be impossible for a complete switch to organic soybeans, small steps can be taken by consumers to improve the outlook for the implementation of organic soybean production. These steps include improving consumer education on issues surrounding GMO soybeans, increasing consumer access to locally grown and seasonal food, and applying political pressure in favor of policies, such as labeling and price systems, that favor a move away from GMO soybean production. Soybeans have become a permanent part of our food culture and will continue to play an important role in our diet. The future is vague as to whether this will be through the production of GMO, non-GMO, or organic soybeans but any movement away from Roundup Ready soybeans will be an agricultural change that will undoubtedly have a positive influence the future of our food .

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Research

Important Distinctions Between Labels and Certifications – and Why They Matter

Inho Choi

Photo Courtesy of US Department of Agriculture

When browsing the grocery aisle, consumers are bombarded with and confused by a myriad of special labels. "Organic," "whole grain," "all natural," and "cage-free," are just some of the more popular ones. Originally intended to help consumers differentiate products by communicating meaningful information about what the products contain and how they were produced, these labels now merely confuse consumers while giving retailers the opportunity to charge premiums on specially labeled items. Clearly, there is a need to educate the general public about the meanings of the various labels found on food products. Before discussing individual labels and what they mean, it is important to clarify the difference between a label and a certification. A label is any claim made on a food product, where such a claim may or may not be regulated by a government agency. A certification, then, is a label that can only be used if the product meets certain standards set and regulated by an agency such as the United States Department of Agriculture (USDA) or the Food and Drug Administration (FDA). Thus, all certifications are labels, but not all labels are certifications. The table below (Figure 1) displays a list of common labels, along with their certifications, if any, and their respective regulating bodies.

The two government agencies regulating food are the USDA and the FDA. The USDA regulates food, agriculture, natural resources, rural development, nutrition, and related issues based on sound public policy, the best available science, and efficient management. One of the more important divisions of the USDA is the Food Safety and Inspection Service (FSIS), which is responsible for ensuring that the nation's commercial supply of meat, poultry, and egg products is safe, wholesome, and correctly labeled and packaged (FSIS). The FDA, on the other hand, oversees the safety, efficacy, and security of biological

Label	Certification	Regulating Body
Organic	Yes	USDA
Non-GMO	No	Non-GMO Project
Hormone- & Antibiotic-Free	Yes	USDA
Whole Grain	No	Whole Grains Council
Multi-Grain	No	FDA
All Natural	Partial	USDA certifies meat/poultry/eggs FDA responsible for everything else but does not certify
Grass-Fed	Yes	USDA
Cage-Free	No	USDA
Range-Free	Yes	USDA
Pasture-Raised	No	USDA

Figure 1: Labels and their respective certifications and regulating bodies.

products, medical devices, human and veterinary drugs, cosmetics, products that emit radiation, and many food products. Some food products that fall under the umbrella of the FDA include dietary supplements, bottled water, food additives, infant formulas, and most other products besides meat, poultry, and eggs (About FDA). Also, in addition to these government agencies, non-profit organizations like the Non-GMO Project and the Whole Grains Council play a part in the labeling of food. These organizations set standards for labeling foods unregulated by the government, such as the "Non-GMO" and "Whole Grain" labels, respectively.

It should be noted that, if labels and certifications were not meant to convey meaningful information about products to consumers, the government and other organizations would not play a part in determining which products get labels. However, these labels assume a certain base level of knowledge about conventional farming methods on the part of the consumer – that is, in order to truly understand what labels are meant to convey, consumers must understand the various ways by which our food is produced. In the past, our food was produced via traditional farming methods – no pesticides, genetically modified crops and animals, etc. As displayed in Figure 2, in 1900 nearly 40% of the population were farmers, a stark contrast to today. Today, according to demographics provided by the Environmental Protection Agency (EPA), just one percent of the American population are farmers. Furthermore, the percentage of farmers that are 65 years and older has been steadily increasing, up from approximately 15% in 1969 to 25% in 2002 (Demographics). Whether the farming population declined naturally or competitive environment have driven them out is unknown. However we can definitely conclude there is an emphasis on efficiency. This efficiency has taken the form of an increased use of pesticides and other agricultural chemicals, the spread of genetically modified organisms (GMOs), and the proliferation of factory farms, all of which have known negative effects.

For example, the use of agricultural chemicals to increase short-term farm gains may not be as efficient when health and environmental effects are considered. According to research from Cornell University, pesticides incur varying financial costs, as shown in Figure 3. And, on top of this $9.6 billion per year, $10 billion is spent annually simply to purchase pesticides. The total known costs associated with pesticides, then, total nearly $20 billion every year, excluding the cost of research for new pesticide development (Pimentel).

However, the harm done by pesticides reaches beyond the monetary. Public health takes a measurable toll from pesticide use. For example, a systematic review done in 2007 found that "most studies on non-Hodgkin lymphoma and leukemia showed positive associations with pesticide exposure," and thus concluded that the

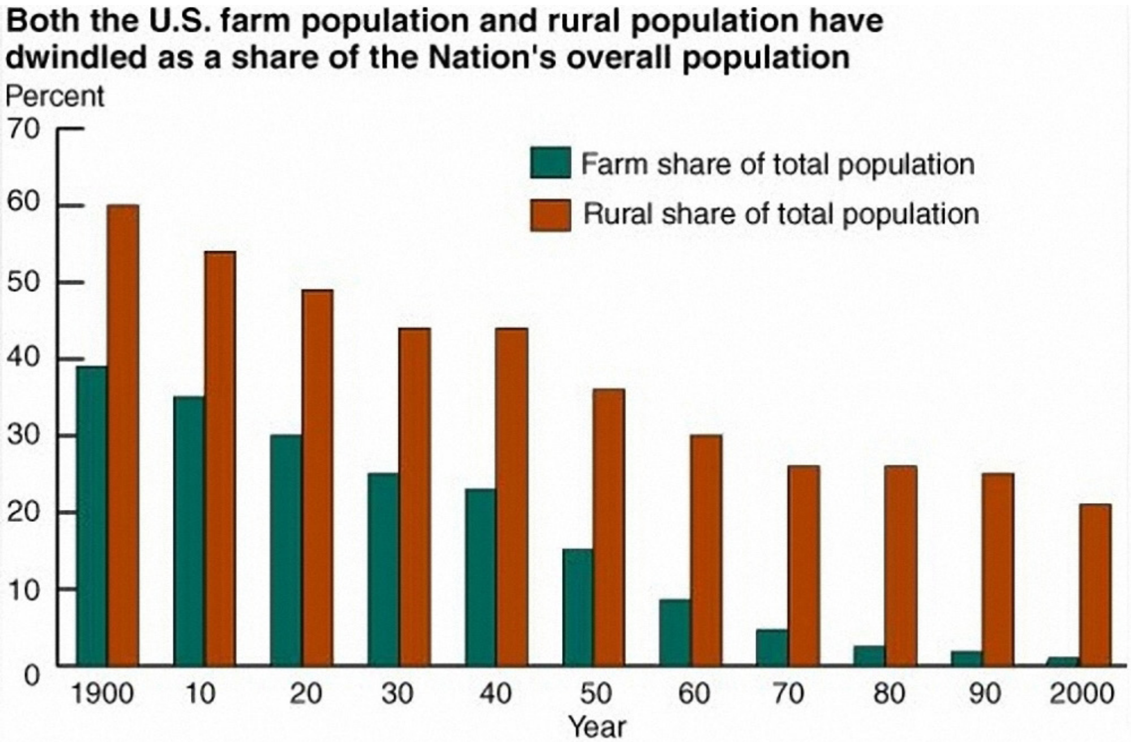

Figure 2: U.S. farm population and rural populations as share of population (Dimitri)

Harm	Annual US Cost
Public Health	$1.1 billion
Pesticide Resistance in Pest	$1.5 billion
Crop Losses Caused by Pesticides	$1.4 billion
Bird Losses due to Pesticides	$2.2 billion
Groundwater Contamination	$2.0 billion
Other Costs	$1.4 billion
Total Costs	**$9.6 billion**

Figure 3: Financial damage caused by pesticide use (Pimentel)

cosmetic or non-commercial use of pesticides should be decreased (Vakil). Strong evidence also exists for other negative outcomes from pesticide exposure, including birth defects, fetal death, and neurodevelopmental disorders (Sanborn). Other agricultural chemicals have been shown to have similar effects. For example, Parkinson's disease has been linked with exposure to pesticides (Ascherio), and studies have suggested that repeated exposure to low levels of organophosphates may result in biochemical effects in agricultural farmworkers (Lopez), as well as enhanced risks of certain cancers, such as leukemia or lymphoma.

GMOs – plants and animals that have been genetically modified with DNA from bacteria, viruses, or other plants and animals – also have various negative effects associated with them. First, most GMO crops are engineered to withstand herbicide and/or to produce an insecticide. Indeed, over 80% of all GMO crops grown worldwide are engineered for herbicide tolerance. According to the non-profit organization Non GMO Project, since the inception of GMO crops, the use of toxic herbicides like Roundup has been ubiquitously increasing the number of negative health effects that have been linked to agricultural chemicals (GMO Facts). Secondly, plants and pests have become resistant to the chemicals normally used to control them, leading to "super weeds" and "super bugs." Professor of Purdue University Bill Johnson has discovered the externalities of using Roundup first hand. He claims that the giant ragweed, a weed that enabled the use of Roundup, can "cause up to 100 percent yield loss" (Purdue University). Despite evidence like the increasing use of Roundup, proponents of chemical treatments claim there are no such things as "super weeds" or "super bugs." For example in 1998 volunteer canola, a weed, was reported to be resistant to three herbicides in Alberta, Canada (Jia). The activist dubbed the canola a "super weed," but supporters of these chemicals state that these weeds can be exterminated with 2, 4-Dichlorophenoxyacetic acid (Jia). What the supporters fail to mention is that the chemical is toxic and used as a major ingredient in Agent Orange. The long-term effects of GMO crops remain unknown; however, producers continue to release them, even though they know full well that these novel organisms cannot be recalled (GMO Facts).

In more than a third of the world's countries, there are significant restrictions on GMO crops and even outright bans. However, in the United States the government has approved GMO crops based on studies conducted by the same corporations that created them, a major conflict of interests. (GMO Facts). Today, those genetically modified crops account for the majority of all crops grown in the U.S.: Canola is 90% GMO; corn, 88%; cotton, 90%; soy, 94%; and sugar beets at 95% (What Is GMO?). Finally, in the drive for greater and greater efficiency the spread of factory farming has led to a multitude of negative effects in the ways we produce our meat. The vast majority of beef and other meats available to consumers in supermarkets is produced using feedlots, or Confined Animal Feeding Operations (CAFOs). These production systems operate on small land areas, where animals are raised in very confined pens, sharing living space with other animals, feed, manure and urine, and dead animals. The number of animals required for an operation to be qualified as a CAFO differs by the kind of livestock, as shown in Fig. 4. The living conditions of these CAFO's are relayed further in Figures 5 and 6.

Concentrating so many animals in such small spaces inevitably leads to the spread of disease among livestock. Cattle and other animals grown in feedlots are routinely given low-dose antibiotics and other drugs to accelerate growth and control disease. Feedlot cattle are not pastured, but are fed a corn and soy diet, which can cause diseases such as ulcers and acidosis, which are then treated with further antibiotics. As the cattle and other livestock are continuously pumped with antibiotics, the bacteria grow immune to them, requiring incrementally stronger doses and versions of the antibiotic. Externalities to constantly pumping antibiotics into livestock are slowly being revealed in threatening, new "super bacteria," like Methicillin-resistant *Staphylococcus aureus*, or MRSA. MRSA is a strain of staph bacteria that causes skin and respiratory infections, regularly infecting people that handle livestock. MRSA does not respond to antibiotics currently used to treat staph infections. Although not all staph infections are derived from resistant bacteria strains from livestock, they are a growing concern, as 20,000 Americans die of staph infections each year (Conley). MRSA is not the only worrying, new "super bacteria"

Animal Sector	Size Thresholds (number of animals)		
	Large CAFOs	Medium CAFOs[1]	Small CAFOs[2]
cattle or cow/calf pairs	1,000 or more	300 - 999	less than 300
mature dairy cattle	700 or more	200 - 699	less than 200
veal calves	1,000 or more	300 - 999	less than 300
swine (weighing over 55 pounds)	2,500 or more	750 - 2,499	less than 750
swine (weighing less than 55 pounds)	10,000 or more	3,000 - 9,999	less than 3,000
horses	500 or more	150 - 499	less than 150
sheep or lambs	10,000 or more	3,000 - 9,999	less than 3,000
turkeys	55,000 or more	16,500 - 54,999	less than 16,500
laying hens or broilers (liquid manure handling systems)	30,000 or more	9,000 - 29,999	less than 9,000
chickens other than laying hens (other than a liquid manure handling systems)	125,000 or more	37,500 - 124,999	less than 37,500
laying hens (other than a liquid manure handling systems)	82,000 or more	25,000 - 81,999	less than 25,000
ducks (other than a liquid manure handling systems)	30,000 or more	10,000 - 29,999	less than 10,000
ducks (liquid manure handling systems)	5,000 or more	1,500 - 4,999	less than 1,500

Figure 4: Classification of CAFOs by livestock type (Fact Sheet)

Figure 5: A CAFO in Washington (Simpson)

either, as farmers administer a veritable cocktail of different antibiotics to their livestock to prevent bacteria, including *E. coli*, *Salmonella*, and enterococci, from developing in their animals (Conley). Furthermore, meat is tested after it has been distributed, leading to massive product recalls as well as fatalities. Thus, the indiscriminate use of pharmaceuticals in factory farming presents us with the very real threat of diseases that are beyond our ability to treat with existing drugs.

Conventional farming methods are troubling not only because of their known health detriments, but also because of the unknown consequences that could result from their use. Pesticides have a grocery list of diseases related to them, while GMOs contribute to high levels of herbicide use and may have yet-to-be-realized negative health effects, and the use of antibiotics in our livestock puts us at risk for developing "super diseases." Given all these problems,

Figure 6: A CAFO discharge to canal often impairing water quality (11.3.09 Discharge 11)

the importance of differentiating labels from one another has never been greater**.** To that end, the rest of this article will be dedicated to discussing the various labels at length.

Organic

USDA ORGANIC

Figure 7: USDA "organic" label (Agricultural Marketing Service- Organic Labeling)

One of the most important and prevalent labels consumers may come across is the "organic" label (Fig. 7), which is heavily regulated by the USDA. In 2000, the Agricultural Marketing Service (AMS), a branch of the USDA, released national standards on the production and handling of products that are considered organic under the National Organic Program (NOP). These standards require that agricultural products labeled as organic originate from farms and handling operations that have been certified by a USDA-accredited state or private agency. In order to get certified, products must meet a slew of requirements, including bans on genetic engineering and the use of ionizing radiation, compliance with the National List of Allowed and Prohibited Substances, special labeling requirements, and requirements for testing, fees, state program approval, certification and recordkeeping, and domestic and foreign accreditation (Organic Farming). Thus, any farming, wild-crop-harvesting, or handling operation that wants to market an agricultural product as organically-produced must adhere to these national organic standards. The standards address three main concerns: the production of crops, the production of livestock, and the handling of these products.

According to the organic crop production standards, prohibited substances are banned from the land at least three years prior to the first harvest. Additionally, the soil fertility and crop nutrients must be managed, which requires processes like crop rotations, supplementation with animal and crop waste, tillage, and cultivation practices. The seeds and stocks must be organic unless the organic variety is commercially unavailable. Detriments to operations such as pests, weeds and diseases must first be controlled with physical, mechanical, and biological controls. Only when these practices fall short can the farmer resort to biological, botanical, or synthetic substances. In addition, questionable practices like genetic engineering, ionizing radiation, and the use of sewage sludge are prohibited (Organic Farming).

Animals used for meat, milk, eggs, and other animal products must follow the organic livestock standards. According to these standards, livestock must be raised under organic management beginning the last third of pregnancy for mammalian livestock and the second day of life for poultry. The organic management mandates that livestock are fed 100% organically, milk-producing dairy are fed 80% organically for nine months followed by 100% organically for three months. Also, as the general organic requirements state, animals cannot be given hormones or antibiotics for any reason unless they are sick – at which time they can be given prohibited substances but are stripped of the organic certification. To prevent such incidents, farmers may use vaccines. Another requirement established for the well-being of the animal is access to the outdoors and pasture. Animals may only be denied this right for their safety, health, and production needs or to protect the quality of soil and water (Organic Farming).

The handling standards deal with the back end of the production process, such as the processing of agricultural items. The standards state that non-agricultural ingredients, synthetic or not, must on the approved portion of the Nation List. Handlers must exercise due care in preventing the mixing of organic and non-organic products, as well as restricting contact with prohibited substances. A processed product labeled organic must source all of its agricultural ingredients organically unless commercially unavailable (Organic Farming).

As if the organic label were not already complicated enough, there are four sub-categories of organic certifications: "100% organic," "organic," "made with organic" and "specific organic ingredients." The following table (Fig. 8) outlines the basic requirements for

100 Percent Organic Raw or processed agricultural products in the "100% certified organic" category must meet these criteria: • All ingredients must be certified organic. • Any processing aids must be organic. • Product labels must state the name of the certifying agent on the information panel. *Principal display panel:* May include USDA organic seal and/or 100% organic claim. *Information Panel:* Must identify organic ingredients (e.g., organic dill) or via asterisk or other mark.	**Organic** Raw or processed agricultural products in the "organic" category must meet these criteria: • All agricultural ingredients must be certified organic, except where specified on National List. • Non-organic ingredients allowed per National List may be used, up to a combined total of five percent of non-organic content (excluding salt and water). • Product labels must state the name of the certifying agent on the information panel. *Principal display panel:* May include USDA organic seal and/or organic claim. *Information Panel:* Must identify organic ingredients (e.g., organic dill) or via asterisk or other mark.
Made with organic Multi-ingredient agricultural products in the "made with" category must meet these criteria: • At least 70% of the product must be certified organic ingredients (excluding salt and water). • Any remaining agricultural products are not required to be organically produced but must be produced without excluded methods (see page 1). • Non-agricultural products must be specifically allowed on the National List. • Product labels must state the name of the certifying agent on the information panel. *Principal display panel:* May state "made with organic (insert up to three ingredients or ingredient categories)." Must not include USDA organic seal anywhere, represent finished product as organic, or state "made with organic ingredients." *Information Panel:* Must identify organic ingredients (e.g., organic dill) or via asterisk or other mark.	**Specific organic ingredients** Multi-ingredient agricultural products that contain less than 70% certified organic content (excluding salt and water) don't need to be certified. Any non-certified product: *Principal display panel:* Must not include USDA organic seal anywhere or the word "organic" on principal display panel. *Information Panel:* May only list certified organic ingredients as organic in the ingredient list and the percentage of organic ingredients. Remaining ingredients are not required to follow the USDA organic regulations.

Figure 8: Various organic certifications, their requirements, and their labeling procedures (Agricultural Marketing Service – Organic Labeling)

each certification and how such products may be labeled.

Whole Grain & Multi-Grain

Figure 9: "Whole Grain" and "100% Whole Grain" labels (About US)

Other highly prevalent labels consumers may see are the whole grain and multi-grain labels. While these labels are not regulated, the FDA does provide guidance on their use. Another organization, the not-for-profit Whole Grains Council, provides more oversight for whole grain labeling. The Whole Grains Council created the Whole Grain Stamp (Fig. 9), helping busy shoppers spot the difference between regular and whole grain bread. This label is now found on over 8,600 products in 41 countries (About Us).

Whole grain and multi-grain labels are seen on grain-based products such as cereals, breads, and snacks. The Whole Grains Council defines whole grain as containing all the essential parts and naturally-occurring nutrients of the entire grain seed in their original proportions – that is, whole grain must contain 100% of the original kernels – while there exists no official definition for the term "multi-grain." However, since both of these terms are not regulated and there are no legal consequences for their misuse, there are not clear standards for what constitutes whole grain or multi-grain (Definition of Whole Grains).

The ambiguity surrounding the whole grain and multi-grain labels has led some to question their validity. One such group, the Center for Science in the Public Interest (CSPA), is a nutrition watchdog group that has petitioned the FDA about the whole grain label. The CSPA claims that some labeled products are not actually made with whole grain and wants companies to be required by law to disclose what percentage of a given product is whole grain. This begs the question: if these companies are not using whole grain, then what are they using? According to the executive director of the CSPI, Michael Jacobson, "[Companies] add caramel coloring (Leamy)." And when asked about multi-grain, he said, "The only thing ["multi-grain"] means is that [the product] has more than one grain. It doesn't mean any of them are healthful (Leamy)." Thus, "multi-grain" could just mean refined flour and not whole grains (Leamy). Clearly, the whole grain and multi-grain labels are ones of which consumers should be wary.

All Natural (No Official Logo)

Another, less-ambiguous label is "all natural" – although, like whole grain, there is no official government standard for what the label means for most products. Despite this lack of a formal definition, however, in 1993, the FDA released a statement saying the agency does "not [object] to the use of the term on food labels provided it is used in a manner that is truthful and not misleading and the product does not contain added color, artificial flavors, or synthetic substances" (Heller). Furthermore, the FDA said in the statement that, with the exception of "natural flavors," the term "natural" is not permitted in the ingredient list (Heller).

For some products, though, the use of the term "natural" is regulated. The USDA has requirements for the labeling of meat, poultry, and egg products as "natural (Heller)." According to the USDA, these products must be minimally processed and must not contain any artificial ingredients. However, the "natural" label does not include any standards regarding farm practices and only applies to the processing of meat and egg products. So, while the "all natural" label is certainly less dubious for certain products compared to the whole grain and multi-grain labels, it is still one consumers should be wary of in the grocery store.

Eggs: Cage-Free, Pasture-Raised, & Range-Free (no official label)

When shopping for eggs, consumers are likely to see several different labels, such as cage-free, pasture-raised, and range-free. The free-range certification indicates that the chicken was provided shelter in a building, room, or area with unlimited access to food, fresh water, and the outdoors during its production cycle. However, the outdoor area may or may not be fenced in and/or covered with netting-like material. This label is minimally regulated by the USDA, as no criteria exists for the size, duration, or quality of outdoor access that must be provided (Agricultural Marketing Service – Consumers). Furthermore, there is no restriction on forced molting via starvation. When forced into molting, the hens are unfed for a week or two, during which time production stops to allow the hens' reproductive tracts to rejuvenate. Another practice, beak cutting, where the beak is partially trimmed to reduce feather pecking and cannibalism, decrease mortality rates, and increase production, is also allowed. Ethical problems arise from this practice, as a hen's ability to consume feed is impaired by pain and stress. Beak cutting and forced molting are major concerns for animal activists like the Humane Society (How to Read Egg Carton Labels).


Figure 10: living conditions in a "cage-free" production (Charles)

The unregulated cage-free label means that the flock was able to freely roam a building, room, or enclosed area with unlimited access to food and fresh water during their production cycle (Agricultural Marketing Service-Consumers). They generally do not have access to the outdoors, and again, beak cutting is permitted. Although the label cage-free sounds pleasant enough, it is rather meaningless, as producers may grow their poultry in such cramped conditions that the difference between a cage and an overcrowded pen is irrelevant (see Fig. 10).

Finally, the also-unregulated "pasture-raised" label means that the hens spend their days outside on fresh pastures. However, due to the number of variables involved in pasture-based agricultural systems, the USDA has not developed a federal definition for pasture-raised products (Agricultural Marketing Service-Consumers).

Of the three labels, only "free-range" is regulated by the USDA, while there are still no third-party auditors to confirm whether farmers are meeting requirements. Thus, consumers should be wary of labels on eggs as well.

Beef: Grass-Fed, Organic, & Conventional Feed-Lot (no official label)

Like eggs, beef can also be found with a multitude of different labels attached. Grass-fed is good alternative to CAFO's, but due to the lack of regulation of harmful substances in grass-fed beef, it falls second to organic beef. The grass-fed certification does not limit the use of antibiotics, hormones, or pesticides. Grass-fed animals receive a majority of their nutrients from grass throughout their life, while organic animals' pasture diet may be supplemented with grain. Although cattle raised mainly on grass tend to be more nutritious, because grass fed cattle are allowed harmful antibiotics, to be discussed later, the superiority between the two certifications is hard to determine. If considering the stringent process of receiving the organic certification, the scale is slightly tilted in favor of organic.

Beef labeled as organic must meet a slew of requirements. Louis Rorimer, owner of Snake Hill Farm, a certified organic farm in Bainbridge, Ohio, describes the various requirements to raise organic beef: *"Organic beef must meet … a 100% organic diet, medication restrictions and requirements, shelter requirements, humane treatment and slaughter, etc. The mother has to be organic, too for the last part of her pregnancy. In addition, it must have year-round access to pasture, and 30% of its diet by "dry matter" weight must consist of pasture during the grazing season. The animal must also be slaughtered and butchered by a certified organic butcher."* Louis describes these rules briefly, not touching upon the various intricacies of the 30% rule. These stringent requirements, along with general organic standards previously described, restrict the scale of the farm. Snake Hill Farm will only produce 7 steer with a target weight of 500 pounds per steer. Understandably given the painstaking nature of the certifying process and the scope restriction of organic beef certification, a premium's inevitably charged.

Hormone- & Antibiotic-Free (no official label)

One of the more-regulated labels is "hormone- and antibiotic-free." According to the FSIS, the allowed usage of hormone and antibiotic differs among poultry, pork and beef. The FSIS states that hormones are not allowed in pork and poultry. Beef, however, is allowed hormones and so can be labeled as "no hormones added." The label "no antibiotics added" can be put on all meats as all animals are allowed antibiotics (FSIS). These regulations seem solid on paper, but the approval process for these labels is lacking. All farmers have to provide is "sufficient documentation" to the agency to claim these labels, meaning agents fail to inspect the animals rather simply check the paperwork. The lack of due diligence has been noted by the European Union, which stopped importing chicken from the United States in 1997. U.S. poultry go through a pathogen reduction treatment (PRT), a method inactivating infectious pathogens through radiation, a practice that is prohibited in the E.U. Although deemed safe by scientific opinions, the E.U. maintains its industry specific embargo on pathogen reduction treated poultry. (U.S. Congressional Research Services).

Non-GMO

Figure 11: Non-GMO label (The "Non-GMO Project Verified" Seal)

Finally, the Non-GMO label (Fig. 11) is certified by a non-profit organization unaffiliated with the government called The Non-GMO Project. The Non-GMO Project began as an initiative of independent natural foods retailers who were interested in providing consumers with more information regarding risks of GMOs, which were described earlier. However, the organization sadly has no legal authority in the regulation of GMO products.

Despite having no legal authority, the Non-GMO Project has done a competent job in labeling. They require ongoing testing of all at-risk ingredients meaning any ingredients used cannot be above a threshold of 0.9%, a standard picked up from the European Union. After the test, rigorous traceability and segregation practices are administered in order to ensure ingredient integrity through to the finished product. For an added measure, verification is maintained through an annual audit, along with onsite inspections for high-risk products. The Non-GMO Projects strives to one day rid all products labeled Non-GMO of any trace amounts of GMO. And to aid achieve this, they make sure the goals of the participant's quality management systems are aligned. (The "Non-GMO Project Verified" Seal)

On one hand, we have the production limitations of sustainable growing methods like organic, but on the other hand we see detrimental health effects of conventional methods like CAFO's. Choosing one method wholeheartedly is an impossible task, at least currently. Choosing sustainable methods will lead to supply shortages and choosing methods like CAFO's will inevitably lead to health epidemics. Since unhealthy growing methods are going to be part of our foreseeable future, consumers should be knowledgeable about which products are healthful and others harmful, which labels carry meaning and others simply a means to a premium. And to that goal this article has touched briefly on the controversy that is food labeling and certification.

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A New Approach to Ohio Pig Farming

Photo Courtesy of Open Clip Art

Hannah Bidigare-Curtis

INTRODUCTION

Although current methods of pig farming now allow cheap pork availability to consumers throughout America, they come at high costs. Through interviews with Ohio pig farmers and research on current and historical developments in the industry, this article explains how the industry has achieved its current methods of production, how consumers and farmers are affected, and where everything should be headed in the near future. There are and will continue to be aspects of pig farming that affect the health of the general public and the health of future generations, and they need to be addressed in open discussion. While this topic often causes strong reactions from various invested groups, it is critical to consider a number of perspectives and integrate them with research to form a cohesive vision for the future.

BACKGROUND

Current, conventional methods of pig farming are generally as follows: sows are bred via artificial insemination, and once born, their tails are docked to keep other pigs from chewing on the tails in their future close quarters. Their teeth are also clipped in order to prevent infection. Once weaned, hogs are shipped sometimes several hundred miles to another facility to be raised on a diet of mostly corn, soybeans, and small amounts of antibiotics. They are kept in pens with many other hogs, and throughout their lives they are closed in a barn with their waste falling through slots into large pits below them. When the sows reach market weight, they are often switched to a different diet plan in order to achieve the slaughterer's desired meat composition, and then shipped to another company to be butchered.

The idealized picture of a typical pig farm that is still used in advertising campaigns by conventional companies has become increasingly rare in reality; they "remind us of a human-pig relationship that…was not always so distanced or as alienated as it is in the industrialized world today" (Mizelle 2011, p. 11). In the early 1800's, livestock laws changed so that the purposes of fences were no longer to keep pigs out but to keep them in. This was quite a controversial decision in pig farming at the time because most Americans tended to allow their pigs free range of the land. This change was a fundamental development in the way pigs have been raised in this country and set pig farms on the path to the current conventional production. Cincinnati, Ohio was the epicenter of the development of the modern industrial pig farm. Despite the fairly decentralized state of hog businesses at the time, Cincinnati grew from 100,000 hogs processed annually in the 1830s to 400,000 annually in the 1840s. In the 1880s, centralization of this large-scale method of raising hogs came to fruition elsewhere due to technological advancements, specifically transportation (e.g. railroads) and refrigeration. In Cincinnati and many other cities, however, pigs remained in the public eye as "important players in urban ecologies and subsistence as well as a public nuisance" (Mizelle 2011). This more intimate relationship was gradually phased out, however, as cities wished to have a more civilized atmosphere.

By the end of World War II, traditional hog farming that allowed the animals seasonal access to the outdoors had all but disappeared. The confined operations of today involving the use of antibiotics, corn and soybean feed, and division of growth stages among facilities became standard practice (Mizelle 2011). The start of the modern day conventional farm, sometimes called CAFO (Concentrated Animal Feeding Operation), is connected to Wendell Murphy, a US state senator who began as a pig farmer in 1962. Murphy strove to mimic the success that industrial chicken production had prior to the development of pig farming. In the 1980s and 1990s, he bought out many pig farms near him and had them move their entire business indoors, as the chicken farmers had done. He also split his farming process into three stages on three separate farms: breeding, growing, and preparing them for market ("Wendell" 2012). This proved to be extremely successful. In North Carolina, he worked within the state's General Assembly to diminish the amount of power that the government had over hog farms. He also voted for and co-sponsored bills that gave hog farms tax breaks, excused them from some environmental regulation, and shielded them from local zoning requirements. During the ten years that he was on the General Assembly, he became the nation's biggest hog producer. Murphy's methods were duplicated throughout the country, and this soon became the norm in hog farming (Stith 2012). This pattern of modernization and development used to distance humans from animals can be seen globally (Mizelle 2011).

PROBLEMS WITH CONVENTIONAL PIG FARMING

Medical

In addition to contributing to growth rate, antibiotics are also constantly administered at low levels to conventional pigs because of their disease susceptibility. This is a controversial practice that began on European livestock farms in the 1970s in order to induce slightly higher growth rates in animals. The Food and Drug Administration (FDA) estimates that 80 percent of our current antibiotic use occurs in the livestock industry, which has led many researchers to document its effects (Xue 2014). Some studies – such as those on the banning of the antibiotic avoparcin in the EU as a livestock feed additive – indicate that eliminating antibiotics from livestock feed greatly reduces the overall prevalence of resistant strains while very minimally affecting the growth rate of livestock (Wegener 2003). It is estimated that antibiotic-resistant diseases cause two million serious illnesses and 23,000 deaths every year in the United States alone, making this a critical issue to address in the pork industry (Xue 2014). Even though there has been definitive evidence of the effect of livestock antibiotics on resistant diseases in humans since the early 1980s, the FDA took its first action to phase the practice at the end of last year (Plumer 2013).

Another medical practice that is now widespread in the industry is the use of artificial insemination (AI); currently over 90 percent of swine breeding uses this method (Mizelle 2011). Artificial insemination has made genetic uniformity in herds easy to generate, allowing producers to obtain consistent meat products. Unfortunately, genetically uniform herds are more susceptible to disease. Nathanael Johnson, a professor of the Graduate School of Journalism and guest writer for Harper Magazine, explains, "The pigs are vulnerable because they live in close quarters; and because they are genetically uniform, a bug that breaches the defenses of one pig's immune system can hop to the next. A bacterium residing between a traveling boar's toes could wipe out half a herd" (Johnson 2006, p. 2). Although farms take elaborate precautions in preventing contamination of their herds, this disease susceptibility has become especially evident with the recent spread of PED, or porcine epidemic diarrhea, which was discovered in Ohio farms in February of this year after already killing four million pigs across 23 states since April 2013 (FOX News 2014)

Waste Management

Aside from disease, another critical problem faced by conventional pig farmers is pig waste. Seeing as hogs on average produce three times the amount of excrement as humans, the waste of these animals presents a significant dilemma. This is especially evident in the largest herds, ranging from 300,000 to 500,000 pigs on a single farm (Imhoff 2010). To put that in perspective, each of these farms has to take care of the amount of waste generated by the human population of Dallas, Texas. In a confined hog operation, the animals' waste is collected underneath the barns in large pits, which are periodically emptied into nearby containment areas. As farmers are not responsible for treating this waste, there have been numerous instances of overflow from containment areas. These lagoons can contain tens of millions of gallons of wastewater, and they break, leak, or overflow too frequently. Concentrated animal waste of any kind can have dramatic effects on both people and ecosystems if it turns into pollutants. Unfortunately, using this concentrated waste as agricultural fertilizer often involves treatment, and even then, runoff from fields sprayed with pig farm waste that enters waterways is often far from safe (NRDC 2013).

The low-quality waste management systems also provide pathways for the development of efficacious diseases. As mentioned before, the prevalence of disease in large herds of hogs is much higher than in smaller, less confined herds due to close proximity and concentrated waste of hogs in large herds. One example of how this can affect the spread of disease in humans is MRSA (methicillin-resistant *Staphylococcus aureus*). This antibiotic-resistant disease originated in hospital wards where methicillin, a form of penicillin engineered after the bacterium became resistant to penicillin, was being used, but now it can be found outside of these environments (Xue 2014). MRSA carriage can be found on pig farms, especially larger farms. In one study, 34 percent of the animals in large-scale swine herds (>10000 pigs) carried the disease as opposed to seven percent on small-scale farms (Fang et al. 2014). This not only affects workers and neighbors of hog farms, but also those exposed to pig *waste*. Proximity to fields fertilized with waste from conventional pig farms has been shown to greatly increase the likelihood of MRSA infections (Zhang 2013). This disease has become a serious medical problem, with tens of thousands of people getting infected with MRSA every year, and over 11,000 of them dying (Xue 2014).

Animal Welfare and Nutrition

In conventional hog farming, the animals are provided with feed mostly consisting of corn and soybeans. This diet, although it produces the desired meat physique for the market, has multiple drawbacks. Primarily, the nutritional value of this diet is severely limited. Hogs are omnivores that are able to consume a variety of foods, potentially making them a highly nutritious meat source for humans, but conventional pork has minimal benefit in this area. This is one dramatic distinction between conventional and alternative farming approaches. For example, Nilzen et al. analyzed the nutrient value of meat from different physical pig farm models and found that free-range pigs had a higher polyunsaturated fatty acid content and a higher level of vitamin E compared to purely indoor pigs, which has to do with both diet and environmental factors (2001).

In highly confined, noisy environments, it is not hard to predict behavior difficulties with the pigs. This was the case with a breeding facility called Oberholtzer Farm in Ashland, Ohio. This breeding facility is required to house the sows in pens of six to ten pigs when they are not gestating or farrowing (Kenneth Oberholtzer, personal communication, March 15, 2014). However, in confined areas there are often conflicts between the pigs, making it necessary to remove select pigs and put them in individual pens, which means extremely limited mobility. High anxiety levels in pigs, has been shown to be related to PSE, or "pale soft exudative" meat quality. These stressful environments raise lactic acid levels in pigs, lowering the pH of the meat so that it is generally unpalatable (Mizelle 2011). This is yet another example of how animal welfare and meat quality are closely related.

It is obvious now that this method of pig farming has significant consequences, though the severity, scale, and time period within which they became evident varied. The nutritional quality of the meat, for example, was an obvious product of the industry that was recognized immediately. Other consequences - such as those of waste containment methods and the regular use of antibiotics in conventional pig farming - were not as palpable initially. Regardless, the strong link between animal and public welfare is evident.

WHAT'S THE SOLUTION?

As with any type of business, there are a variety of models for pig farms with different rewards and challenges. The physical model of raising pig farms has sparked arguments from consumers, farmers, animal rights activists, and so on. The diversity of the domesticated pig has provided humans with a range of possible methods of raising the animal, "ranging from free-range husbandry to sty-reared, urban and industrial agriculture- and a concomitant variety of human-pig relationships as well" (Mizelle 2011, p. 15). This has inevitably led to complex marketing strategies of pork. One example of such marketing is the practice of using certifications that appeal to the consumer, such as 'vegetarian diet', 'pasture-raised,' 'organic,' and 'antibiotic-free.'

The validity and worth of these labels, which often also change the cost of the meat, are often debated. From the perspective of pig farmer Pat Hord, CEO of Hord Livestock Co. in Bucyrus, Ohio freedom of choice is key.

"Agriculture is probably as guilty as anybody of trying to call one thing right and one thing wrong… There's a broad, diverse consumer and some consumers want to have a certain characteristic or a way that their food was raised, and if they have the disposable income to spend on that, that's great, that's awesome, and I think they should have that ability. I think what concerns me is that there are the activist groups that want to change our food system to what they think is the right thing versus what the consumer really wants, and I think now we're starting to limit choice and freedom" (Hord 2014).

For others, converting the entire industry into a new standard of pig farming is not only desirable, but unquestionably necessary. Labels and certifications are constantly appearing on meat products that are supposed to communicate a higher quality, healthier product compared to conventional meat. Unfortunately, as Michael Pollan explains in his acclaimed book *The Omnivore's Dilemma,* many of these certifications are simply not enough. Organic, for example, essentially means organic corn and soybean feed, access to (though no guaranteed use of) an outdoor pasture, and prohibition of most veterinary drugs including antibiotics and growth hormones. The concentrated waste, lack of genetic diversity, and unsustainable nutrient cycle can all still take part in a purely organic operation (Pollan 2006).

Conventional methods have caused the general public to become accustomed to lean and inexpensive pork that is often less tasteful. Farms throughout Ohio, however, are rejecting the standards. For example, the owners of New Creation Farm in Chardon, Ohio started raising antibiotic-free hogs on pasture many years ago when a physician told them that conventional meat was damaging their child's health. Sweet Meadows in Zanesville, Ohio has raised organic, pasture-raised, heritage breed hogs for fifteen years to sell in their farm's store and to businesses around Ohio. These types of farms are small-scale operations that offer a feasible, more nutritious and environmentally safe alternative to conventional pork.

One of the main arguments for continuing conventional pig farming is that it is the most effective way to produce large amounts of pork, which is what we need to "feed the world." Conventional pig farming, people argue, has developed the way it has for a sole purpose: to produce as much meat as possible. Efficiency is the mantra of modern-day conventional farming. However, this is a deceiving ideology; the pork industry as a whole has created methods to generate profit. This does not have to correlate with producing as much meat as possible using the smallest amount of resources, and extensive research has shown that it in fact does not. In a study on Holmes County, Ohio, the production of a mixture of small conventional and traditional Amish farms was found to be twice that of the US average of pork production. This shows that large, concentrated pig farms are not only harmful to the environmental and the public, but they are also less effective in producing large amounts of pork as efficiently as small-scale farmers (Bender 2003).

FUTURE STEPS

Despite evidence of alternative pig farming's ability to take the place of conventional methods, alternative approaches are struggling to become mainstream. These limiting factors involve intensive labor and a tendency to focus less on efficiency and more on quality. Alternative farming methods can be less appealing to the farmer because there is a high amount of involvement and labor that goes into raising the animals, as expressed by Brown and Boehnlein. In many ways, this is an inevitable part of this farming approach. However, there are still aspects of the conventional business model that can be used in alternative farming without reverting to harmful methods. Besides the mechanization of feed and water and the confinement of herds indoors, one way that conventional farming makes their labor more efficient is through contracting. Kenneth Oberholtzer owns a breeding farm in Ashland and is on contract with Hord Livestock Co. Compared to when he owned a conventional farm independently, Oberholtzer notes that now he experiences little risk from market variability and is allowed to focus on the aspects of pig farming that he enjoys most. Without having to worry about dealing with feed orders, drug companies, and hedging the price of his pigs, "the only thing that I concentrate on anymore is producing pigs, which is really the thing I *like* to do, it's the thing I understand how to do, it's probably the thing that I'm best at doing," said Oberholtzer (Kenneth Oberholtzer, personal communication, March 15, 2014). Allowing for a higher division of labor in the alternative method with a more complex business structure would create a model that is easier to support and spread throughout Ohio.

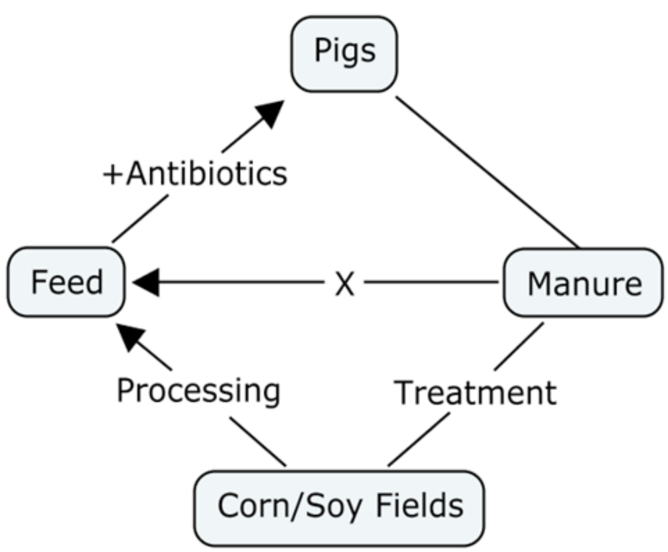
The conventional model of pig farming adds components to a system that would otherwise be simple and efficient by design. While the nutrient cycle for pasture-raised hogs is in many ways a self-contained system that can virtually continue until the sun fails, conventional methods involve outside inputs and wasted resources (Figure 1). In the same way that the FDA has begun to phase out the use of antibiotics, it would be prudent to make steps in the direction of limiting these inputs so that pig farming can improve in this aspect of efficiency.

It is evident that sustainability and high productivity do not have to live under different roofs. However, modern alternative farms may not always be as focused on a culture of efficiency as farms run by conventional methods. Although often resourceful in their methods, Brown and Boehnlein are less focused on high productivity. Neither expressed extreme interest in increasing the size of their farms or striving to produce more per acre. Oberholtzer and Hord, however, both spoke of efficiency as their driven goal, something they strive for on a daily basis, with Oberholtzer priding himself on running a farm that is more efficient than 95 percent of other farms (Kenneth Oberholtzer, personal communication, March 15, 2014). From the small-scale farmer's perspective, however, there is value in realizing the sustainable limits of the land on which the animals are raised.

The government provides subsidies for corn and soybean crops, a large portion of which is used for livestock feed. If some of this money was reallocated to supporting alternative methods of pig farming, it could encourage this sector's development. For example, one aspect of infrastructure that alternative methods are currently struggling with is butchering. The consolidation of the pork industry drove many smaller, niche slaughterhouses out of business. Now, although the movement towards small-scale pig farming is growing, many farmers, including farm owners Brown and Boehnlein, still have difficulty finding slaughterhouses that do not operate at the industrial level and provide the humane, stress-free butchering that many consumers prefer. Brown has gone through four different butchers in order to find one that would consistently produce the specific cuts required by customers, and now has to travel close to two hours to get to the butcher (Katie Brown, personal communication, March 30, 2014). Boehnlein must travel several hours to Columbus, Ohio to reach her butcher (Kristen Boehnlein, personal communication, April 12, 2014) With a stronger infrastructure, the development of contract farming and the increased number of small-scale, humane butchering companies would aid the growth of alternative methods in Ohio.

OHIO: A LEADER IN THE WORLD OF PIG FARMING

It is time to collectively concern ourselves with the current production of pork. The largest pork production corporation in the world, Smithfield Foods, is located only a couple states away in Virginia. Shuanghui International Holdings Ltd., a large Chinese pork producer, recently bought this corporation. This means major growth for Smithfield despite the U.S.'s fairly stagnant pork market, creating more large-scale conventional farms (Felberbaum 2013). Lying within this industry are critical issues that are changing as we speak, and action can be taken now. Ohio invented conventional pork production, and we can choose to be the first to reform it. By taking the appropriate steps, this state can be at the forefront of a movement towards better forms of pig farming.



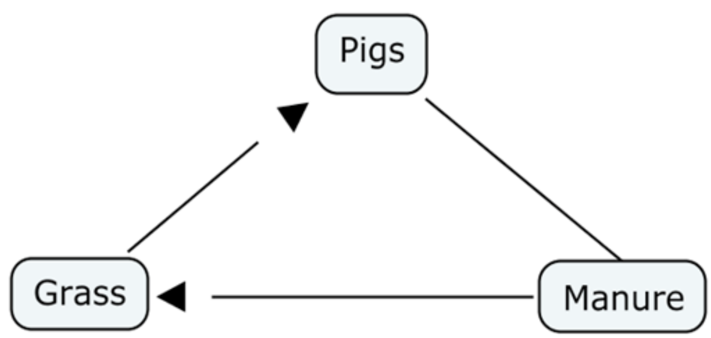


Figure 1. Conceptual nutrient cycles of conventional pig farming (left) and alternative methods, specifically pasture-raised pigs (right).

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Research

The GM Crop Network:
An overview of the environmental, political, economic, and human health contexts surrounding Bt corn

Alexander Razavi

A genetically modified (GM) crop is defined as a recombinant-deoxyribonucleic acid plant, in which genetic material has been changed through *in vitro* nucleic acid techniques (Food and Agriculture Organization of the United States, 2014). Food and its constituting ingredients derived from GM crops were introduced to the United States food supply in the 1990s (Food and Drug Administration), and have since then become a controversial topic everywhere from family households to governmental settings . Pro and anti-GM partisans have continued to mold the conversation through debates interfacing several disciplines, yet has this polarization and lack of balanced consumer education benefited the public? Have individuals been provided with enough background knowledge through public health programs, scientific research, or even through food labeling to construct opinions? At first glance, GM crops appear to simply exist within a philosophical controversy, however upon further inquiry, an entirely different puzzle emerges.

Plant science, agriculture, and human medicine are all disciplines linked to the GM conversation, but is this connection the same for economics and politics? How do seed patenting rights, pursuits to increase farm yields, and global food demands affect the cultivation of these crops? Complexity can indeed quickly overshadow this dialogue about genes and food, further increasing the existent barrier between food producers and consumers. Thus, evaluating the overall success of genetically modified crops requires a case-by-case analysis and an evaluation of their respective agricultural, human health, economic, and political contexts. In particular, research regarding *Bacillus thuringiensis* (Bt) corn should undoubtedly be of interest to several professions including, doctors, scientists, businesspeople, and elected officials as it is one of the most commonly planted GM crops in the world.

Bt is a gram positive soil bacteria that produces a family of crystal (Cry) proteins, which contain insecticidal properties (Neppl, 2000). Many of the topical insecticides that were previously manually sprayed on crops, are now genetically inserted into certain plant genomes to obtain greater efficiency and efficacy. This background information regarding Bt crops illustrates the revolutionary effects genetic engineering may have on agriculture in the future. Without a doubt, molecular biology techniques are an enticing mechanism to increasing crop yields, thus growing greater quantities of food and feeding more people. That being said, does this simple arithmetic add up? Has this *truly* been the primary motive in the global expansion of Bt corn?

The agriculture industry is greatly shaped by external influences . The everlasting struggle of the Food and Drug Administration to control the prophylactic use of antibiotics in livestock feed and the mere presence of grocery store aisles stocked with calorie rich but nutrient poor foods serve as examples illustrating the strong corporate influences within the industry. Moreover, with specific respect to corn, outside data and research reveal the primary factors driving this crop's production, thus indirectly promoting the use Bt transgenic technology.

The use of stover, also known as leaves and stalks derived from corn, is increasingly being used for livestock feed and industrial purposes. The Iowa Corn Organization reports ethanol, distiller grain, and "other processing" as the top three uses of corn in the United States (Iowa Corn Organization, 2013). Likewise, it is useful to note that the USDA reported that in 2012, 88 percent of corn grown in the United States was genetically modified (Dupont, 2013). Although Bt is not the only genetic modification incorporated into corn plant genomes, it comprises a majority of this overall percentage. Analyses will demonstrate that Bt corn is encompassed within a multidisciplinary network of external influences, which continue to drive its cultivation, growth, and industrial promotion. Ironically, we see that human nutrition, health, and environmental preservation interests are no where to be found in within the primary motives for planting Bt corn.

Ethanol is primarily used as an oxygenate in gasoline production to produce various common ethanol

Photo Courtesy of bark, Flickr, 2010

fuel mixtures (US Department of Energy). While such biofuels have been noted to be more "eco-friendly", a recent study released in a peer-reviewed journal, *Nature Climate Change*, concludes that biofuels made with corn residue release 7% more greenhouse gases in the early years compared with conventional gasoline (Liska et al., 2014). This federally funded study states that while corn biofuels may help decrease carbon dioxide emissions in the long run, they fail to classify corn-based ethanol as a renewable energy source as defined by the Energy Independence and Security Act of 200. In addition to these research conclusions, we must also consider the machinery and fertilizer used, transportation needed, ,and water used to plant and harvest corn in assessing the biofuel's carbon footprint (McKenna, 2007). The United Nations Intergovernmental Panel on Climate Change has stated that, "Increasing bioenergy crop cultivation poses risks to ecosystems and biodiversity" (IPCC, 2013), and attributing 30% of corn usage to ethanol production seems to be an awful lot for the amount of conflicting research regarding its carbon emissions .

Regardless of ethanol biofuel's potential positive impact, it is curious to note the country's dedication to using precious agricultural land to plant corn, most likely of a Bt variety, which is not feeding its citizens . Yes, many would still certainly refuse to consume Bt corn for various reasons if it were actually being shipped directly to grocery stores. The importance, rather, is the concept that agricultural land should be used for its specific purpose, feeding and nourishing individuals. Those opposing may indicate that these crop fields actually are contributing to satisfied appetites, perhaps indirectly. Livestock feed, through the use of corn distiller grain, has become the primary external factor driving the production of corn.

Though the demand for milk has decreased 36% since the 1970s in the United States (Cardello, 2013), global meat production has tripled in the last four decades (World Watch Institute, 2011). Danielle Nierenberg, Director of the *Nourishing Planet Program* , states that, "Much of the vigorous growth in meat production is due to the rise of industrial agriculture…" and that, "Factory farms pollute the environment through the heavy use of inputs such as pesticides, herbicides, and fertilizers, used for feed production". Putting this all together, we see a direct relationship between corn and meat production; increased demand for meat propels more Bt corn to be planted. This association again illustrates that corn is not being grown feed people, contradicting industry voices that claim planting more of their patented seeds will feed more individuals. To food activists or others interested in the complex conversations regarding food, these are not novel concepts or facts. The difference has rather been the continued production of genetically modified crops without the necessary emphasis on human health or environmental research.

We have briefly touched upon the primary external drivers affecting Bt corn: agriculture, ethanol biofuel and livestock feed production respectively. It is clear that corn-based ethanol biofuel and industrial animal farming negatively impact the environment as well. Furthermore before proceeding into the human health implications associated with Bt corn, it is important to critically analyze two more portions of this network: crop yields and seed patenting rights.

On paper, Bt corn seeds should be attractive to every farmer and environmentalist. Why? In theory, this transgenic technology results in decreased grower handling and diminished topical application of insecticide to the crop fields. The plant is able to grow with innate insecticide properties that protect it from specific species, such as the European corn borer. These pests have been labeled as "silent thieves" because many growers often do not realize the 5-10% decrease in yields due to corn stalk tunneling and ear injury from the corn borer (Hellmich, 2012). Within this same crop yield study, Dr. Richard Hellmich at Iowa State University states that, "…the cumulative decrease in insecticide active ingredient use on Bt maize was 35% globally". The paper however, does not indicate what the "active ingredient" is. Regardless, this study and several similar research articles associating Bt corn with increased crop yields clearly demonstrate that the GM crop can carry out its function. Bt corn has the capability of increasing crop yields and decreasing insecticide use due to increased protection against a specific group of pests.

Despite these noted benefits of Bt corn, contrary research exists. Multiple studies have evidence that contradicts the claim that Bt corn is beneficial for increasing crop yields and decreasing insecticide use. One such paper from the University of Canterbury in New Zealand in 2013 includes two very bold paragraphs:

"GM cropping systems have not contributed to yield gains, are not necessary for yield gains, and appear to be eroding yields compared to the equally modern agroecosytem of Western Europe. This may be due in part to technology choices beyond GM plants themselves, because even non-GM wheat yield improvement in the U.S. are poor in comparison to Europe."

"Herbicide reductions can be achieved in European countries that do not adopt GM crops. In contrast, use is rising in the U.S., the major adopter of GM crops. Chemical insecticide use is decreasing both agroecosystens, but more profoundly in France (also Germany and

Switzerland) that do not use GM plants and only modestly in the U.S. Total insecticide use is not decreased in the U.S. when insecticidal plants are included in total insecticide use." (Heinemann et al., 2013).

At the very least, the aforementioned University of Canterbury and *Nature* studies regarding Bt corn serve as exemplars for all aspects of the GMO debate. Completely opposing viewpoints continue to persist, and this polarization will frustrate none more than the lay food consumer. Analyzing studies from both sides and further noting their models and methods for research conclusions is certainly beneficial, but the answers can only ultimately be found through increased uniformity and stability within research methods and governmental policies. We know that Cry proteins are effective at inhibiting certain species from feeding on developing Bt crops, and we are certainly correct in our pursuit to minimize the use of insecticide in agriculture. However, we need to evaluate Bt corn in perspective of the whole ecosystem. How do Cry proteins interact with non-target organisms? Can Cry protein concentration build up in the soil or contribute to untoward effects through water runoff? Such research questions are presently being explored. Furthermore, we must continue to remain informed and promote the pursuit of evidence-based science to provide the necessary answers.

The genetic modification of crops has great intentions, similar to all other aspects of science. As we reviewed earlier, the simple equation all along has been to increase efficiency of crop agriculture in order to help produced more food to feed our growing global population. But this relationship does not do justice to the full capabilities of genetic engineering. Pamela Ronald, a plant geneticist and professor at U.C. Davis, cites several examples which illustrate the positive side of GM crops many consumers fail to see. Ronald, in one instance, notes how genetic engineering helped papayas resist ring-spot virus, and ultimately saved the whole Hawaiian papaya industry (Little, 2014). Moreover in her personal research, Ronald and colleagues have created a flood-tolerant rice that can grow in submerged fields. This seed has been accepted with open arms in Bangladesh and India where losing valuable crop to floods is a critical issue. These cases illustrate that GM crops cannot all be classified into one neat category, and that this science undoubtedly has a reserved seat in the future of agriculture. Unfortunately though, at least two problems still exist with the current state of this scientific technology: First, corporations have manipulated the system to use GM crops as a tool to primarily increase profit. Second, little research has been conducted studying the long term genetic and immunological effects on humans associated with those consuming GM crops.

The existence of seed patenting rights is a severe hindrance to science, agriculture, and human health. The purpose of science is to share new findings about the world with our fellow community members, and more importantly use this new knowledge as a tool to progress collectively as a group. Biotechnology and genetic engineering classify as science and continue to provide novel methods for improving the food system. Despite this fact, these scientific principles have been used as tool to primarily increase profit, and the concept of seed patenting rights supports this idea. GM seeds are in the hands of a few organizations, most notoriously Monsanto, Dupont, and Syngenta, who have patenting rights and therefore control over who plants the crops and where they are to be used. As of 2006, these three companies together accounted for $9,000 million, or 39% of the worldwide proprietary seed market; the proprietary seed market refers to commercial seed that is subject to intellectual property (ETC Group, 2006). Why do these concepts cause problems? Seed patenting rights have restricted how GM seeds can be used, thus inhibiting any of the potential positives of this agricultural science. A mere three companies, Monsanto, Dupont, and Syngenta, control 53% of the world's commercial seed market (Harris, 2013). This consolidation directly thwarts all of the well-intended efforts GM crops may have, because it takes away farmer rights and promotes seed homogenization. Have we adequately assessed how planting the same Bt corn seed all around the world affects the biodiversity needed to maintain success and viability in agriculture ? One major drawback of GM crops is that they promote genetic homogeneity and large-scale monocultures. The problem with monocultures, or continuously growing a single crop or plant species over a wide area, is that they contribute to loss of biodiversity and increase vulnerability of crops to climate change, pests, and diseases (Gertzberg, 2011). Why have the rights to plant and replant seeds been stripped away from the individuals who are actually producing our crops? In order for GM crops to truly be used as a tool promoting health, science, and progress, the concept of seed control must be abolished from the discipline. In addition, we should also realize that genetic engineering is not the only modern agricultural technique that can be used. For example, Rattan Lal, director of the Carbon Management and Sequestration Center at Ohio State University, has emphasized the need to develop farming practices that promote carbon sequestration. Lal argues that we can capture carbon that has been released due to fossil fuel use by developing novel farming practices that promote carbon sequestration (Schless-Meier, 2014). We must use all of this knowledge we are increasingly gaining, including genetic engineering, to improve the food system as opposed to creating a consolidated entity that is profit-driven.

Knowledge of this entity we have coined as the "GM crop network" may have paradoxically overwhelmed individuals. However we need to remember that, "knowledge is power" and that the goal of education is to empower or rather activate the power that comes prepackaged with learners (Vella, 2002). The paragraphs above explain how environmental, economic, and political factors directly relate to GM crops, and how Bt corn is more than simply a seed that has been scientifically enhanced.. That being said, we have left out arguably the most important branch of the network, the relationship between human health and Bt corn. Specifically, it is interesting to ask how the greatly evolved and sophisticated human immune system recognizes Bt corn.

How is it that humans have been able to compete with species such as bacteria and viruses, which replicate thousands of times quicker and thus evolve more rapidly than us? Evolution requires a change in the germ line, and thus has potential to occur every time a species reproduces or a cell replicates. The problem is that our low frequency of reproduction and non-error prone or "faithful" DNA polymerase provides us with relatively little opportunities to evolve as quickly as bacteria does. To this extent, we must thank our flexible and "plastic" immune defenses for our survival, as our immune responses are able to evolve during the course of our lifetimes.

Adaptive immunity is just that, a system which is able to change and adjust to the foreign pathogens we habitually encounter. It is created so that our bodies can recognize an infinitely diverse spectrum of molecules that may be harmful. Mechanistically, it is formed by random rearrangements at the DNA level in regions encoding for B cell or T cell receptors. Why does this matter with respect to Bt corn though? Recall that the crop's pest protection is encoded for by a gene. When expressed, a bacterial protein binds to the intestinal epithelial cells of specific insects which forms a pore. This induces cell death due to osmolarity imbalances. Mammalian intestinal epithelial cells lack the primary receptor for this set of Bt (Cry) proteins. It is not too extreme too question if our immune system recognizes these bacterial-derived proteins as foreign, and thus generates a specific immune response to them.

Cry proteins, due to their bacterial origin, have the potential of inducing a human immune response, innate or adaptive. Opposite to adaptive immunity, the innate immune system, recognizes conserved pathogen-associated molecular patterns , which can be of bacterial, viral, fungal, or parasitic origin (Kuby, 2011). Receptors of the human innate immune system can bind to and interact with these broad classes of foreign molecules or patterns and are therefore referred to as pattern recognition receptors (PRRs). With this information, the scientific hypothesis of my research project can be demonstrated. Bt corn expresses a gram-positive bacterial protein that binds to insect intestinal epithelial cells, to ultimately induce cellular death. And although human intestinal epithelial cells lack the Cry protein receptor, we have an immune system that is genetically programmed to recognize "foreign" molecules. It is thus hypothesized that humans consuming Bt corn can be exposed to a certain concentration of Cry protein(s) expressed by the crop, and generate a peripheral and/or intestinal immune response .

Towards answering such questions, I have developed an individual research project which studies peripheral and mucosal immunity to the Cry1Ab protein expressed in Bt crops.

I have always had a curiosity for food, its connected disciplines, and how they collectively influenced health. And due to the lack objective, evidence-based information available to the lay food consumer and my interests in this subject, I aimed to create a project that could begin to pursue answers but also pose more intriguing questions regarding Bt crops.

The study I created investigates the interaction between the humoral adaptive immune system and the Cry1Ab protein, one member of the Bt toxin family. I hypothesized that due its bacterial origin and immunogenicity in animal models, the Cry1Ab protein is not seen as an innocuous food antigen, and is thus capable of overriding homeostatic oral tolerance mechanisms to induce an antibody response in humans. In order to test this hypothesis, I have created a highly sensitive enzyme-linked immunosorbent assay (ELISA) specific for the CryAb protein that will enable appropriate serological testing.

The primary aim of this study is to determine whether humans develop Cry1Ab-specific antibodies. Specifically, the study is interested in testing for the presence of Immunoglobulin G (IgG) and Immunoglobulin A (IgA) antibodies present in serum and intestinal secretions respectively. The goal is to correlate and compare the humoral response within the mucosal and peripheral immune systems, and thus answer questions regarding Cry1Ab immunogenicity in humans.

As we continue to incorporate these GM plants into the global food system, there is an increasing need for evidence-based research regarding such transgenic crops . We must realize the future of our environment and health is tied largely to both agriculture and food production methods. However, food is also central to the traditions many of us look forward to each year; food's impact on culture, and therefore larger societal growth, must also not be forgotten. Going forward, it is vital that we consider the individual, public, cultural, and environmental aspects of food and genetically modified crops for a better tomorrow.

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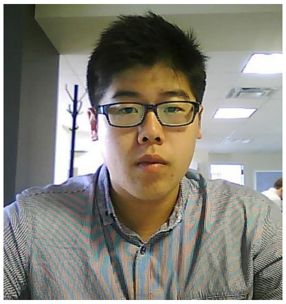

BIOGRAPHY
A graduate with a B.S. in Accounting and Management: Finance, Inho Choi is on track to become a CPA. Although unrelated to his coursework, Inho has always taken an interest in food and holistic medicine. His interests in these topics have inspired him to discover the truth behind the many labels and food certifications. In his free time he likes to look into nutrition and health and hopes for a brighter future for food and medicine.

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Hannah Bidigare-Curtis

No Photo Available

BIOGRAPHY

Hannah Bidigare-Curtis graduated from Granville High School in central Ohio and is going into her fourth year at CWRU as a Biology and Environmental Studies Major. She is currently an executive member of CWRU's Student Sustainability Council and has participated in various school programs such as CCEL Scholars. Hannah has previously grown produce to sell at her hometown's farmers market and presently works at the University Farm. She hopes to be involved in agriculture in the future.

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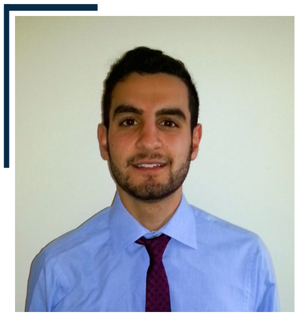
Alexander Razavi



BIOGRAPHY

Alexander Razavi is a senior biochemistry, pre-medicine student. He has been working at the Center for Global Health and Diseases at the Case Western School of Medicine since August 2012. Alex's interests in food as it relates to public health, medicine, and science have led him to start Case Western's own Slow Food campus chapter as well as create an individual research project studying Bacillus thuringiensis (Bt) crops. His research project involves studying systemic and mucosal humoral immunity to the Cry1Ab protein expressed in Bt crops, and in addition to pursuing his scientific laboratory goals, he would like to inform students and faculty about the multidisciplinary network surrounding genetically modified crops in general.

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