Faith & Reason Honors Program

**SENIOR THESIS**

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The Face of Hunger
By: Oswald Mbuyiseni Mtshali

I counted the ribs on his concertina chest
bones protruding as if chiselled
by a sculptor's hand of famine.

He looked with glazed pupils
seeing only a bun of some sky-high shelf.

The skin was pale and taut
like a glove on a doctor’s hand.

His tongue darted in and out
like a chameleon’s
snatching a confetti of flies.

O! child,
your stomach is a den of lions
roaring day and night.

The picture of hunger is not something which we are unaccustomed to seeing. It is in our newspapers, on the news station, and especially on those television specials that ask for donations in order to sponsor children. However, it is something with which many of us are not familiar. To paint a truer picture of hunger, here are some statistics. Approximately one in six people on the planet is hungry. One in twelve people worldwide is malnourished, including 160 million children under the age of five. Nearly one in four people live on less than $1 per day. An additional 3 billion people survive on $2 per day. Every year 15 million children die of hunger. Every 3.6 seconds someone dies of hunger. 800 million people still live with chronic

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2 Hunger Report 2005
hunger and suffer malnutrition which is about 100 times as many as those who actually die from it each year.

Though, overall global food security will improve during the next 10-20 years, but it is expected to decrease in sub-Saharan Africa and South Asia. The issue is not that there’s a lack of food. In recent years, famines have only occurred as a result of wars. The last major non-war famine was the Chinese Great Leap Forward famine which occurred from 1958 to 1961.\(^3\) The reality is that the world produces enough food to feed everyone.\(^4\) In fact, here is enough food for every single person to have about five pounds of food per day.\(^5\)

So why aren’t we feeding everyone? There are many reasons, but one major reason is the cost of distribution. Much of the food is produced in developed countries. After the food is produced, it is necessary to consider the cost of packaging it, transporting it, and distributing it. Take the following statistic for example:

A survey of all the costs involved in producing a loaf of bread and delivering it to a UK retail store found that less than one third of energy was spent on growing and milling the wheat. Getting it to market, including packaging and transportation accounted for almost two thirds of energy needed.\(^6\)

If the cost of delivering food to a UK retail store is so high, imagine what it would be to deliver food to a developing country. Now imagine what the cost would be to deliver the food to an entire continent. Now imagine that this continent is a

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\(^3\) http://library.thinkquest.org/C002291/high/present/index/htm
\(^4\) Hunger Report 2005
\(^5\) http://library.thinkquest.org/C002291/high/present/index/htm
\(^6\) http://library.thinkquest.org/C002291/high/present/index/htm
continent with a poor infrastructure, corrupt governments, a large youth population, and a health epidemic...Africa. It is, without a doubt, expensive and difficult.

The logical solution to the high costs of packaging, transportation, and distribution would be to produce the food closer to the hungry. Many people shout for genetically modified crops to cure the problem of starvation. A leading biotechnical company, Monsanto, says: “Biotechnology is one of tomorrow’s tools in our hands today. Slowing its acceptance is a luxury our hungry cannot afford.”

Another remarks that “Genetically-modified foods have the potential to solve many of the world’s hunger and malnutrition problems, and to help protect and preserve the environment by increasing yield and reducing reliance upon chemical pesticides and herbicides.”

Despite these strong professions of certainty that genetically modified crops are the answer to world hunger, there are reasons to doubt their truth. Genetically modified crops are not the answer to starvation in sub-Saharan Africa.

**Africa Today**

Today Africa is not in the best position. In the midst of corrupt governments, Africa is struggling to get by. To help Africa, it is necessary to focus on farmers in rural areas because three out of four hungry people in the world live in rural areas. Half the world’s hungry live on marginal lands, meaning that the lands are

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8 Deborah Whitman. Genetically Modified Foods: Harmful or helpful? p. 13
subjected to whether problems, poorer soils, more pests, and unfavorable conditions like steep slopes. 75% of Africans depend on farming for a living. Despite this, most countries in Africa have invested less than five percent of their budgets in agriculture. Other problems besides hunger in Africa include education, HIV/AIDS, and women’s rights. As the World Report 2005 puts it, “Where there is hunger there is poverty, as well as a raft of other problems. To address one without the others misses the complexity of the problem.”

In sub-Saharan Africa, one third of the population is undernourished and the numbers are increasing. It is the only region in the world where the proportion of people living in extreme poverty has increased over the past two decades. Besides HIV, the population is also facing diseases such as malaria and tuberculosis. These diseases hit harder than one would realize. In Zambia, one study showed that households headed by a chronically ill member planted up to 53% less area than households without a chronically ill member.9 Sixty to seventy percent of farms had labor loses due to HIV/AIDS alone. These people rely on their bodies as their most important tool, however. “The poorer people are, the less educated or skilled, the more their livelihood is likely to involve physical work, whether in farming or other physical urban or rural activities. Shortage of food and sickness then not only cause pain and anguish but also weaken and devalue the asset and reduce returns to work.”10

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9 World Hunger Report 2005
The good news is that Africans are not being ignored. In 2000, the UN developed 8 Millennium Development Goals for the year 2015 which, if achieved, would significantly help Africa. They are as listed below:

1. To eradicate extreme poverty and hunger: Reduce by half the proportion of people living on less than a dollar a day and reduce by half the proportion of people who suffer from hunger
2. Achieve universal primary education
3. Promote gender equality and empower women
4. Reduce by 2/3s the mortality rate for children under five.
5. Reduce by 3/4s the maternal mortality ratio
6. Halt and begin to reverse the spread of HIV/AIDS, incidence of malaria, and other major diseases.
7. Ensure environmental stability
8. Develop a global partnership for development

Unfortunately for sub-Saharan Africa, these goals, as of 2007, are not becoming a reality. By breaking the eight goals into 18 sub-goals, Africa has only seen progress in one sub-goal. Nine of the sub-goals were rated as “No progress, or a deterioration or reversal.” Eight other sub-goals were listed as “Target is not expected to be met by 2015.” The only goal that is still expected to be achieved by 2015 if current trends persist is measles immunizations.11 After seeing these results, it is easy to turn to a quick answer such as genetically modified food.

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Genetically Modified Food

Genetically modified food is a subdivision of genetic engineering. Genetic engineering is the process of changing the genetic material in a living organism. The genetic material is stored in DNA, which is essentially a long chemical molecule. There are several ways of rearranging, deleting, and combining genetic material.

This technology, known as recombinant DNA technology, was discovered in 1972 by a man named Paul Berg. Berg inserted viral DNA into bacterial DNA. In 1973, two men, Herbert Boyer of the University of California and Stanley Cohen of Stanford University, reported functioning organisms that were constructed by the combination of genetic information from different species. Theses species were also able to replicate this information.\(^\text{12}\)

How does this technology work? Basically, new DNA can be constructed by taking a fragmentally modified end of DNA and attaching it to a previously prepared DNA vector which can replicate on its own in an appropriate host. The vector is prepared by cleaving it or cutting it at a certain site which will make the two pieces complementary or capable of being attached.\(^\text{13}\) The technology makes it possible for specific mutations to be created.

There are three ways to make these specific mutations. The first way is a deletion. It involves a circle of DNA called a plasmid. The plasmid is found mostly


in bacteria, but can be found in higher functioning cells. They act as “accessory chromosomes” which means they contain genetic material. This circular DNA can be cut in two places and a section of DNA can be removed. The ends of the circle are then reattached. A smaller deletion can be made by making only one cut and digesting the ends before reattaching. The second way to make a mutation is to make a substitution. Using this method, it is possible to change a single amino acid if the sequence around the targeted amino acid is known and if there is an available plasmid containing the gene. The third method is insertion. In this method, a section of the plasmid DNA is cut and removed, but another section of DNA is inserted in its place. New genes or designer genes can be produced by combining fragments that are not associated with each other in nature.\(^\text{14}\)

New DNA can be inserted into plant cells in two ways. One method is called electroporation. In this method, the hard outer wall or cellulose wall surrounding the cell is removed using an enzyme, cellulase. The plant cells are then combined in a suspension with plasmid DNA molecules. Electric pulses are then applied making the plant cells permeable enough to allow the plasmid DNA molecules to enter. The cell wall is then allowed to reform. Afterwards the cells express both its own DNA and the new DNA from the plasmid molecule. Two examples of crops this method has been used on are maize cells and carrot cells. The plasmid inserted into these crops included genes for resistance to antibiotics.

Another way DNA can be inserted into plant cells is using bombardment-mediated transformation or “gene guns”. In this method, the DNA is coated onto

\(^{14}\) *Biochemistry* p. 147-148.
tungsten pellets and fired at the plant cells with velocities greater than 400 m/s. This method is highly effective and has been used in soybean crops, corn crops, wheat crops, and rice crops.  

There are many anticipated advantages to these crops and many advantages that are said to have been achieved. One major advantage in crops that are widely manufactured is pest resistance. Pest resistant crops help cut financial lost to farmers since their crops are no longer being destroyed. These crops also allow for fewer chemical pesticides which has the dual advantage of being more environmentally friendly and cheaper for farmers. Another widely manufactured advantage is herbicide tolerance. The advantage for farmers is they can spray weed-killer without worrying it may also kill their crops. Farmers using this technology would only have to spray once, using one powerful herbicide product instead of multiple times which reduces cost to farmers and limits the amount of agricultural waste run-off. A third potential advantage is disease resistant crops. These crops are modified so that viruses and fungi that would normally destroy the crops no longer do. Currently, only the virus resistant crops are on the market. 

Several more advantages deal with modifying the crop to survive in conditions it would not normally be able to survive in. For example, a fourth advantage is cold tolerant crops. The major advantage for farmers is that they can plant their crops earlier in the season and not worry about frosts. Cold tolerant
crops are engineered by inserting an antifreeze gene from a cold water fish into the plant. A fifth advantage is salinity tolerance and drought tolerance. These crops have a better chance of growing on marginal lands. There is some belief that salt water will be used to water some crops.

There is also hope that genetically modified crops will not only increase yields as in the above examples, but also go beyond the crops natural ability. For example, researchers at the Swiss Federal Institute of Technology Institute for Plant Sciences engineered a “golden” rice which contains a very high content of vitamin A. This project was funded by the Rockefeller Foundation; this means that golden rice seeds will be available to any third world country. Continued efforts have been waged improve the nutritional value of staple crops in order to fight malnutrition. There is also research on engineering edible vaccines, specifically in tomatoes and potatoes. These vaccines would be easier to ship, store, and administer than the current injectable vaccines.\textsuperscript{18}

Some potential advantages, like the fungi resistant crops have not yet been achieved. Also, researchers have yet to make available drought tolerant crops.\textsuperscript{19} In fact, in 2000, 74\% of the genetically modified crops were herbicide tolerant, 19\% were insect pest resistant, and 7\% were both,\textsuperscript{20} leaving an insignificant percentage for the remaining potential benefits.

\textsuperscript{18} Whitman, Deborah B. Genetically Modified Foods: Harmful or Helpful? Page 3
\textsuperscript{19} http://www.enn.com/agriculture/article/29184
\textsuperscript{20} Whitman, Deborah B. page 4
Issues with genetically modified crops

The first food to be commercialized was a tomato made to keep its firmness for a longer period of time. This was done by introducing DNA that disrupted an enzyme called polygalacturonase. In a normal tomato, polygalacuronase destroys pectin, which is responsible for the tomatoes’ firmness. Unfortunately, the tomato was not successful on the market because it did not taste good.\textsuperscript{21}

However, the failure of the first tomato does not mean that many other genetically modified crops have failed as well. Today, the use of genetically modified food is prevalent in the United States. In 2000, 68\% of all genetically modified crops were grown by U.S. farmers. The next three largest producers were Argentina, Canada, and China at 23\%, 7\%, and 1\% respectively. The remaining 1\% of all genetically modified crops were grown by Australia, Bulgaria, France, Germany, Mexico, Romania, South Africa, Spain, and Uruguay. Soybeans and corn made up 82\% of all genetically modified crops followed by cotton, canola, and potatoes. From 2000 to 2006, the acres of land supporting genetically modified food increased from 109 million acres to 253 million acres.\textsuperscript{22,}\textsuperscript{23} In 2000 in the U.S., 54\% of all soybeans, 61\% of all cotton, and 25\% of all corn was genetically modified. While most fruits and vegetables at the supermarket are not genetically modified, consumers unknowingly consume genetically modified products in highly processed foods such as vegetable oils and breakfast cereals. Soybean derivatives are used in

\textsuperscript{21} Biochemistry p. 158
\textsuperscript{22} Whitman, Deborah B. page 4
\textsuperscript{23} Genetically Modified Foods and Organisms, genomics.energy.gov
so many processed products that it is very unlikely a consumer in the U.S. has not been exposed to a genetically modified crop.\textsuperscript{24}

More recently, in 2006, the United States produced 53\% of all genetically modified crops. They were followed by Argentina at 17\%, Brazil at 11\%, Canada at 6\%, India at 4\%, China at 3\%, Paraguay at 2\%, and South Africa at 1\%.\textsuperscript{25} While the overall percentage of genetically modified crops produced in the United States decreased, the United States is still producing more than half of them. This does not mean that the United States is producing fewer crops, on the contrary, genetically modified crops have increased in the past few years. The chart below shows the percentage of acres on which five different genetically modified crops are planted.\textsuperscript{26} The herbicide tolerant crops (HT) are the most used crops in the United States. In fact, in 2007, over 90\% of the land used to grow soybeans supported herbicide tolerant soybeans. The Bt crop lines in the chart represent pesticide tolerant crops. These crops use genes from one soil dwelling bacteria, bacillus thuringiensis, to create toxins harmful to pests but not to humans. Since the total percentage of all genetically modified crops grown in the United States decreased, and the amount of genetically modified crops grown in the United States increased, the implication of this chart is that the amount of genetically modified crops grown worldwide has increased in the past 6 years.

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\item\textsuperscript{24} Whitman, Deborah B. Page 4
\item\textsuperscript{25} Genetically Modified Foods and Organisms, genomics.energy.gov
\item\textsuperscript{26} http://www.ers.usda.gov/Data/BiotechCrops/
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While the amount of genetically modified crops increased, it must be noted that the United States is, by far, the largest producer. Despite approval by the F.D.A., other developed countries have their doubts in working with genetically modified crops. The European Union had a ban on imports of genetically modified food from 1984-2004 that ended only when the United States, Argentina, and Canada sued the European Union for violating international trade laws. The World Trade Organization decided the European Union had until November 21, 2007 to lift its band. This date was later extended to January 11, 2008. This ruling does not alleviate the controversy that genetically modified crops have caused in Europe.

Austria is still refusing genetically modified imports from Bayer in Germany and Monsanto in the United States. While there is debate upon mandating Austria to accept these crops, there is not an end in sight due to potential health hazards and overall public opinion that genetically modified foods are not safe. Whether or not they are safe, European consumers do not when them on their shelves. Despite
the fact the United States insist these crops are safe, and that a EU study in 2005 reached the same conclusion, the Environmental Commissioner insists that new evidence has come to light that requires further investigation.\textsuperscript{27}

The European Union has argued that each country must make its own decision to whether genetically modified crops are appropriate for its own people. Besides potential threats to human health and the environment, Europeans argue that many of these crops have some undesirable characteristics that, while safe in some places, will not necessarily be safe in other areas. Even if these crops are put on the market, it does not mean they will be purchased. In a 2005 poll by the European commission, 54\% of people said they thought genetically modified food was dangerous. Also, unlike the United States, European countries have stricter labeling policies and genetically modified food will be no exception to this labeling process, as will processed food that contains genetically modified crops. The WTO decision also cannot force farmers to grow genetically modified crops.\textsuperscript{28}

The European countries are not the only places that do not want genetically modified food. China has banned commercial planting of genetically modified rice, wheat, corn, and soybeans. Egypt has said it will not import genetically modified wheat. Greece has banned AgroEva herbicide-resistant seed and imposed a moratorium on all genetically modified crop trials. In India, farmers spoke out against genetically modified crops, but the government is trying to promote them. Japan imports genetically modified corn from the United States, but has banned

\textsuperscript{27} http://www.iht.com/articles/2007/11/22/business/geneticallymodifiedo.php
\textsuperscript{28} http://www.genewatch.org/article.shtml?als%5Bcid%5D=405264&als%5Bitemid%5D=507938
genetically modified wheat. Additionally, 82% of Japanese consumers view the genetically modified movement as negative. Saudi Arabia has banned all imports of genetically modified crops. In Scotland, 25 of 32 school districts banned genetically modified foods from their menus. Many other countries are implementing mandatory labeling.\textsuperscript{29}

Why are all of these countries exercising such caution in dealing with this new technology? The major reasons are potential health issues and potential environmental issues. Because the technology is so new, there has been much debate over the available scientific research. Companies that promote genetically modified foods find problems with research done by anti-genetically modified scientists while those scientists opposed to genetically modified crops criticize research done by those companies. However, there are enough reports with negative findings to warrant the cautionary approach taken by the above countries.

In \textit{Censored 2007: Media democracy in action}, four previous research studies were examined. The first study was done by the Russian Academy of Sciences. These researchers found that “more than half of the offspring of rats fed genetically modified soy died within the first three weeks of life, six times as many as those born to mothers fed on non-modified soy. Six times as many offspring fed genetically modified soy were also severely underweight”

A second study, which was done in Australia in 2005, stopped their research on a genetically modified pea cultivator after finding it caused an immune response in laboratory mice. Also in 2005, an Italian research team found that, “absorption

\textsuperscript{29} http://www.thecampaign.org/international.php
of genetically modified soy by mice causes development of misshapen liver cells, as well as other cellular anomalies.”

Finally, in 2005, a controversial report was published on the affects of Monsanto’s MON 863 corn in The Independent/UK. Dr. Arpad Pusztai, an independent scientist, was asked by German authorities to review the scientific report. The study found, “‘statistically significant’ differences in kidney weights and certain blood parameters in the rats fed the genetically modified corn as compared with the control groups.” However, the corn was approved and is on the market. While some may insist that the corn would only be approved if it was deemed safe, this may not be the case. The United Nations’ Food and Agriculture Organization has stated, “In several cases, GMOs [Genetically modified organisms] have been put on the market when safety issues are not clear.”

Arpad Pusztai, an expert in his field, is familiar with research done in the field of genetically modified food. Dr. Pusztai has a degree in chemistry from Budapest Hungary, a B.Sc. in physiology from the University of London, and a Ph.D. in biochemistry from the University of London. He has worked at universities and research institutions throughout the world and published almost 300 peer-reviewed papers as well as wrote and/or edited 12 books. In one such paper, Pusztai writes on the safety of genetically modified foods to humans and animals. He looks at several animal studies and the requirements for crops to be approved for commercial sale. Pusztai finds that many of the studies were poorly conducted and insists that the requirements for crop approval are much too lenient.

\[30\] Censored Media Democracy in Action 2007: The Top 25 Censored Stories
Pusztai states that there are three reasons why there is very little information about the safety of these foods. First, these crops are much more difficult to evaluate than drugs or food additives because they vary in their composition according to growth and agronomic conditions. Secondly, there is little information on potential affects of these crops on the human body. No peer-reviewed publications of clinical studies on the effects of genetically modified food on human health exist. Pusztai also mentions that while there are animal studies, they are few. This is because animal studies are only required when genetically modified food is not the “substantial equivalent” of traditional crops. However, “substantial equivalence is an unscientific concept that has never been properly defined and there are no legally binding rules on how to establish it.”

Instead of using substantial equivalence, Pusztai recommends using animal testing. This is because the methods used to make genetically modified crops could have potential side effects. DNA does not always break down in the digestive tract and could be picked up by gut bacteria, which would then contain genes for antibiotic resistance. It is unpredictable how inserted genes will react with host DNA and the insertion can lead to new allergens. Further, it is impossible to test for new allergens since they are unpredictable. While new crops are being tested against known allergens, Pusztai pushes for further animal testing since not all allergens can be known.

Pusztai continues his article by evaluating several studies that claim to demonstrate the safety of genetically modified food. The first one is the FLAVR

31 http://www.actionbioscience.org/biotech/pusztai.html#fullbio
SAVR tomato which was designed by a method that was neither peer-reviewed nor published. While this crop was deemed safe and approved by the FDA for commercial sale, Pusztai finds:

- The unacceptably wide range of rat starting weights (±18% to ±23%) invalidated these findings.
- No histology on the intestines was done even though stomach sections showed mild/moderate erosive/necrotic lesions in up to seven out of twenty female rats but none in the controls. However, these were considered to be of no importance, although in humans they could lead to life-endangering hemorrhage, particularly in the elderly who use aspirin to prevent thrombosis.
- Seven out of forty rats on genetically modified tomatoes died within two weeks for unstated reasons.

Another evaluation involved two lines of herbicide-resistant genetically modified maize. Because these lines were found to be substantially different, toxicity tests were done using rats. Pusztai claims the research was flawed and may have some potential health problems for humans because:

- The starting weight of the rats varied by more than ±20% and individual feed intakes were not monitored.
- Feed conversion efficiency on PAT-PROTEIN was significantly reduced.
- Urine output increased and several clinical parameters were also different.
- The weight and histology of the digestive tract (and pancreas) was not measured.

Feed conversion efficiency relates to the ability of the organism to convert food to body mass. If this ability was reduced it means the rats were no longer efficiently digesting their food.

A safety test of an herbicide resistant soybean determined it substantially equivalent to the parent line. However, in the scientific study, significant
differences were recorded and the method used to evaluate them was flawed. Pusztai claims the soybean should not be regarded as substantially equivalent.

In a lengthy study conducted to see if two strands of glyphosate-resistant (weed resistant) soybeans affected animals differently then conventional soybeans, the researchers concluded that the effects of the crops on animals were similar. Pusztai finds among other factors:

- The feeding value of the two GTS lines was not substantially equivalent either because the rats grew significantly better on one of the GTS lines than on the other.
- The experiment with broiler chicken was a commercial and not a scientific study.
- The catfish experiment showed again that the feeding value of one of the GTS lines was superior to the other.
- Milk production and performance of lactating cows also showed significant differences between cows fed genetically modified and non-genetically modified feeds.

In terms of allergic reactions, Pusztai says that, “it is at present impossible to definitely establish whether a new genetically modified crop is allergenic or not before its release into the human/animal food/feed chain.”

Besides potential health risks, there are also several environmental risks despite the belief that genetically modified foods can be more environmentally friendly than conventional crops. The one major risk associated with genetically modified food is that of genetic drift. Genetic drift is the fluctuation of a gene pool overtime. The problem with planting genetically modified crops is that most of them have genes with traits that resist herbicides and pesticides. If these plants breed with native plants or weeds through wind pollination or insect pollination,

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32 http://www.actionbioscience.org/biotech/pusztai.html#fullbio
the herbicide and pesticide resistant genes are introduced to the native population. The concern is that weeds will become herbicide resistant and spread much more rapidly, overtaking other populations. Issues also arise if the genetically modified plant breeds with conventional plants or other genetically modified species.

An important thing to remember is that this process does not happen overnight. Full introgression, meaning a specific gene from one species is integrated into the gene pool of another species, takes a lot of time and requires backcrossing for the gene to be stable in the new species. The process requires several generations of hybrids exchanging genes over several years. In order to test for introgression, small populations can be used.

There are 65 sufficiently documented cases of introgression. The actual number of cases is believed to be much higher. This is because most identified cases involve plants that are distantly related or involve cases of recent introgression. It is much more difficult to detect introgression between closely related species because of their similar make-up. It is more difficult to detect older cases of introgression because there has been more time for mutation and to disguise genes. It also must be noted that when traditional introgressions have been done, certain species are forced to be pollinated. In nature, it takes much longer for these crossings to occur.

One review looked at several genetically modified crops in the United States and placed them in four categories based on the likelihood of the crops spreading to their wild relatives. The very low risk crops included the soybean, finger millet,
pearl billet, common bean, peanut, and potato. One reason for the lack of drift is that some plants, such as soybean, are planted geographically far from their wild relatives. There is no chance for the crops to mix.

The low risk crops include corn, cotton, and rice. Some caution should be taken with these crops to keep them away from their wild relatives. Corn has been known to hybridize with its wild relative, teosinte, however, the gene flow is usually from the teosinte to the corn rather than from the corn to the teosinte. There also has been introgression from a natural weedy Asian rice and its wild relative in Thailand. However, the hybridization levels are only around 1-2% and not considered overly significant. Cotton is capable of introgression, but its wild relatives are mostly grown in the American tropics.

The moderate risk crops include alfalfa, sugar beet, wheat, canola, and sunflower. Some of their wild relatives are agricultural weeds which means there is a chance for the weeds to become tolerant to stress, insects, or herbicides. In the cases of alfalfa and sugar beet, “they would probably introgress into their wild relatives and produce herbicide tolerant weeds.” Bread wheat is related to goatgrass, which is a weed used in cereal production. Most bread wheat has not been made to be glyphosate-tolerant due to the fear of it mixing with goatgrass. While most hybrids of the two are sterile, two are not, and field studies have shown a 1% backcross seed production rate. This is significant because it means that a small number of hybrids have crossed with a plant genetically identical to its parents, which makes the hybrid more stable. In Canada, herbicide-resistant weeds
have become a reality, as glyphosate-tolerant weed has appeared in canola fields. The high risk crops in this study only include sorghum which is a cereal grass. It is known to hybridize with its wild cousin, a harmful weed, and should not be genetically modified for herbicide resistance.

Despite the above categories, the above review cautions that, “we do not have a comprehensive understanding of the risks of transgene [genetically modified] introgression.” Furthermore, “there is still much research to be done before we fully understand the risks that are associated with introgression from transgenic crops.”

Besides the glyphosate-tolerant weed in Canada, there have been several other reports that cite evidence of genetically modified food crossing with other plants in its surrounding environment. In 2006 study, glyphosate-tolerant creeping bent grass was found 3.8 km from the control area. In a different study, scientists used a model under realistic field conditions. They planted three of the 1st generation hybrid plants of a radish and its weedy relative and three of the weedy radish plants. They stimulated agricultural management and environmental conditions until they had 3rd generation hybrids. They then grew the parent species with the 3rd generation hybrid in different densities. In their study, they found that the hybrid would replace the original radish population throughout the state of California. Finally, in 2002, Prodigene’s pharmaceutical maize cross-pollinated in Nebraska with soybean and cross-pollinated in Iowa with conventional maize. It

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33 Transgene introgression from genetically modified crops to their wild relatives
34 Born to run: competition enhances the spread of genes from crops to wild relatives
cost more than three million dollars to clean up the mess. While this mistake was
catch before the hybrids spread, it is not a lone incident. Similar incidents have
occurred with Starlink maize and Liberty Link rice 601.  

The issue of genetic drift is not only an environmental one, but also a legal
one. If two neighboring farms raise different crops, one genetically modified maize
and the other conventional maize, and genetic drift occurs, one farmer could be
raising some of the genetically modified maize without buying rights to it. This
raises several questions. Can the company take legal action against the farmer who
unknowingly raised the genetically modified crops? Should the company take legal
action against the farmer who bought the crop, but allowed it to spread? Is it even
possible to take action against the spreading of the crop? Whose responsibility is it
to fix the problem and separate the genetically modified crop from the conventional
crop? Who should monitor the spread in the first place? If the company should
monitor it, how will they do it? If all farmers are responsible for monitoring their
own crops and make sure genetic drift isn’t occurring, how should they do it?

In the case of Schmeiser v. Monsanto Canada, the Supreme Court of Canada
attempted to answer some of these questions. In this case, Monsanto brought a
farmer to court for growing its patented ‘Roundup Ready’ canola on the farm
without buying the seed. Schmeiser did not know how the seeds got on the land,
but she cultivated them anyway. While Schmeiser did not make use of the benefits
the crop provided by spraying Roundup, she did cultivate the crops and was found
liable. Instead of cultivating the crop the farmer should “have been able to

35 GM biotechnology: friend and foe?
demonstrate that the presences of the crop ‘was accidental and unwelcome’” and should have “acted quickly to arrange for its removal.” This is a dangerous ruling because it shifts the burden of controlling the spread of genetically modified crops to non-genetically modified farmers. However, a the court refused to award Monsanto financial remedies because Schmeiser had made no profit using the crop and the yield was the same as if conventional seeds were used. As one US circuit judge said in a different US case, “The implication- that the patent owner would be entitled to collect royalties from every farmer whose cornfields contained even a few patented blue stalks – cannot possibly be correct.”

Besides health risks, environmental risks, and legal risks, doubt is raised as to whether or not genetically modified crops really do what they are suppose to do. In a ten year study, four genetically modified crops were grown in twelve different habitats and compared with their conventional counterpart. Two crops, oilseed rape and maize plants, were tolerant to the herbicide glufosinate. The sugar beat was tolerant to glyphosate. Two types of genetically modified potatoes were used – one was Bt resistant (pest resistant) and the other contained pea lectin.

After the first year, neither the genetically modified nor the conventional crops increased in abundance. In fact, populations for all crops decreased due to competition from native plants. The genetically modified lines did not last longer than the conventional lines. In terms of seedling establishment in oil rape seeds, the genetically modified plants had significantly less establishment in six out of the twelve cases and were not greater in any case. In the maize crop, seedling

36 Case Note : Patent liability and genetic drift
establishment was less for the genetically modified crop in only two out of twelve cases, but not higher in any of the cases. Potato survival of the genetically modified crop was higher in one case out of eight, but lower in one case out of eight, indicating no true difference. After ten years, only one site retained potato crop, but all the survivors were the conventional crop. As for the sugar beets, survival of the genetically modified seedlings was significantly lower at one site, but all crops were extinct within three years.\textsuperscript{37}

One professor of agronomy at the University of Wisconsin has been studying soybean varieties for the last 25 years. In 1999, Ed Oplinger looked at the 12 states that grew 80\% of the soybean yields in the United States. He found that yields from the genetically modified soybeans were actually 4\% lower than from the conventional varieties.\textsuperscript{38}

Despite these cautions, some still argue that genetically modified crops do work, because people would not be spending money buying them or time cultivating them if they didn’t. Why shouldn’t we send the genetically modified seeds to Africa to help feed their hungry? The risks appear small and Americans have been eating genetically modified food for a long time. Don’t we have the moral obligation to feed our brothers and sisters if we have the means to do so?

\textsuperscript{37} Transgenic crops in Natural Habitats: Nature
\textsuperscript{38} Poverty: Opposing viewpoints
Genetically Modified Crops in Africa

Although there is not much research on it, some animal studies have had negative effects from consuming genetically modified food, including death, abnormal cell growth, stomach lesions, and digestion problems as mentioned above. There is no research saying Americans have been similarly affected. However, before these crops are introduced to the African people, further tests need to be done. In animal studies, the largest, if not only, part of their diet is the genetically modified food being tested or its conventional counterpart in the control group. In contrast, it is likely that Americans are eating several varieties of genetically modified food and no one crop is affecting them greatly. Additionally, Americans usually do not eat just one type of food (ex. Maize or wheat) as the main staple of their diet. This may be why Americans have not noticed any health risks. In remote areas of Africa, seventy to eighty percent of the calorie intake is from staple crops. Any health risks that show up in animals will most likely also show up in these people.

Genetically modified advocates are not unaware of this fact. They actually want to use it as a way to help people. As of now, despite all the genetically modified crops planted, the poor have not seen any benefit. Initially, genetically modified companies did not have a market in developing countries. They did not pour research money or time into developing a crop for Africa that would not pay off. However, things are changing. Not only are independent, non-profit organizations in on the new “golden rice”, but genetically modified giants are
offering their services. To some, this seems like progress. Others criticize it as a ploy to make genetically modified food more acceptable. It doesn’t matter which way you look at it, because the “golden rice” is not all it is boiled up to be.

The main focus is currently on a line of rice with an added beta-carotene pathway, which is the precursor for Vitamin A. Vitamin A deficiency is a major cause of pediatric blindness in developing countries. The first issue with this crop is that the free license agreement is unclear in what parts of production it covers. It definitely covers the cost of research, but it may not cover release or commercialization, which means the rice would be developed, but it may not be freely transported to the people who really need it. While the cost of research was free, farmers may still be paying for this crop. Another issue with this crop is that it is only one crop and limits biodiversity. If people rely on this rice and something happens to the one staple food source, a repeat of the potato blithe of Ireland would occur. According to the UN Food and Agricultural Organization, “variety is the key and should be the norm rather than the exception in farming systems.”

If that’s not enough, this “golden” rice would not even efficiently help those with vitamin A deficiencies. An adult would be required to consume 300 g of the golden rice every day in order to reach about 20% of their daily requirement of vitamin A. A child requires only 50 micrograms less of vitamin A each day than an adult. In the Philippines, it was found that a preschool child only consumes about 150 g of rice each day. 150 grams of the golden rice only equates to about 10% of a child’s daily requirement of vitamin A. Ten percent is better than none, but the fact

39 http://www.hki.org/programs/vitamin_a.html
that ten percent of the Vitamin A allowance is in the digested rice does not mean it is biologically available. Dietary fat is needed for the body to absorb Vitamin A. In areas that rely on rice to survive, people are not taking in enough fat.

An alternative approach to these genetically modified crops is growing foods that naturally have vitamin A. It only takes two tablespoonfuls of yellow sweet potatoes, half a cup of dark green leafy vegetables or two-thirds of a medium-sized mango in a day to meet the vitamin A requirement of a pre-school child. It is also important to remember that while this step is meant to stop malnutrition in developing countries, one vitamin will not end it.

Another promise that genetically modified crops are not quite fulfilling is the promise to resist pests. Mother-nature is quite impressive in her ability to adapt to change and survive. Pests, such as insects, which were being effected by the Bt-resistant crops, are starting to build a resistance to the toxins the plants release. At the University of California, research was done to find the genetic and molecular structures that allow a roundworm to develop resistance to Bt toxins in hopes of coping with the mounting pest resistance. At this time, they are unsure how they will fight the resistant pests, but hope to do so in order to avoid future problems.

“There are insects in the wild now that contain gene variants that allow them to be resistant to Bt toxins, but fortunately they are small in number,” says Raffi V. Aroian, an assistant professor of biology at UCSD who headed the study. "However, as more crops with Bt genes are planted, it's only a matter of time before populations of Bt-resistant insects grow numerous enough to become economically troublesome to farmers hoping to control these insects.”

40 http://www.grain.org/briefings/?id=18
41 http://www.universityofcalifornia.edu/news/article/3465
In 2005, Cornell University found Bt resistant diamondback moths that feed on the plants stems. These findings are important because Bt resistant crops have only been commercialized in the United States since 1996. This one breed of moths developed resistance in about nine years. How do we promise developing nations that these crops will improve their yields if they stop improvement after as little as nine years? After that period, farmers will be stuck buying seeds every year (since rights must be bought yearly) for crops that do not do what they advertise.

Comparing the potential advantages of genetically modified crops listed earlier in the paper, and the realities of these crops, we find very few advantages. The first advantage was pest resistance crops, but pests develop resistance to the resistant plants, and the plants no longer hold any advantage. The second advantage was herbicide tolerance meaning crops could be sprayed with weed killer and not die. While these crops are still tolerant to weed killers, there is evidence that the weeds are also becoming tolerant to the weed killer, and this potential advantage is useless. Additionally, crops have not been made to be drought tolerant, nutritionally enhanced at any meaningful level or vaccine carrying. The only advantages that have been achieved are cold tolerance and resistance to some disease causing viruses.

Despite all this, some advocates are attributing the genetically modified crops to the Green Revolution in Asia and promising to increase yields. The Green

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42 http://www.news.cornell.edu/stories/June05/Bt.kr.html
Revolution, (~1940-1970), focused on increasing yields by planting hybrids of staple crops in developing countries. While yields were increased greatly, the Revolution has done little to help world hunger and poverty. According to the International Rice Research Institute, the Green Revolution may have actually increased malnutrition among the poor. Additionally,

In India, annual rice and wheat production has more than tripled from pre-Green Revolution levels. On the other hand, household consumption of vegetables has dropped 12 percent over the last two decades. Pulse and legume consumption is down even more and is becoming more and more costly, and malnutrition remains high.43

Other developing areas have seen similar results. In South America, food capita rose by 8% while the number of hungry people rose by 19%. In South Asia, by 1990, there was 9% more food per person, but also 9% more hungry. Statistically, there was more food for each person, but people were hungrier. The only place the Green Revolution worked was China, and that progress may be partly based on the Chinese Revolution, especially the improved access to roads.44

Even if we ignore the doubt that genetically modified food has the potential to increase yields and help the hungry, genetically modified food is still not the answer to starvation in sub-Saharan Africa. Even if these crops do everything they say they do, their benefits will be lost to the continent.

Sixty percent of Africa’s producers are also the consumers, meaning that helping the producers (the farmers) is the quickest way to helping the majority of

43 http://www.grain.org/briefings/?id=18
44 http://www.foodfirst.org/media/opeds/2000/4-greenrev.html
Helping farmers will also help urban inhabitants because the two groups increasingly rely on each other for trade. However, producing more food is not necessarily the way to help these farmers, as it is not expanding the market for trade. It is no secret that when the economy is good, people fair better. According to the 2005 Hunger Report, “the potential benefits to developing countries from increased trade far surpass anything possible through aid alone.”

Developed countries can help by limiting subsidies for their own farmers and removing high import tariffs. According to the World Bank, removing subsidies would decrease the number of people living on less than $2 per day by 144 million. Sixty-seven million of these people would be Africans. As for tariffs, they are five times higher for agricultural goods than manufactured goods. Not only can poor farmers not pay these prices to sell their goods in markets that would give more profit, but farmers from developing countries are subject to the overproduction of farmers from developed countries. For example, cotton subsidies in the United States guarantee that farmers get paid for whatever cotton they produce. This allows them to produce more cotton than the current demand because, for them, overproduction may depress the market, but it will not depress their profits. Unfortunately for cotton producers in West Africa who produce cotton much more cheaply than U.S. farmers (21 cents per pound vs 73 cents per pound), the surplus of U.S. cotton is “dumped” on the world market at very inexpensive prices. Africans

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45 Poverty: Opposing viewpoints p 193
cannot compete. One country that is especially hurt is Benin since 75% of its export revenues come from cotton sales.\textsuperscript{46}

Another problem that Africans have is transporting goods to a nearby market. A 1999 study found that in Madagascar the more remote an area was, the higher poverty rate it had. Poverty rates in the least remote areas were around 66% while poverty rates in the most remote areas were about 83%. There are two major reasons for this—lack of good roads and lack of banks. It is more difficult for people further from banks to get a loan because banks do not reach into remote areas. If the people could find a local lender, interest rates are exceptionally high and poverty is more likely to continue longer. As for rural roads, most are poorly maintained or even absent. It is extremely difficult to transport produce from the farm to the market and goods such as fertilizer and seeds from the market to the farm. Without roads, people could only trade what they could carry. The lack of ability or money to get fertilizer could explain why the yields of rice, cassava, and maize in the most isolated areas were only half the yields of the least isolated areas. In Tanzania, it was found that, “households within 100 meters of a gravel road that was passable year-round and offered bus service earned about one third more than average.” Additionally, in a study across Africa, “villages with stronger infrastructure had fertilizer costs 14 percent lower, wages 12 percent higher and crop production 32 percent higher than villages with poor infrastructure.” Africans realize the true of advantage of a road. In a poll, two of Kenya’s provinces named roads as the most useful government service. In Ghana and the Cote d’Ivorre, roads

\textsuperscript{46} Hunger Report 2005 p 32,33,38, 39
were ranked higher than “education, health, and water supplies on a list of needs.” Another reason poor roads hinder trade is that people living in remote areas do not have knowledge of the current market. They have to trust traders who come to their villages to supply them with reasonable prices for the goods they are selling and purchasing. In some of the more remote areas, farmers have to take the first offer because they do not know when the next trader is coming. With the conditions of roads in Africa, greater yield does not equate to a better economy.

The final reason genetically modified crops would not do well in Africa is that the Africans do not want the crops. In 2002 and in the face of a famine, several southern African countries rejected U.S. food aid because it contained some genetically modified grain. All the countries, except Zambia, changed their minds and agreed to accept the grain as long as it was milled. They accepted the milled grain because it would prevent planting of the grain. Africans have also expressed resentment that companies use the image of their hungry people in their advertisements. They feel that companies are using their suffering to push the companies’ own agendas. Delegates from eighteen African countries expressed this sentiment at a UN Food and Agriculture Organization meeting in response to Monsanto’s advertisements.

We...strongly object that the image of the poor and hungry from our counties is being used by giant multinational corporations to push a technology that is neither safe, environmentally friendly, nor economically beneficial to us. We do not believe that such companies or gene technologies will

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47 Hunger Report 2005 p 19-41
48 More heat than light. Nature
help our farmers to produce the food that is needed... On the contrary...it will undermine our capacity to feed ourselves. ⁴⁹

Conclusion

The United States citizens are letting genetically modified food overtake our nation. We are gambling our health for a product that has not been proven to be safe. As a nation we value our safety. We give our kids safety scissors for arts and crafts. We monitor what they watch, who they hang out with, and how they spend their free time. We keep our money in banks. We shred our mail. We lock our doors and windows at night and sometimes during the day. We filter our water or drink bottled water. We air anti-marijuana commercials. We take cartoons off television if they are deemed too violent. Why would we allow ourselves to eat food that has been changed on a genetic level? Aren’t our bodies and our loved ones the most important things we have? Why would we not protect them and allow something not proven safe to enter them?

We value our freedom. We debate about gun control, abortions, gambling, elections, the Patriot act, and so much more. We like the option to choose Suave or Herbal Essence; Chevy or Ford. Why do we not mandate labeling for genetically modified foods? Shouldn’t we be able to choose organic or genetically modified?

We value our land and our animals. We have laws about urinating close to bodies of water. We have wildlife reserves and wetlands. We know the value of

⁴⁹ Poverty: Opposing viewpoints. P 198-199
biodiversity. Why would we let crops that will spread genes to invasive plants foster at our farms?

We value our individuality. We know we are complex beings with complex problems. We know life is not black and white. Then, why would we try to pawn off genetically modified food as an answer to hunger? With all the problems in developing countries, why simplify the complexity of hunger into one solution?

We think of ourselves as inherently good people. We respond to disasters with time, food, and monetary aid. We organize fund-raisers for churches, scouts, sport groups, cancer, leukemia, and other diseases. We even donate to the poor children in developing countries. All that is apparently not enough. People are still hungry, malnourished and dying. Should we donate more money? Would it really take that much out of our pockets? Actually, it wouldn’t. For the price of one missile, a school full of hungry children could eat lunch every day for five years. Should we practice peace instead of war? Absolutely. Is it possible? Probably not. However, there is something we could do to help hunger and sanitation together. We could open our eyes and get over ourselves. To satisfy the world’s sanitation and food requirements would cost only 13 billion U.S. dollars—which is what the people of the United States and the European Union spend on perfume each year.\(^{50}\) Depressing?

Would free money really solve hunger and sanitation problems? It may provide aid for that year. Will that aid put people on their feet? I don’t know. It

\(^{50}\) Thinkquest
may or may not be the way to go. However, it is one possible alternative, because genetically modified crops are not the way to go.
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