THE WORLD FOOD PRIZE
SUMMER INTERNSHIP
2000

THE OFFICE OF BIOTECHNOLOGY
IOWA STATE UNIVERSITY
AMES, IOWA

MICHAEL CLARK
Senior- Lamoni High School, Lamoni, IA

Throughout human history, biotechnology has played an important role in world history and continues to today. The long journey on the road to biotechnology began more than 100,000 years ago, when humans walked the earth, hunting and gathering food that were growing naturally. Since eight thousand years before the birth of Christ, agriculture has enabled people to live and plant specific crops on one piece of land. This has helped people to establish vibrant communities that thrive on these crops as a vital source of food. (BioNEWS, Monsanto, 1999)

Since the time that farmers first began to till the earth's fertile soil, people have begun to develop technology that can help sustain life within developing nations and local communities. Developing nations need food that people can safely consume that is free from harmful toxins, such as pesticides. By planting and harvesting seeds that yield large quantities of food, we can accomplish this. Farmers have used a common agricultural technique known as crossbreeding to create these new varieties of food, long before scientists discovered genetic material. Crossbreeding allows two different sets of genetic information to merge and create a new hybrid crop. (BioNEWS, Monsanto, 1999)

Many technological innovations have improved biotechnology as a whole. One such innovation has been the discovery of plant hybrids, plants created when two different varieties or species cross-pollinate. As early as the 1700's, naturalists had identified many kinds of hybrids. By the late 1930's, hybrid plants were working wonders for agriculture by successfully increasing crop production. Corn hybrids have contributed in tripling the overall corn yield in the twentieth century. (BioNEWS, Monsanto, 1999)

Scientists introduced another innovation that was responsible for dramatically improving food production, beginning around the eighteen hundreds. It was during this time when people first began using bacteria to create new foods by employing yeast and

processes of fermentation. The use of this revolutionary technique has caused the creation of products such as wine, beer and leavened bread. When certain types of bacteria grow in foods, they produce desirable flavors and textures. Because of this discovery, we have used many bacteria to enhance the flavor in many common foods, including cheese, yogurt, soy sauce and tofu. Several other scientific discoveries have had, and are continuing to have an even greater impact worldwide, changing agriculture and politics forever. (BioNEWS, Monsanto, 1999)

In the 1800's, researchers knew and understood that all living things consisted of cells that were the same. Yet, when the turn of the nineteenth century came around, researchers made an important discovery. These researchers discovered that all cells contain a sticky substance, which they called deoxyribonucleic acid (DNA). During the 1950's and 1960's, American biochemist James Watson and English physicist Francis Crick researched DNA and built a detailed model of this genetic material. From the information gathered from their research and the model, these two scientists learned how DNA works. Besides learning how DNA functioned, they also learned how to construct it. Their research was so significant that both scientists jointly received the 1962 Nobel Prize for their accomplishments in the field of Genetics. (BioNEWS, Monsanto, 1999)

Through their research and long hours of study, Watson and Crick had discovered many intriguing things about DNA. They learned that DNA consisted of a double-helix structure that closely resembles a spiral ladder. The legs of this spiral ladder consist of two alternating chemicals. Joining the legs of the ladder is a series of rungs, made up of two other chemicals made up of nitrogen bases. When they properly align the bases, they pass on the correct information or trait to genes. The research that these two

scientists have done has aided other scientists and researchers in determining that DNA does affect the growth and development of all living organisms. (BioNEWS, Monsanto, 1999)

Once scientists had discovered that all living organisms could decipher the same basic DNA code and that genes are interchangeable, they began to explore the process of gene transformation. This procedure involved the transfer of either a gene or a specific piece of DNA from one organism to another. In 1973, as a joint effort, Dr. Stanley Cohen of Stanford University and Dr. Herbert Boyer of the University of California-San Francisco transferred the first gene. (BioNEWS, Monsanto, 1999)

This achievement led to the beginning of biotechnology. Biotechnology is any technique that uses living organisms or their parts to help create or modify plants, animals or microorganisms for specific uses. (Biotechnology, CAST, December 1999) This technology has made it possible for new advancements in technology, which will be vital for several industries including health care, agriculture and environmental protection. (BioNEWS, Monsanto, 1999)

Food processing companies also will benefit from the new products that biotechnology has to offer. Biotechnology is helping to cause miraculous breakthroughs in the health care industry. Since the time scientists introduced human insulin production to treat diabetes better, they have made other advancements, due to biotechnology. Through biotechnology, scientists have created vaccines and medicine that they have proven more effective. These new treatments have been beneficial to hundreds of millions of people who suffer daily from unfortunate diseases such as cancer, heart disease, diabetes, Parkinson's, Alzheimer's, and AIDS.

This new technology holds great promise for the future. Because of biotechnology, consumers can take advantage of new genetically engineered foods that will directly contribute to improved human health and better nutrition for all of humankind (Promise, Monsanto, 1999). The American Dietetic Association has issued a statement that says that biotechnology techniques have the potential to enhance the quality, nutritional value and variety of food available for human consumption and in increasing the efficiency of food production, food distribution, and waste management. (Biotechnology, Council for Biotechnology Information, April 2000)

As mentioned previously, biotechnology has the potential to provide increased food and nutrition to the world population. Although biotechnology has allowed us to do this, many nations have found this extremely unethical. Economic, social, and moral issues dealing with the planting and harvesting of genetically modified crops have become a priority for some environmental and religious groups. Many countries belonging to the European Community have boycotted either the production or importation of GM crops or products. Because these countries have not allowed GMO producing nations to export these crops to them, a concern has arisen with many international corporations. These corporations export products enhanced genetically from the US to Europe. Some of these international buyers have issued statements saying that they will not purchase GM crop products because they cannot separate GM from conventional crop commodities. (Risks, pub. 2/2000, accessed 7/28/2000)

Many of these companies do not want to lose potential clients that fear these products. Some countries, such as Thailand, use genetic technology to detect if a crop

commodity was grown from GM varieties, just to prevent these products from coming into their country. (Risks, pub. 2/2000, accessed 7/28/2000)

On the other hand, some commodity buyers, such as Cargill, have released statements saying that they intend to purchase genetically modified crops. In Colorado, most corn buyers are not concerned about this kind of corn. They are not concerned because it is feed for livestock; therefore humans do not consume it. At the center of the controversy surrounding the use of GMO products are the ethical questions regarding the transfer of DNA across organisms. The critics of GM products are, overall, well fed, so they have not experienced famine on a personal level. (Risks, pub. 2/2000, accessed 7/28/2000)

Perhaps one reason that many people from many nations, including people from the United States is strongly concerned about the safety of GMOs, is the fault of the media. Because the media has constantly warned people about risks of GMOs, they become frightened. When they are frightened, they think only about the •risks and do not pay any attention to the bright benefits of Biotechnology.

Because of multimedia and the fact that Genetic Engineering is a new field of science, they have led people to believe that GMOs are unethical. An excellent example of how multimedia, such as movies, is frightening the American public about GMOs is the 1997 Fox film, *The X-Files*. In one scene, Mulder and Scully are seen walking in the middle of nowhere, when they stumble across a cornfield that bees are pollinating. They later find out that someone had genetically modified the bees to carry a deadly alien virus. What was supposed to happen was when the bees pollinated the corn; the bees would transfer the virus to the corn. When people ate the corn, the corn would infect

them with the virus and thus become carriers of a new alien race. Because of this scene, many people have become paranoid toward genetically modified organisms. Through education about Biotechnology, we must correct people's misconceptions and convince them of the benefits of GMOs.

Because mass media has led people astray and told them that genetically modified organisms are bad, they have several concerns. Consumers have a fear that a scenario may occur that would be very similar to the science-fiction situation seen in *The X-Files*. They are concerned that because scientists commonly bioengineer plants with antibiotic resistant marker genes, crops having these marker genes could lead to antibiotic germs that might infect humans. The truth of the matter is that the Food and Drug Administration has carefully considered if this scenario could happen and has found little evidence that it could. People are also concerned that the new proteins that the genes inserted in foods make would have adverse effects on humans, such as allergies. The FDA has found that all of the proteins placed into foods by biotechnology were nontoxic, rapidly digestible. These proteins did not have the characteristics of proteins that the FDA knew did cause allergies. In fact, Dr. Jane E. Henney, the commission of the FDA, issued a statement in the January/February issue of the *FDA Consumer*. She issued this comment: •We (the FDA) have seen no evidence that the bioengineered foods now on the market pose any human health concerns or that they are in any way less safe than crops produced through traditional breeding. (Foods, *FDA Consumer*, January/February 2000)

A concern of many people is a very troubling one. People think that biotechnology cannot relieve world hunger. It turns out that many people's fears about this issue

are largely founded on much false information. Biotechnology can alleviate world hunger. We estimate that in the next fifty years, the world population will skyrocket to eight billion people. Exponential population growth such as this will require the world's food supply to increase by at least 250 percent. The current amount of land committed to food production is at 36 percent, which is less than adequate to feed the Earth's six billion inhabitants. (Facts, IFIC, Oct. 1999).

Many individuals support the use of biotechnology to fight world hunger. Jimmy Carter, former president of the United States, had this to say about the need for biotechnology. He said, •Responsible biotechnology is not the enemy, starvation is. Without adequate food supplies at affordable prices, we cannot expect world health or peace. Dan Glickman, United States Secretary of Agriculture, also supports the use of biotechnological techniques to fight world hunger. He said there is no doubt that biotechnology will be an indispensable tool as we try to serve global agricultural demand in a sustainable manner. With more and more people to feed, more and more fiber to produce, and a limited amount of arable land to put into production, we need biotechnology. (Biotechnology, Council for Biotechnology Information, April 2000)

Plants derived from biotechnology can deal with many situations and bless the lives of millions around the world. GMO crops can handle adverse scenarios such as droughts and can dramatically increase the percentage of crops harvested each year (Facts, IFIC, December 1999). We are using Biotechnology to engineer vital crops such as the sweet potato, cassava, rice, and corn with immunity to deadly viruses (Biotechnology, Council for Biotechnology Information, April 2000). What is more

important though, is the fact that genetically modified crops will prevent millions of deaths worldwide, caused by the lack of good, nutritional food. (Facts, IFIC, Oct. 1999)

Another issue concerning people's misunderstanding the benefits of transgenic organisms is the fact that people are afraid of what the long-term effects might be. We have learned from years of intensive research that the benefits of genetically modified organisms are wonderful and innumerable. Current studies addressing this topic conclude that foods created with the use of biotechnology are safe for people to eat and they will not harm the environment. Consumers can be assured that genetically engineered foods have met the United States strictest government regulations. (Facts, IFIC, Oct. 1999)

Two methods that scientists commonly use are the Agrobactrium and Gene gun methods. (Foods, FDA Consumer, January/ February 2000) One overlooked method of gene transfer, which has played a major factor in the transfer of genes for centuries, is wind. This force of nature can initiate massive storms such as hurricanes and tornadoes. Wind, the source of tornadoes and hurricanes, is often the agent of massive destruction. Sometimes wind, through cross-pollination, may create many new species of plants.

Cross-pollination is a major factor in the creation of a genetically modified organism by the wind. This process happens when the wind and lands on the anther of a different plant species carry pollen grains from the stamen of one plant. Two common plants that scientists have genetically engineered are corn and soybeans. Since soybean plants are self-pollinating crops, cross-pollination is highly unlikely to occur. However, cross-pollination happens in corn more often than in soybeans. (Wallaces Farmer, June 2000)

A typical corn plant has two separate flowers: a male flower (tassel) and a female flower (ear). Take into consideration that the average corn plant produces between two million to five million pollen grains. Also consider that an average ear produces from seven hundred fifty to one thousand corn silks. For every individual corn silk that the corn plant produces, the plant also produces two thousand to five thousand pollen grains.

Pollen movement is a key factor in deciding if wind does play a part in creating a genetically modified corn plant. In research conducted at Stanford University, Dr. Stuart Weiss gathered some very startling information. He found that at wind speeds of 11 miles per hour or less, most pollen grains fell close to the field edge. The reason for this was due to the large size (ninety to one hundred microns) of the pollen particles. (Corn pollen, Monsanto, 1999) However, some grains of corn pollen may be blown and carried by the wind at least quarter of a mile. The pollen grain could eventually settle on some corn in a neighboring field and begin the process of cross-pollination. (Wallaces Farmer, June 2000)

However, plants do not shed pollen continuously. On days when it is raining, the wind is blowing hard, and when it is extremely hot or cold, corn plants will not shed their pollen. Another factor that affects cross-pollination is the life expectancy, or viability of pollen. The average viability of a pollen grain is twenty minutes, so once corn plants shed pollen it must land on a plant in a neighboring field quickly. (Wallaces Farmer, June 2000)

Another plant that has been genetically modified is *Brassica napus*, more commonly known as the oil-seed rape plant. The FDA approved this plant for production, but they did not approve it for animal or human consumption. At first, the literature advertis-

ing this plant claimed that the oil-seed rape plant had very little to no risk of cross-pollination with any other plant. Experiments have now shown that the oil-seed rape plant does cross-pollinate with *Brassica campestris*, a wild, weedy form of *Brassica rapa*. *Brassica rapa* is commonly associated with turnip, turnip-rape and some forms of American canola. Oil-seed rape, *B. Napus*, was also found to cross-pollinate with *Hischfeldia incana*, a variety of the hoary mustard plant. *B. napus* exhibited effective weed-to-plant gene transfer with this plant variety. (Risks, TIBTECH, Elsavier Science Ltd., December 1996)

Because seed companies bioengineer crops these companies own patents to the genetically modified seed they manufacture. Now what happens if the wind becomes involved? Percy Schmeiser is a Canadian farmer, who, for the last fifty years, has been farming near Bruno, Saskatchewan. His life has been very ordinary. Now suddenly, Schmeiser is fighting what may be the strangest battle in the history of agriculture.

"My grandfather and my father homesteaded here," Schmeiser says. "There was no such thing as chemical companies, or even seed companies. They were free and independent."

Schmeiser learned a long time ago that the wind is often a farmer's worst enemy. Wind blows the seeds and pollen of weeds into farm fields, choking out crops.

Now the wind may have brought a new threat to Schmeiser's farm. This problem is now forcing him to fight for control of the seeds planted in his field. It seems that he has picked a fight with Monsanto, the world's largest agrochemical company.

Monsanto makes the weed killer called Roundup that enables farmers to spray it onto a field and kill everything growing there. This company has also genetically engi-

neered a canola seed so that Roundup does not hurt it. A farmer can spray Roundup herbicide over an entire field, and not hurt the canola crops, if it comes from Monsanto's genetically modified canola seed.

Many Canadian farmers have pest control problems and want to purchase the special canola seeds containing Monsanto's DNA. However, while farmers can buy the special seed, Monsanto keeps the rights to the DNA itself. That is what make the seed special and is where Monsanto makes its money.

Farmers traditionally plant their fields using seeds saved from their previous year's crop. Just like in human beings, they pass the DNA of seeds along from generation to generation. A farmer could buy Monsanto's special seed once and then never have to pay for it again.

So the problem for Monsanto is protecting its investment. In the brave new world of agriculture, it is Monsanto versus the farmer. Farmers buying Monsanto's seed must sign a contract promising to buy fresh seed every year. Then, they must let Monsanto inspect their fields for cheating.

Randy Christenson is Monsanto's regional director for Western Canada. Because of Monsanto’s new technology, Randy realizes that Monsanto has to keep a close eye on it. "We have put years, years and years of research and time into developing this technology. So for us to be able to recoup our investment, we have to be paid for that, Christenson says.

Percy Schmeiser says he has never used Monsanto's seed. He saves the seeds from his own crops and then replants them in the spring. Monsanto investigators say they have found Monsanto’s herbicide-resistant DNA in Schmeiser's crops. Monsanto says

Schmeiser never paid for the rights to use its DNA. Now the company is suing Schmeiser for the money.

"I have been farming for fifty years, and all of the sudden I have this," Schmeiser says. "It is very upsetting and nerve wracking to have a multi-giant corporation come after you. I don't have the resources to fight this." (Wind, CBC)

Monsanto ordered its investigators to trespass into Schmeiser's fields and collect samples. Then Monsanto agents paid a secret visit to the company that processes Schmeiser's seeds for planting. (Wind,CBC)

The problem is that Mother Nature has been moving DNA around for thousands of years. "It will blow in the wind. You cannot control it. You can't just put a fence around it and say that's where it stops. It might end up 10 miles, 20 miles," Schmeiser says. (Wind,CBC)

Some impressive research backs up Schmeiser. Scientists from Agriculture Canada say wind can blow seeds or pollen between fields, meaning the DNA of crops in one field often mixes with the DNA from another plant. Seeds or pollen can also be blown off uncovered trucks and off farm equipment. (Wind,CBC)

Monsanto has said that it is up to farmers to dig out any Monsanto crops blowing into their fields. Yet this incident has raised an important question: can Monsanto put a patent on a piece of nature? (Wind,CBC)

Genetically modified organisms will open a new world of technological wonders that are beyond our wildest imagination. These genetically enhanced organisms will help to provide a brighter future for victims of food starvation in developing nations. Here in the United Stated, we can alleviate the fears and concerns that people have about genetically modified organisms by telling them about the benefits these crops have to offer. When someone asked Dr. James Watson, the Nobel Prize winning scientist about the hysteria surrounding the application of biotechnology to food, he responded by alluding to the initial ban on medical biotechnology. If the ban had not been lifted, it would have stopped us from understanding cancer and a whole host of things, he noted. To argue that you don't know what is going to occur is true about everything in life. People wouldn't get married, have children, do anything (Facts, IFIC, Oct. 1999). As it is with all things, some people will still be paranoid. Yet hopefully, in time, they will realize the great benefits of this technology

Works Cited

Wallaces Farmer, (publisher?), June 2000

•The Promise of Plant Biotechnology• The Monsanto Company, 1999

•New BioNEWS• The Monsanto Company, 1999

Williamson, Mark, •Can the risks from transgenic crops be estimated,• *TIBTECH* vol. 14, (1996)