Evolution of Genetically Modified Organisms and its controversial future

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[Abstract] Genetically modified organisms (GMOs) are organisms that have been modified using genetic engineering methods. Although genetic engineering is a common and essential practice in biotechnology, its specific use in crops is controversial. The key steps involved in genetic engineering are identifying a trait of interest, isolating that trait, inserting that trait into a desired organism, and then propagating that organism. Methods for genetic manipulation have rapidly improved over the last century from simple selective growing, to inserting genes from one organism into another, to more recent methods of directly editing the genome.

[keyword] GMO, genetic engineering technology, herbicide tolerance, safety testing, labelling regulated.

1] Introduction

Genetic modification, also known as "genetic engineering," is a technologically advanced way to select desirable traits in crops. While selective growing has existed for thousands of years, modern biotechnology is more efficient and effective because seed developers are able to directly modify the genome of the crop.
The technology of genetic modification or genetic engineering was first developed in the early 1970s, commercialized in pharmaceutical applications in the early 1980s, and then agricultural applications in the early 1990s. Pharmaceutical companies are looking to manufacture drugs that are purposed to have deliberate effects on the biochemistry of their targets. While agricultural companies are adding traits that will help farmers or benefit consumers, without affecting the safety of the crop. GMOs produced through genetic technologies have become a part of everyday life, entering into society through agriculture, medicine, research, and environmental management. However, while GMOs have benefited human society in many ways, some disadvantages exist; therefore, the production of GMOs remains a highly controversial topic in many parts of the world.

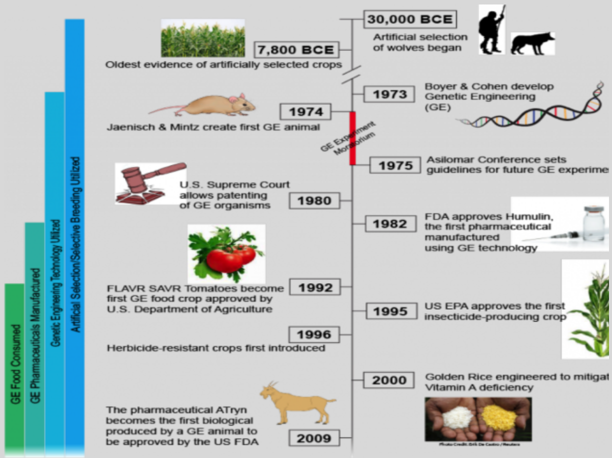
[History of GMO]

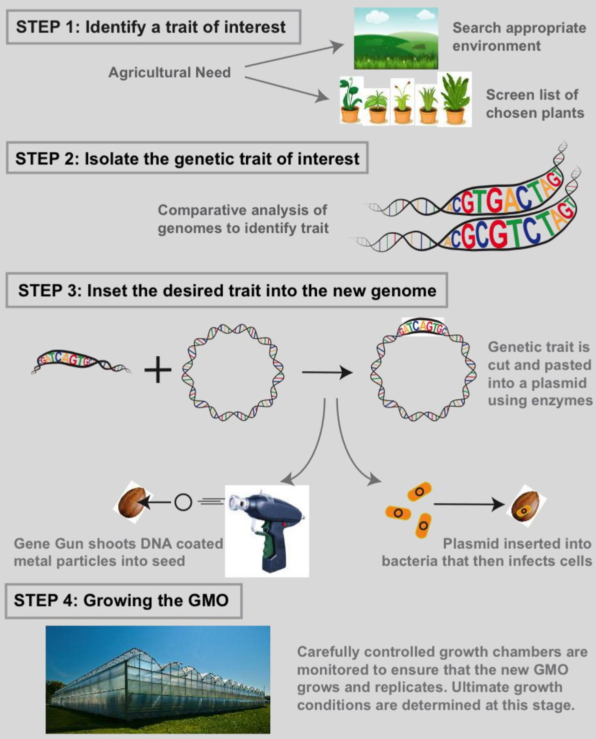
GMOs have a very long history. In fact, there´ve been around for thousands of years. So perhaps the conflict over their safety and efficacy shouldn´t be about whether they're safe for humans to consume, but rather how they will impact long-term, supportable agricultural efforts. The GMO breakthrough came in 1973, with the creation of the first genetically engineered (GE) organism. Immediately the media, government officials, and scientists began to worry about the potential ramifications on human health and Earth's ecosystems. At the Asilomar Conference of 1975, scientists, lawyers, and government officials debated the safety of GE experiments and concluded that the GE projects should be allowed to continue. Here, some important contributions along the time: Prehistoric Times - Contrary to popular belief, humans have been messing with food and its genes for a long time, even if they originally gave most of the control to nature. The earliest evidence of artificial selection of plants dates back to 7800 BCE.

1800s – Gregor Mendel became the father of genetics due to his plant hybridization experiments.

1954 – Watson and Crick described DNA´s shape as a double helix, paving the way for genetic engineering to make a real debut.

1970 – Monsanto became the biggest supplier of glyphosate-resistant crops, known as "Roundup Ready" seeds, which will be one of the commonly used herbicides among harmers, helping to keep pesky weeds at bay.





1973 – Herbert Boyer and Stanley Cohen developed a technique that allowed to commercialized biotechnology in 1976. That allowed companies to experiment inserting genes whether for medicinal food or chemical reason.

1982 – The U.S Supreme Court ruled that GMOs could be patented.

1988 – Scientists started inserting gene into different weeds with the intention of making these crops resistant to insects, antibiotics, diseases, herbicides, and pesticides. Nowadays, there hasn't been enough research to determinate whether GMOs are entirely healthy for humans, although the FDA has listed them as safe.

[GMO Techniques]

Behind every single seed is at least a decade of research involving geneticists, engineers and farmers, working to produce a seed that will grow exactly as expected, and in a way nature may not have intended. Here's how it's done:

STEP 1 - Successful discovery of a new genetic trait of interest is often a combination of critical thinking and luck.

STEP 2 - The genomes of the plants with the trait are compared to genomes in the same species without the trait, with the goal of identifying genes present only in the former.

STEP 3 – Inserting them into the plants. There are a couple of ways to do this, including using "gene guns" that literally shoot pieces of DNA. A .22-caliber charge fires a metal particle coated with DNA into plant tissue.

STEP 4 - Those chambers are home to countless thousands of seedlings being tested for drought tolerance, salt tolerance, pest and disease resistance, and more. Currently, plant biologists have to study their charges by hand, taking pictures of their roots and testing their viability.

In spite of the widespread international use of GM crops, the portfolio of available crop-trait combinations is still very limited. At present, only a few first-generation technologies have been commercialized. The principal technology is herbicide tolerance (HT) in soybeans, which made up 53% of the global GM crop area in 2008. HT soybeans are currently grown mostly in the

United States, Argentina, Brazil, and other South American countries. This technology accounts for 70% of worldwide soybean production.

GM maize is the second-most principal crop and covered 30% of the global GM area and 24% of total maize production in 2008 (James 2008). GM maize involves HT and insect resistance, partly as separate and partly also as stacked technologies. Insect resistance is based on different genes from the soil bacterium Bacillus thuringiensis (Bt). Bt maize is grown mostly in North and South America, but it is also planted to a significant extent in South Africa and the Philippine.

[GMO in Food and Medicines]

Genetic modification can improve the nutritional profile of food and therefore serves as a key element in reducing global rates of malnutrition. For instance, golden rice is improved with beta-carotene and therefore provides a dose of vitamin A, a nutrient lacking in many diets around the world. Vitamin A deficiency leads to the death of nearly 700,000 children each year, so golden rice is a crucial initiative in reducing malnutrition. Additionally, in India, using Bt corn led to the consumption of more nutritious foods, including fruits, vegetables, and animal products because of increased incomes. Another study in India showed that each hectare of Bt cotton increased caloric intake by 74 calories per person per day and that 7.93% of households using Bt cotton were food insecure as opposed to 19.94% of those using non-GM cotton.

In spite of the great potential of GM crops and the benefits that have already materialized, public attitudes toward the technology are often negative, and consumer acceptance remains an issue. Consumer perceptions are often dominated by health, environmental, social, and ethical concerns, which are not always based on the best information but which have emerged as important driving forces of biotechnology policies social, and ethical concerns, which are not always based on the best information but which have emerged as important driving forces of biotechnology policies. One reason for the partial acceptance may be that most GM crops now available involve agronomic traits with limited direct benefits to consumers. Consumer acceptance may increase when second-generation, quality-enhanced GM foods or crops with combined agronomic and quality traits are introduced. Gene transfer medicinal products are presented for treating or preventing disease in human subjects, or are administered to human subjects via gene therapy. Coupling stem cell technology with recombinant DNA methods allows stem cells derived from a patient to be modified in the laboratory to introduce a desired gene with a view to make a medical diagnosis or to restoring, correcting or modifying physiological functions in the subjects.

[Health implications]

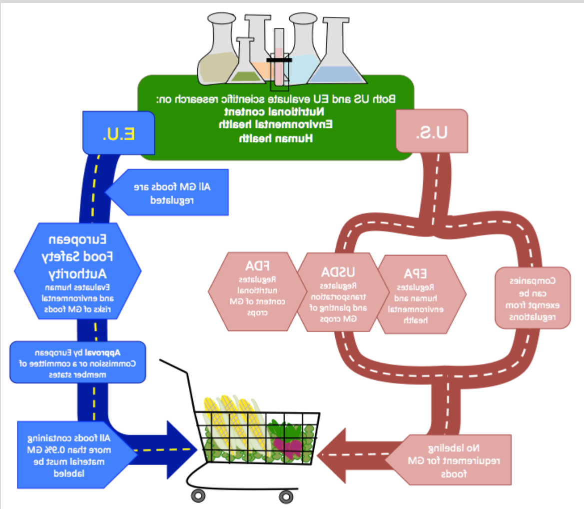
GM crops, especially Bt crops, are also associated with health benefits. Direct health advantages for farmers are a result of less insecticide exposure during spraying operations. Often, the health hazards for farmers applying pesticides are greater in developing as opposed to developed countries because environmental and health regulations are more lax, most pesticides are applied manually, and farmers are less educated and less informed about negative side effects. Pray et al. (2001) and Huang et al. (2003) showed that the frequency of pesticide poisonings was significantly lower among Bt cotton adopters than among nonadopters in China. Hossain et al. (2004) used econometric models to establish that this observation is causally related to Bt technology. Bennett et al. (2003) made the same observation for Bt cotton in South Africa, and there is first evidence that similar effects can also be expected for other Bt crops in smallholder agriculture, such as Bt rice in China (Huang et al. 2005, 2008). Using econometric estimates and a cost-of-illness approach, Krishna & Qaim (2008b) projected that Bt egg- plant in India may produce farmer health benefits worth approximately $4 million per year.

For consumers, Bt crops can yield health benefits through lower pesticide residues in food and water. Furthermore, in a variety of field studies, Bt maize was shown to contain significantly lower levels of certain mycotoxins, which can cause cancer and other diseases in humans (Wu 2006). Especially in maize, insect damage contributes significantly to mycotoxin contamination. In the United States and other developed countries, maize is carefully inspected, so lower mycotoxin levels may be most responsible for reducing the costs of testing and grading. But in many developing countries, strict mycotoxin inspections are uncommon. In such situations, Bt technology could contribute to lowering the total health burden (Wu 2006, Qaim et al. 2008).

[Advocates & Regulation of GMO]

Because GM crops are associated with several potential market failures, the technology is heavily regulated. For instance, GM crops may be associated with environmental and health externalities, so biosafety and food safety regulations have been put in place.

GM food companies submit the same types of scientific data to U.S. and EU regulatory bodies for approval, as is showed in the figure. Three separate agencies in the U.S. evaluate the potential risks of GM foods, while a centralized approval process is established in the EU. Approval and labeling requirements are stricter in the EU.



Most Asian countries have guidelines for research on GMOs, but the process to obtain commercial approval to grow GM crops is still broadly ambiguous in many countries. The industry is indeed needed for biosafety regulations which act as enabling tools for the development of the biotech industry while at the same time safeguarding human and animal safety as well as the environment based on scientific principles.

Several countries have introduced or considered introducing a food-labeling system. In general, mandatory or voluntary labeling is possible. Mandatory labeling is often used to warn consumers of specific health risks (e.g., cigarettes), whereas voluntary labeling is more common to differentiate products with desirable characteristics for marketing purposes (e.g., organic). Both systems can deliver the same information to consumers. Given that only GM products that are considered to be safe are approved for market release, no warning of risks is required on labels. However, the EU has established a mandatory system, which is costlier and can reinforce the notion that GM products are inherently unsafe. The motivation underlying the EU approach is that consumers have a right to know, which is different from the need to know approach in the context of risk communication.

GM approval process has been problematic and generate a slow and smooth implementation. That is the case of EU approval which is defined by the breeding process. For instance, if an herbicide tolerant crop is made using particular recombinant DNA methods (e.g. the insertion of a defined piece of DNA via genetic transformation), it is deemed to be a GMO and must undergo a full risk assessment estimated to cost the breeder about $10 million. If however, an herbicide tolerant crop is made using other methods to recombine DNA (such as mutation breeding), then it is not required to under- go GM risk-assessment procedures and of course labelling is not required. Because they are not GMO, herbicide tolerant crops made via mutation breeding are freely available and cultivated by EU farmers today. While this is clearly illogical, at least **the breeders know** the legislative landscape and can work within it. However, there are new breeding techniques that were simply not fore- seen by the EU regulators 15 years ago and for which the definitions of genetic modification in 2001/18/EC are not well-suited. These uncertainties are paralyzing innovation and could generate EU agricultural practices falling behind the rest of the world.

The EU, in particular, has established rules to ensure the coexistence of GM crops with conventional and GM farming, which involve a number of technical and legal specifications, from minimum distance requirements for cultivation to liability and insurance measures. The high degrees of complexity, uncertainty, and direct costs associated with these coexistence rules represent clear disincentives for EU farmers to adopt GM crops.

[Future of GMO]

Due to the enormous cost and time investment in developing successful GM products, patents exist to protect the rights of companies. There are many genetic engineering techniques and GM products that have been patented. In the biotechnology field, patent infringement is a huge and controversial issue.

Unfortunately, there are economic concerns around the use of patents. Placing a patent on a new kind of GM plant, the price of the seeds can be raised to such an extent that small-scale farm operations and farmers in developing countries will not be able to afford these GM varieties of crops. Being the highest worry in the future of GMO.
In this way, the divide between wealthy and poor nations will be increased quite significantly. Some people have the hope that costs can be lowered when companies are seeking to sell GM seeds to developing and third world countries.

To develop successful GM product there are three big challenges to adopt by EU. Firstly, to move away from the current position of regulating new varieties based on process and adopt an appropriate regulatory framework for biotechnology that can adapt to changes in breeding methods and future agricultural practices in a logical and predictable manner. Secondly, to apply a proportionate, transparent risk/benefit analysis to novel crop types on a case-by-case basis using conventional varieties and farming practices as the base- line comparator and also taking into account the risks of not adopting change. Thirdly, to enable informed choice in all sections of the agricultural and food/feed supply chain by openly communicating the benefits, and also taking into account the risks and longer-term sustainability of different agricultural systems.

In spite of these potentials, public opinion regarding GM crops remains divided, especially in Europe. Concerns about new risks and lobbying efforts of antibiotech groups have led to complex and costly biosafety, food safety, and labelling regulations, which slow down innovation rates and lead to a bias against small countries, minor crops, small firms, and public research organizations. Overregulation has become a real threat for the further development and use of GM crops. The costs of regulation in terms of foregone benefits may be large, especially for developing countries. This is not to say that zero regulation would be desirable, but the trade-offs associated with regulation should be considered. In the public arena, the risks of GM crops seem to be overrated, while the benefits are undervalued.
Economics research has an important role to play in finding ways to maximize the net social benefits. More work is needed to quantify possible indirect effects of GM crops, including socioeconomic outcomes as well as environmental and health impacts. Furthermore, economists need to contribute to the design of efficient regulations and innovation systems. Although the gradual move from public to private crop improvement research is a positive sign of better-functioning markets, certain institutional factors seem to contribute to increasing industry concentration. This could lead to adverse outcomes in terms of technology development and access. Such issues need further analysis.

[Conclusion]

GM crops have been used commercially for more than 30 years. To date, most of the GM crops employed have been HT and insect resistant. Available impact studies show that these crops are beneficial to farmers and consumers and produce large aggregate welfare gains. Moreover, GM crops bring about environmental and health benefits. GM crops may also be well suited for small-scale farmers, because such seed technologies are scale neutral. The empirical evidence shows that Bt crops in particular can have significant income-increasing and poverty-reducing effects. Farmers in developing countries some- times benefit more than farmers in developed countries, which is partly a result of weaker IPR protection and, thus, lower seed prices. Yet, income distribution effects also depend on the wider institutional setting, including farmers' access to suitable seed varieties, credit, information, and other input and output markets. More public and institutional support will be needed to realize the benefits for the poor on a larger scale. GM technologies currently in the research pipeline include crops that are tolerant to abiotic stresses and crops that contain higher amounts of nutrients than traditional crops. The benefits of such applications could be much greater than the ones already observed. Against the background of a dwindling natural resource base and growing demand for agricultural products, GM crops could contribute significantly to food security and sustainable development at the global level. New technologies are crucial for the necessary production increases.

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. Nowadays there are still many challenges ahead for governments, especially in the areas of safety testing, regulation, international policy and food labelling. Many people feel that genetic engineering is the inevitable wave of the future and that we cannot afford to ignore a technology that has such enormous potential benefits. However, we must proceed with caution to avoid causing unintended harm to human health and the environment as a result of our enthusiasm for this powerful technology. There are many claims about genetically modified organisms (GMOs) –such a basis for increasing food production, without the need to convert more land to cultivation, for example. These claims, however, are countered by the claims that GMOs may have a variety of impacts on people and animals, and especially on ecosystems and lands not under cultivation, and concerns about whether and how the benefits of GMOs are actually experienced in developing countries.

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