GE Factsheet ::
What we do and don't know about genetically engineered food crops

Q: Are genetically engineered foods safe?

A: We don't know because the biotech industry has suppressed or restricted independent scientific research into efficacy and impacts of GE crop technology. The studies that do exist are largely sponsored by industry and have "major scientific flaws" including non-reproducibility. No safety trials have been carried out twice in the same conditions by different research teams.

Opponents of California's ballot initiative to label GE foods claim that hundreds of scientific studies have proven that there are no adverse health effects from consumer food that contains genetically engineered crops. In fact, we do not know whether these products are safe because industry has restricted and suppressed science looking into their potential effects both on human health and the environment, and U.S. regulators do not require independent studies verifying safety. Regulators instead must rely on industry-sponsored science. Independent studies documenting the efficacy of GE crops are likewise lacking, as noted by 26 corn entomologists in a 2009 statement to EPA, describing how strict intellectual property agreements effectively give industry a "chokehold" on research:

> "Technology/stewardship agreements required for the purchase of genetically modified seed explicitly prohibit research. These agreements inhibit public scientists from pursuing their mandated role on behalf of the public good unless the research is approved by industry. As a result of restricted access, no truly independent research can be legally conducted on many critical questions regarding the technology."

Industry suppression and restriction of independent research into GE crops is pervasive and ongoing. When scientists do receive permission to do research, it is typically with strings attached that restrict the usefulness of the studies for comparing crop varieties.

> *"It is important to understand that it is not always simply a matter of blanket denial of all research requests, which is bad enough, but selective denials and permissions based on industry perceptions of how 'friendly' or 'hostile' a particular scientist may be toward [seed-enhancement] technology."*
>
> - *Elson J. Shields, entomologist at Cornell University, in a letter to EPA*

As far back as 1999, weed scientists were also noting restrictions on their research about herbicide tolerant GE crops. A 2010 *Scientific American* editorial noted both the lack of access and the subsequent suppression of research:

> "… only studies that the seed companies have approved ever see the light of a peer-reviewed journal. In a number of cases, experiments that had the implicit go-ahead from the seed company were later blocked from publication because the results were not flattering."

Recent (2011, 2012) literature reviews investigating the safety and toxicological data on GM food note that the science that has been published is deeply flawed and/or paid for by the biotechnology industry.[i] **Critically, no medium- or long-term studies have been repeated.** Reproducibility is a core criterion for valid scientific research, and yet, as one research team notes, "No trials have been carried out twice in the same conditions by different research teams."[ii]

Q: What human health risks are of particular concern, given the state of the evidence?

A: Transgenerational and epigenetic effects. Organ (especially liver) damage. Allergenicity.

Given their documented potential for transgenerational effects, we may not know for a generation or more whether these products are safe at a population level. What we do know now is that conservative interpretations of medium-term (ca. 90-day) animal studies point to potential mechanisms of harm that require further study.[iii] Specific concerns that remain to be studied include horizontal gene transfer, transgenerational effects, organ damage and allergenicity. The long-term effects of horizontal gene transfer and multigenerational epigenetic effects are unknown and need to be investigated before any conclusion regarding the safety of GE products can be drawn.

- *Horizontal gene transfer*
  - Animal studies have found that foreign DNA present in food can be transferred from the digestive tract to the bloodstream and other tissues and to the offspring of pregnant mice.[iv] Studies indicate that GE DNA in food can be taken up in the organs of animals that eat it, and can be detected in the meat and fish that people eat.[v]

- *Transgenerational and epigenetic effects*
  - New GE technologies involve microRNA and RNA interference. In these instances, the microRNAs — very short RNA molecules whose key role in gene regulation was discovered around a decade ago — target and block the function of specific genes in pests. If ingested, microRNA can turn genes on or off, not only in the organism that ate it (the interference part), but also in that organism's offspring. A recent Chinese study found that microRNAs from rice can travel from the gut of healthy men and women who consumed that rice into their blood sera. Similarly, in mice, a rice microRNA was found to move from the gut to other organs, where it regulated gene expression and affected the mice's physiological condition.[vii]

- *Organ damage*
  - Seralini et al. (2007) identified several flaws in Monsanto's study design and in the company's statistical analyses, and re-analyzed Monsanto Company data on rats fed with GE maize. Using appropriate statistical analyses, Seralini et al. (2007) identified significant and sex-specific differences in weight gain in the groups provided with GE food: males on GE diets gained less weight than controls and females on GE diets gained more weight than controls. The study also linked GE food-based diets to increased toxic effects in the rats' kidneys and livers. Although a more extensive study is now needed, the initial results from this study suggest that GE corn should not have been declared safe for consumption given the data at hand.[viii]

  - In another re-analysis of other data from Monsanto, Vendômois et al. (2009) re-examined a rat feeding study using three varieties of GE corn. The authors concluded further evidence of hepatorenal (liver and kidney) toxicity, with the cause potentially being pesticide residues on the GE feed used in the study.[ix]

  - Malatesta et al. (2008) conducted a small feeding study on mice fed with GE soybeans resistant to RoundUp (and treated with RoundUp in the field) versus non-GE soybeans. They found a significant decrease of two markers known to decrease in aged rats, suggesting that the mice fed with GE soybeans displayed characteristics associated with aging in the liver.

- *Allergenicity*
  - In a March 2012 letter titled "Reasons for Labeling of Genetically Engineered Foods" addressed to the American Medical Association Council on Science and Public Health, Dr. Michael Hansen from Consumers Union cited examples of places where "significant scientific uncertainty" existed in risk analysis of GE foods. As an example, Dr. Hansen described a scenario where a synthetic gene encoding a modified protein was inserted into a tomato, with the modified novel protein causing a strong but delayed allergic reaction in a small subset of the population. This GE food would be extremely difficult to identify as a source of an allergy, particularly if only a small number of people were affected. Because risk assessment with regards to allergy to proteins inadvertently or intentionally modified in GE foods

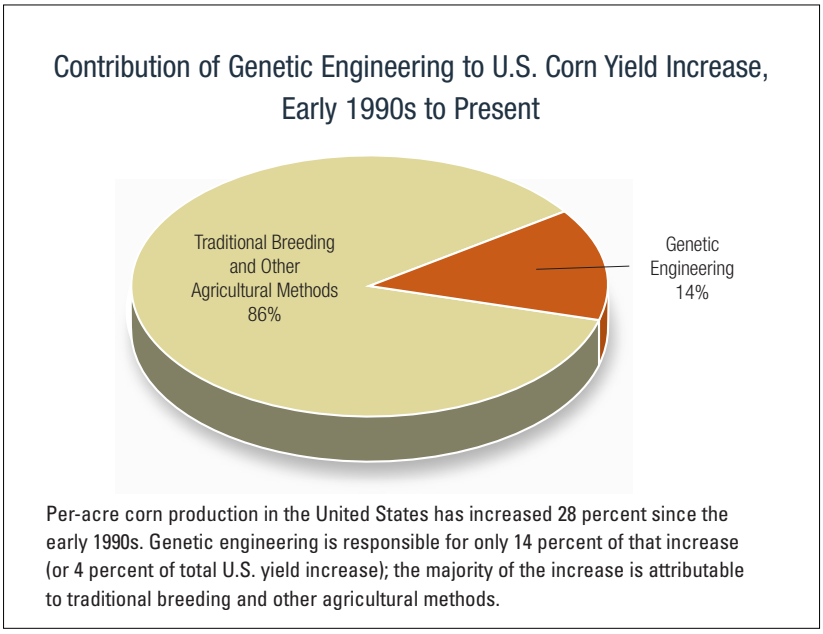
has not been conducted, this scenario is possible. Dr. Hansen explains that "labeling of GE food can serve as a risk management measure" to address this problem.

Q: Do genetically engineered crops produce more food?

A: Despite decades of research and over 15 years of commercialization, genetic engineering has failed to significantly increase U.S. crop yields. Reports to the contrary are anecdotal or derived from data sources that conflate important distinctions.

No currently available GE varieties increase the intrinsic yield of any crops (i.e. what a crop can be expected to yield under ideal conditions, sometimes called "potential yield"). Since their introduction, GE crops have typically performed no better than non-GE crops, and in some cases have shown "yield drag" or reduced yield due to disruption in plant physiological processes associated with the GE transformation.[x] A U.S. Department of Agriculture report confirmed the poor yield performance of GE crops, saying, "GE crops available for commercial use do not increase the yield potential of a variety. In fact, yield may even decrease."[xi] A 2009 Union of Concerned Scientist (UCS) report, *Failure to Yield,* provides the most up-to-date analysis of the evidence.

A second key yield consideration explained in the UCS report is known as "operational yield" or how crops perform under actual field conditions where other factors (drought, temperature, pests, etc.) can have an impact. The evidence here indicates that GE herbicide-resistant soy and corn have not increased yield under field conditions at all. Only a couple of insecticide-containing GE crops have slightly improved yields in corn and this *only under limited conditions* (i.e. when pest infestations have been very high).



Source: Gurian-Sherman, Doug. *Failure to Yield: Evaluating the Performance of Genetically Engineered Crops*.

Regarding the insecticide-containing GE crops, controlled field trials – carefully designed and run by academic scientists – demonstrate that on a per-acre basis, these corn crops are responsible for only 4% of total U.S. yield increases in corn since their introduction in the 1990s, amounting to only a 0.2 or 0.3% increase per year.[xii] In contrast, the vast majority (96%) of yield increases in corn have come from traditional breeding and other farming practices. These non-GE practices have resulted in high-yielding varieties and increased the productivity of farms, with far lower research costs and without the restrictive contracts and high out-of-pocket costs to farmers of expensive GE seeds.

Industry claims that GE boosts yield are generally anecdotal and/or spurious, as teasing out the relative contribution of GE to yield increases is difficult. One problem for farmers is the difficulty in distinguishing the impacts of naturally-occurring crop genes and engineered genes. In conventional (selective) breeding, scientists and farmers works with the genes that naturally occur in the crop; they preferentially choose plants that have desired traits such as higher yield and save their seed for future breeding. GE companies, however (and some public breeders), rely on conventional breeding to improve corn, soy and cotton seed first; they then insert an engineered gene – such as for herbicide tolerance – into those

conventionally improved varieties, patent the new seed, and claim that the yield benefits are a result of genetic engineering. The reality is that those GE crop varieties had already been improved through conventional breeding.

Q: We have been modifying the genetic profile of plants and animals for over a century through selective breeding. How is genetic engineering different?

A: Genetic engineering is different in kind from traditional breeding. Because genetic material is inserted from species that are unrelated (or even belonging to different kingdoms entirely), there are often unintended consequences ranging from outright crop failure to indirect effects that are difficult to measure and require further investigation before we can declare GE to be a safe or reliable technology.

Genetic expression is complex, context-dependent, and still poorly understood by scientists. GE technology involves crossing the species barrier with direct manipulation of genetic material and removal of DNA function from its native environment within the organism, where its expression is normally controlled and stabilized. Furthermore, the laboratory techniques used in genetic engineering are imprecise and can lead to unstable and unintended effects.

Genetic engineering is not an extension of natural or conventional plant breeding. By making claims about precision, GE-proponents rely upon and reinforce a simplistic and outdated notion of how genes work. It is now known that genes frequently interact and control other genes, acting in far more complex ways than previously thought. GE technology claims of "precision" cannot be made in light of these complex gene interactions that are only beginning to be understood.[xiii]

Examples of undesirable on-the-ground impacts include the severely reduced performance of Bt cotton crops in India in recent years, where harvests have dropped 50% due to the GE plants' greater susceptibility to bacterial and insect pests, as well as their increased need for water and fertilization in comparison with non-GE crop varieties.[xiv]

Q: Do GE crops reduce reliance on pesticides?

A: No. GE crops require more pesticide use, either because they are engineered to be used with high applications of herbicides, or because they accelerate the pesticide treadmill by creating "superweeds" and "superbugs" that have developed resistance. The data on this point are clear and often misrepresented.

Six chemical companies – Monsanto, Dow, DuPont, Syngenta, BASF and Bayer – control 75% of the global pesticide industry and a majority of the world's seed industry. Monsanto alone controls 1/4th of global seed markets and 60% of the U.S. corn and soybean seed markets. Through the development and marketing of GE seeds, these corporations have grown the global market for their pesticide products as well.

- Virtually 100 percent of GE crops on the market are engineered to either contain a pesticide or survive repeated applications of herbicides.[xv] In the first 13 years of commercial use, these crops increased pesticide use by over 300 million pounds.[xvi]

The surge in herbicide use brought on by commercialization of GE crops has led to contamination of our air, soil, and water; millions of acres of farmland infested with RoundUp-resistant "superweeds" and "superbugs"; and recourse to older, more toxic pesticides like 2,4-D.

More GE crops are in the pipeline, awaiting approval from the U.S. Department of Agriculture (USDA). Nearly all of the "next generation" of GE crops have been engineered to be used with chemical herbicides.

Resources:

NGO science reports:

Gurian-Sherman, Doug. *Failure to Yield: Evaluating the Performance of Genetically Engineered Crops*. Cambridge, MA, USA: Union of Concerned Scientists, April 2009.

Benbrook, Charles. *Impacts of Genetically Engineered Crops on Pesticide Use: The First Thirteen Years.* Boulder, CO, USA: The Organic Center, November 2009.

M. Antoniou, C. Robinson, and J. Fagan. *GMO Myths & Truths: An evidence-based examination of the claims made for the safety and efficacy of genetically modified crops.* London, UK: Earth Open Source, June 2012.

Literature reviews:

J.L. Domingo, J. Gine Bordonaba. "A literature review on the safety assessment of genetically modified plants," *Environment International* 37 (2011) 734-742.

- Have done three reviews of the data over time. In 2000 & 2006, they concluded that "if data on toxicological assessment of GM foods/plants existed, these had not been reported in scientific journals, and therefore, they were not available to the general scientific judgment." A number of other reviews came to the same finding (listed on p735).
- Note as a key problem in the lack of studies the use of "substantial equivalence."

C. Snell, A. Bernheim, J-B Bergé, M. Kuntz, G. Pascal, A. Paris, A.E. Ricroch. "Assessment of the health impact of GM plant diets in long-term and multi-generational animal feeding trials: A literature review," *Food and Chemical Toxicology,* 50 (2012) 1134-1148.

- Authors note major flaws in the available literature, including:
    - Lack of genetically comparable (isogenic) lines;
    - Statistical power underestimation;
    - Over-interpretation of differences & poor toxicological interpretation of the data;
    - Lack of repetition or reproducibility, "very few studies for a given plant line have been reproduced using the same animal model. Moreover, studies using the same animal model were performed with different parameters, which lead to the fact that no trials have been carried out twice in the same conditions by different research teams."

A. Dona, I.S. Arvanitoyannis. "Health risks of genetically modified foods." *Crit Rev Food Sci Nutr* 2009: 49: 2073-85.

ENDNOTES

[i] J.L. Domingo, J. Gine Bordonaba. "A literature review on the safety assessment of genetically modified plants," *Environment International* 37 (2011) 734-742; C. Snell, et. al.,"Assessment of the health impact of GM plant diets in long-term and multi-generational animal feeding trials: A literature review," *Food and Chemical Toxicology,* 50 (2012) 1134-1148.

[ii] C. Snell, *ibid*. It is worth noting that despite the "major flaws" outlined in this literature review, this research team nevertheless concludes, "The studies reviewed present evidence to show that GM plants are nutritionally equivalent to their non-GM counterparts and can be safely used in food and feed."

[iii] Séralini, Gilles-Eric, Dominique Cellier, and Joël Spiroux Vendomois. "New Analysis of a Rat Feeding Study with a Genetically Modified Maize Reveals Signs of Hepatorenal Toxicity." *Archives of Environmental Contamination and Toxicology* 52, no. 4 (March 13, 2007): 596–602; Malatesta, Manuela, Federica Boraldi, Giulia Annovi, Beatrice Baldelli, Serafina Battistelli, Marco Biggiogera, and Daniela Quaglino. "A Long-term Study on Female Mice Fed on a Genetically Modified Soybean: Effects on Liver Ageing." *Histochemistry and Cell Biology* 130, no. 5 (July 22, 2008): 967–977.

[iv] Antoniou, Michael, Claire Robinson, and John Fagan. *GMO Myths and Truths: An Evidence-based Examination of the Claims Made for the Safety and Efficacy of Genetically Modified Crops*. London, United Kingdom: Earth Open Source, June 2012. de Vendômois JS, Roullier F, Cellier D, Séralini GE. A Comparison of the Effects of Three GM Corn Varieties on Mammalian Health. *Int J Biol Sci* 2009; 5(7):706-726.

[v] Schubbert, R, U Hohlweg, D Renz, and W Doerfler. "On the Fate of Orally Ingested Foreign DNA in Mice: Chromosomal Association and Placental Transmission to the Fetus." *Molecular & General Genetics: MGG* 259, no. 6 (October 1998): 569–576; Antoniou, Michael, Claire Robinson, and John Fagan. *GMO Myths and Truths: An Evidence-based Examination of the Claims Made for the Safety and Efficacy of Genetically Modified Crops*. London, United Kingdom: Earth Open Source, June 2012.

[vi] Schubbert, R, U Hohlweg, D Renz, and W Doerfler. "On the Fate of Orally Ingested Foreign DNA in Mice: Chromosomal Association and Placental Transmission to the Fetus." *Molecular & General Genetics: MGG* 259, no. 6 (October 1998): 569–576; Antoniou, Michael, Claire Robinson, and John Fagan. *GMO Myths and Truths: An Evidence-based Examination of the Claims Made for the Safety and Efficacy of Genetically Modified Crops*. London, United Kingdom: Earth Open Source, June 2012.

[vii] Zhang, Lin, Dongxia Hou, Xi Chen, Donghai Li, Lingyun Zhu, Yujing Zhang, Jing Li, et al. "Exogenous Plant MIR168a Specifically Targets Mammalian LDLRAP1: Evidence of Cross-kingdom Regulation by microRNA." *Cell Research* 22, no. 1 (September 20, 2011): 107–126. Hansen, Michael. Letter to American Medical Association Council on Science and Public Health. "Reasons for Labeling of Genetically Engineered Foods." Letter to American Medical Association Council on Science and Public Health, March 19, 2012.

[viii] Séralini, Gilles-Eric, Dominique Cellier, and Joël Spiroux Vendomois. "New Analysis of a Rat Feeding Study with a Genetically Modified Maize Reveals Signs of Hepatorenal Toxicity." *Archives of Environmental Contamination and Toxicology* 52, no. 4 (March 13, 2007):

[ix] de Vendômois JS, Roullier F, Cellier D, Séralini GE. A Comparison of the Effects of Three GM Corn Varieties on Mammalian Health. *Int J Biol Sci* 2009; 5(7):706-726.

[x] Evidence of the Magnitude and Consequences of the Roundup Ready Soybean Yield Drag from University-Based Varietal Trials in 1998. Benbrook C. Benbrook Consulting Services Sandpoint, Idaho. Ag BioTech InfoNet Technical Paper, Number 1, 13 Jul 1999. http:// www.mindfully.org/GE/RRS-Yield-Drag.htm.Glyphosate-resistant soyabean cultivar yields compared with sister lines. Elmore R.W. et al. Agronomy Journal, 93: 408-412, 2001. Development, yield, grain moisture and nitrogen uptake of Bt corn hybrids and their conventional near-isolines. Ma B.L. and Subedi K.D. Field Crops Research, 93: 199-211, 2005.

[xi] U.S. Department of Agriculture. The Adoption of Bioengineered Crops. US Department of Agriculture Report, May 2002.

[xii] Gurian-Sherman, Doug. *Failure to Yield: Evaluating the Performance of Genetically Engineered Crops*. Cambridge, MA, USA: Union of Concerned Scientists, April 2009.

[xiii] Latham, Jonathan R., Allison K. Wilson, and Ricarda A. Steinbrecher. "The Mutational Consequences of Plant Transformation." *Journal of Biomedicine and Biotechnology* 2006 (2006): 1–8

[xiv] Bouissou, Julien. "India loses faith in GM cotton." *Guardian Weekly*: 15 May 2012.

[xv] According to industry reports, herbicide resistance accounts for 62.4% of GE crop acreage worldwide, insect resistance 16.2% and both traits 21.4%. Percentage of other traits are considered even by industry as too miniscule to measure. ISAAA (2009). "Global Status of Commercialized Biotech/GM Crops: 2009 - The first fourteen years, 1996 to 2009." ISAAA is an organization funded by the biotechnology industry and has been heavily criticized for misrepresentation of facts, particularly regarding health, economic and environmental impacts of its products. Unfortunately no other source of data on international GE crop acreage exists.

[xvi] Benbrook, Charles. *Impacts of Genetically Engineered Crops on Pesticide Use: The First Thirteen Years.* Boulder, CO, USA: The Organic Center, November 2009.