What they don't want to tell you about genetically modified crops and foods

GMO

MYTHS & FACTS

Claire Robinson

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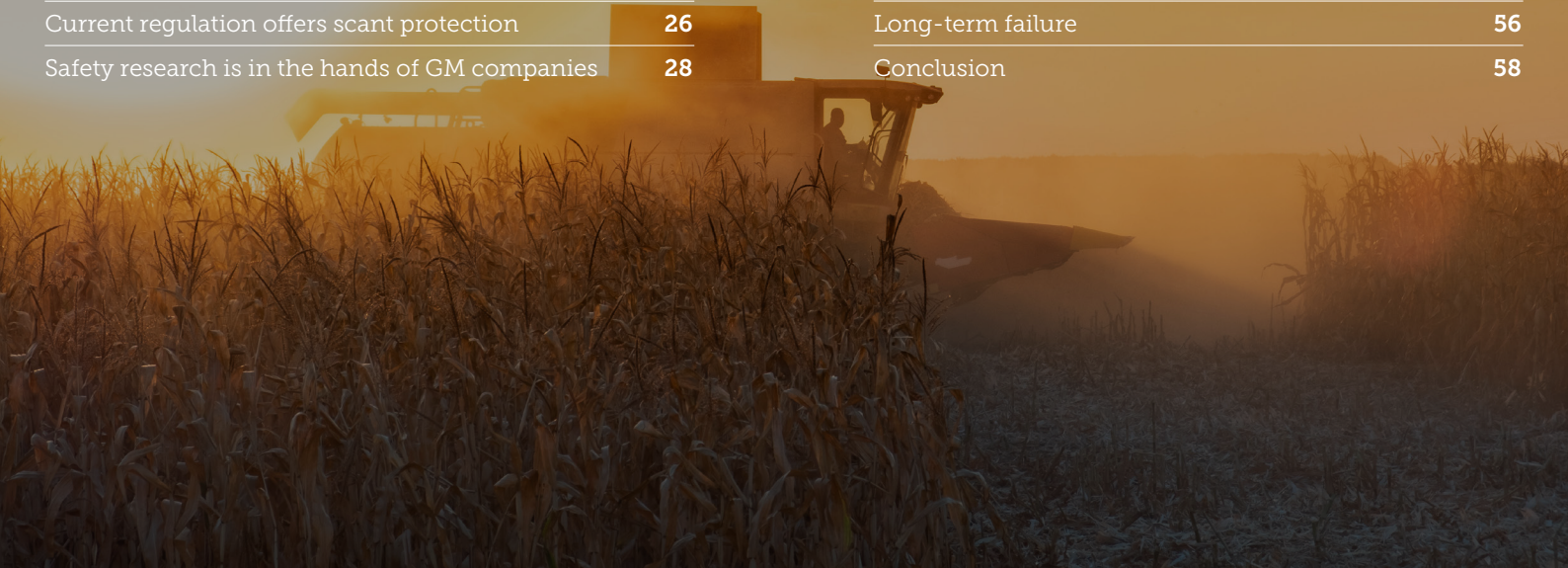


Introduction

The public is constantly told that genetically modified (GM) crops and foods are needed to feed the world's growing population and to meet the challenges that face farmers – climate change as well as pests and diseases. It is claimed that GM crops will make agriculture more sustainable, giving higher yields, reducing pesticide use, and providing more nutritious food. GM foods are said to be as safe as non-GM foods.

But these claims are at best questionable and at worst false. There is no GM crop or food that has sustainably delivered the hyped benefits. At best, GM crops have performed no better than non-GM crops. At worst, they have introduced new risks into food and farming or exacerbated existing problems. Studies point to potential and actual harm to animal and human health and the environment from GM crops and the foods derived from them. But often this evidence does not reach the public and is buried under a deluge of exaggerated claims generated by a well-funded pro-GM lobby.

Now the same inflated claims are being made for a new generation of "gene-edited" GM crops as were made for the first generation. We are told that gene editing our food supply can protect it from the challenges of climate change. Even our livestock animals are being "gene-edited" in the name of improving them. The narrative of the moment is that gene editing is more precise and controllable than older GM techniques and that therefore it is safer – though this implies that old-style GM was not as safe as originally claimed!

However, the evidence shows that new gene-editing techniques are not as precise, predictable, or natural as claimed, and that they pose major risks. The products of these techniques will inevitably prove a disappointment – or even dangerous. Just like old GM, "new GM" will gobble up valuable resources and distract from the existing proven solutions to the problems of food production and agriculture.

During the writing of this booklet post-Brexit, the UK government was working on a trade deal with the US. If the deal goes ahead and the UK gives in to the US's demands on agricultural products, inadequately tested, potentially unsafe and unlabelled GM foods, including gene-edited ones, will be imported into the UK. Shoppers will not be able to choose GM-free foods and farmers will not be able to plant GM-free seeds.

The current UK government aims to de-regulate GM and gene-edited crops and foods within England to "liberate" the country's biotechnology sector from legislation put in place by the EU to protect human and animal health and the environment from adverse effects of GMOs.

This booklet has been written by Claire Robinson, editor of GMWatch.org, and produced by the Sheepdrove Trust to educate and inform the public about the serious risks posed by the GM food venture.

References for this booklet can be viewed at: www.gmwatch.org/en/uncategorised/18765

Feeding the world

MYTH We need GM crops to feed the world's growing population.

FACT There is no global or regional shortage of food.

We already produce enough food for 14 billion people, far more than we will ever need to feed the projected world population in 2050 of 9 billion.[1, 2, 3] In the US, 40 per cent of all food produced is wasted.[4] What is more, only a tiny proportion of the American GM crop harvest goes to feed people.

Of the US maize crop:

- Nearly 50 per cent goes into feed for US livestock farms.[5]
- Around 30 per cent is used for biofuels. [5]
- Only 8 per cent is used for food-related products, mostly in the form of high-fructose corn syrup, an unhealthy ingredient of processed foods.[5]
- The rest is exported, mostly for animal feed.[5]

Of the world's soy crop:

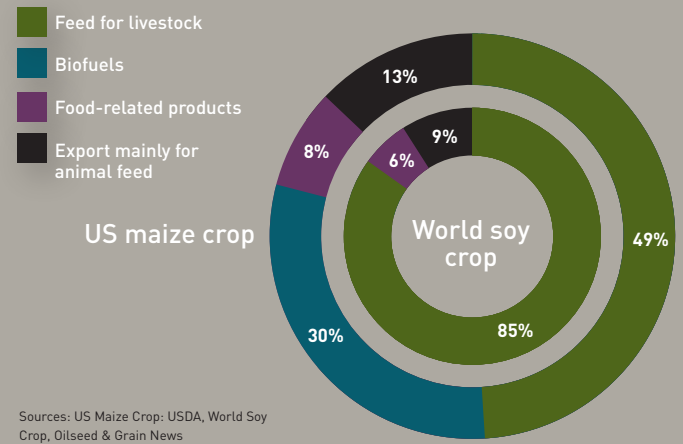
- Around 85 per cent goes into animal feed.[6]
- Around 6 per cent goes directly to feed humans.[6]
- The rest goes into industrial products, such as biodiesel.[6]

Although animal feed leads secondarily to human food, it is a hugely inefficient way of alleviating hunger. About 13kg of grain is needed to produce 1kg of intensively farmed beef.[7]

GMOs fail small-scale farmers

Experiments involving GM crops targeted at poor and small-scale African farmers have been much publicized but have largely ended in failure.[8,9,10,11,12,13] In contrast, non-GM alternatives have been developed at a fraction of the cost and time required to produce their GM versions.[11,14,15]

US maize use and world soybean use



Sources: US Maize Crop: USDA, World Soy Crop, Oilseed & Grain News

Food poverty is not caused by food shortage

In many areas of the world people are hungry not because of inadequate food production, but because of poverty: they simply cannot afford to buy the food that is available in their local markets and they lack the land on which to grow it for themselves.

Grown to feed industry, not people

According to Dr Jonathan Foley, environmental scientist and executive director of the California Academy of Sciences, "Industrial agriculture and biotech interests have built entire campaigns saying that we 'need' genetically engineered organisms to 'feed the world' … But it's just not true … Most of the GMOs in use today aren't even primary food crops that feed the world – like rice, wheat, roots and tubers, pulses, and fruits and vegetables."[16]

> ***"Europe has learned to grow more food per hectare and use fewer chemicals … [compared with the US]. [US] choices in biotechnology are causing it to fall behind Europe in productivity and sustainability."***
>
> Professor Jack Heinemann, University of Canterbury, New Zealand, first author of study based on FAO data showing no yield benefit from GM

Dr Foley points out that most of the world's production of GM crops – notably feed corn (used for making animal feed, high-fructose corn syrup, and corn ethanol), soybeans (mainly for animal feed), cotton, and canola – are not used to alleviate world hunger but are used in wealthier countries, mainly to fatten animals, make unnecessary biofuels and food additives, or to make cheap clothing.[16]

He argues, "If GMOs really were going to 'feed the world', we would grow GMO crops poor people actually eat. But where's the profit in that?"

GM crop yields

MYTH GM crops give higher yields.

FACT GM crops do not produce higher yields.

Conventionally bred plants continue to outperform GM crops in terms of yield and other useful traits, such as tolerance to extreme weather conditions and poor soils, disease resistance, and enhanced nutritional value.[17]

A study used Food and Agriculture Organisation (FAO) data to compare yields of staple crops in the US, which are mostly GM, with yields of the same crops in Western Europe, which are mostly non-GM. The study concluded, "We found no yield benefit when the United States was compared to W. Europe."[18]

A US Department of Agriculture report stated, "GE [genetically engineered] seeds have not been shown to increase yield potentials ... In fact, the yields of herbicide-tolerant [HT] or insect-resistant [Bt] seeds may be occasionally lower than the yields of conventional varieties if the varieties used to carry the HT or Bt genes are not the highest yielding cultivars."[19]

There is no GM gene for high yield. Yield depends on the genetics of the crop into which the GM gene for herbicide tolerance or insect resistance is inserted. In other words, it is a product of conventional breeding, which is solely responsible for the remarkable yield increases of modern agriculture.[20]

> *"Europe has learned to grow more food per hectare and use fewer chemicals in the process [compared with the US]. The American choices in biotechnology are causing it to fall behind Europe in productivity and sustainability."*
>
> Professor Jack Heinemann, University of Canterbury, New Zealand, first author of study based on FAO data showing no yield benefit from GM

Natural farming: the key to food security

MYTH There are no alternatives to GM if we are to increase food production.

FACT Low-input farming can provide food security for future generations.

Agroecology (a range of low-input farming methods) can ensure enough food for the current population and that the land improves in productivity in the future.

In 2008 a groundbreaking study on the future of farming was published. Sponsored by the World Bank and the United Nations (UN) and conducted by over 400 international scientists, the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) specifically did not endorse GM crops as a solution to world hunger.

GMOs could undermine food security

The IAASTD report noted that yields of GM crops were "highly variable" and in some cases there were "yield declines". It added that safety questions remained over GM crops and that the patents attached to them could undermine seed saving and food security in developing countries. The report concluded that the key to food security lies in agroecology.[21]

The answer to world hunger is not GMOs

When asked at a press conference if GM crops were the answer to world hunger, IAASTD director Professor Bob Watson (subsequently chief scientist at the UK's Department for Environment, Food and Rural Affairs – DEFRA) said, "The simple answer is no."[22]

Agroecology: a sustainable solution to food security

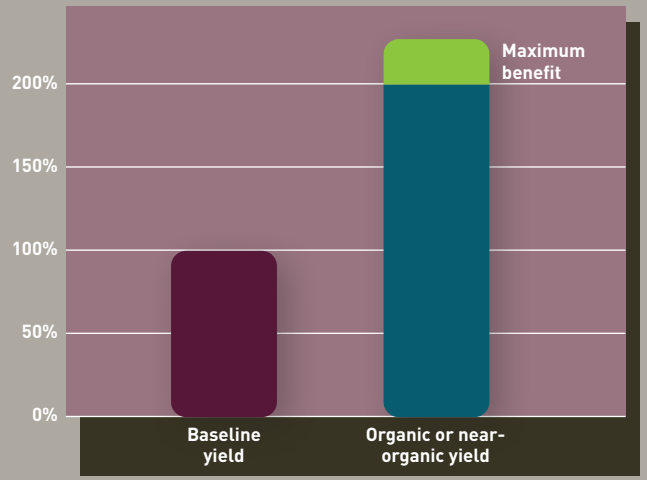
The natural approaches of agroecology include low-input and organic methods that preserve soil and water while minimizing the use of external inputs, such as pesticides and fertilizers.

Dramatic yield increases from natural methods

Agroecology projects in the Global South and other developing regions have produced dramatic increases in yields and food security.[23,24,25,26,27,28]

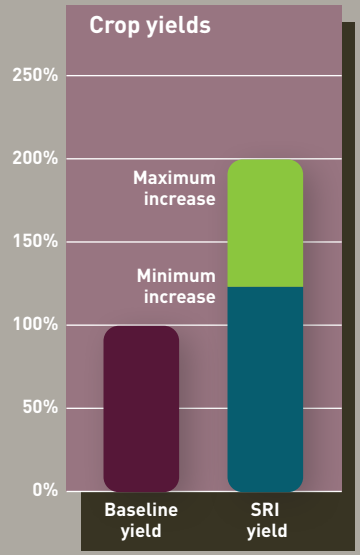
- A UN report looked at 114 farming projects in 24 African countries and found that the adoption of organic or near-organic practices resulted in yield increases of up to 128 per cent over baseline. The report concluded that organic agriculture can improve food security more effectively than chemically based systems and that it is more sustainable in the long term.[26]

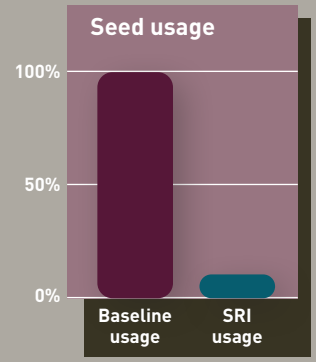
Organic or near-organic yields compared with yields over baseline

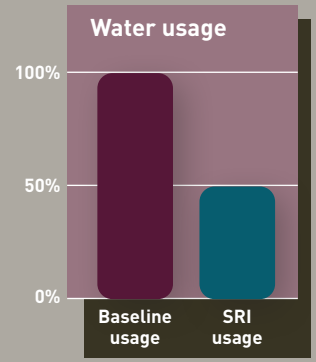


- The System of Rice Intensification (SRI) is an agroecological method of increasing the productivity of rice by changing the management of plants, soil, water, and nutrients. The benefits of SRI include yield increases of 20–100 per cent, up to 90 per cent reduction in the amount of seed required, and water savings of up to 50 per cent.[29]

System of Rice Intensification (SRI) compared over baseline







Genetics: what we don't know

Our understanding of genetics has made huge leaps forward in the past half century, but in many ways the progress made in this science has only revealed that there is a vast amount that we have yet to learn. In particular, we are only just beginning to understand the complexity of the interactions between different genetic components and how these components respond to environmental factors.

A genetic ecosystem

John Vandermeer, Professor of Ecology and Evolutionary Biology at the University of Michigan, has pointed out that our understanding of the genome is still incomplete. He has said: "We now know that there are an enormous number of complications that are involved … Molecular biology has now advanced to the point that we now understand that the genome is like a complicated ecosystem. Doing just one thing such as inserting a piece of DNA into a big genome and expecting just the single protein you are planning for and nothing else is probably not possible."[31]

> ***"Genetic engineering is based on a dramatically incomplete knowledge of the genome."***
>
> Professor John Vandermeer, University of Michigan

Not simply a boost to natural selective breeding

MYTH GM is just an extension of natural breeding.

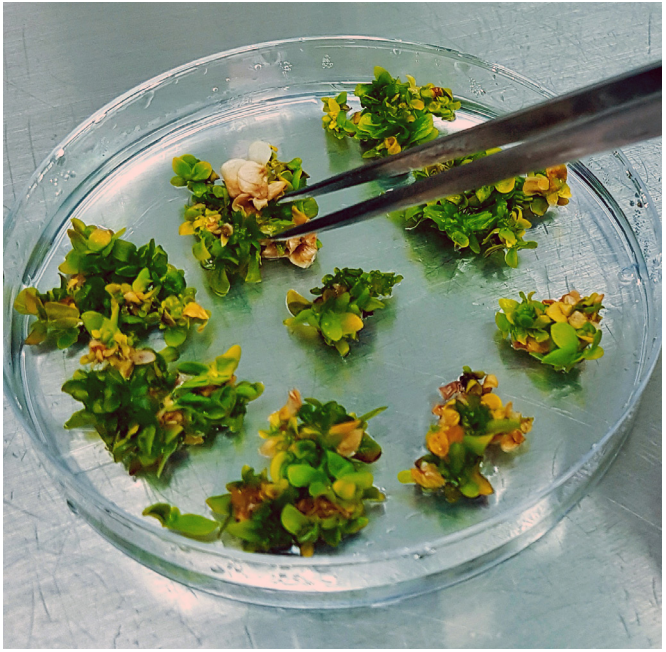
FACT GM is different from natural breeding and poses greater risks.

The techniques involved in genetic engineering are radically different from conventional plant-breeding techniques and the consequences cannot be predicted. Proponents of GM crops claim GM is more precise and allows genes coding for the desired trait (characteristic) to be inserted into the host plant with minimal unexpected effects. But the GM transformation process is totally artificial and would never happen in nature.

Key elements of the technique include:

- Randomly inserting an artificial foreign gene unit into the cells thereby altering the host genome (total DNA).
- Growing plant cells on dishes in the laboratory in a nutrient culture (plant cell tissue culture).

Unlike in natural breeding, genes can be moved between different species and even different kingdoms, such as between plants and animals.



Dangerously unpredictable results

Genetic engineering processes are not precise but are highly mutagenic (damging to DNA) both at the genetic and the epigenic (gene regulatory) level. [32,33,34] Genetic modification can lead to unpredictable changes in the DNA and consequently to proteins and the overall biochemical composition of the resulting plant. This can result in the GM plant being unexpectedly toxic or allergenic (allergy-producing). The changes can also alter the nutritional value of the crop, as well as having unpredictable effects on wildlife.

Unintended outcomes and dangers of gene editing

MYTH Gene editing is precise, controllable, and as safe as natural breeding.

FACT Gene-editing techniques can have unexpected outcomes that could pose dangers.

Gene-editing technologies (including CRISPR-Cas9, TALENs and ZFNs) are being used to generate new varieties of food crops and farm animals. Proponents claim that these techniques are precise and controllable, especially in comparison to older GM techniques. They also claim that the changes to genes brought about by gene editing could happen naturally.

Uncontrollable consequences

A growing body of scientific research shows that gene-editing gives rise to unpredictable results, including unexpected mutations (damage to DNA) both at the site targeted for editing ("on-target mutations") and elsewhere in the genome ("off-target mutations").[35,36,37,38] The tissue culture process, an obligatory part of gene-editing technologies as well as older GM techniques, is mutagenic, causing major damage to the organism's DNA.[39] Another process used in many gene-editing and older-style GM applications, Agrobacterium-mediated transformation, is highly damaging at the DNA and gene regulatory (epigenetic) levels.[34]

In the case of gene-edited food plants, these effects could lead to the production of unexpected toxins or allergens, or altered nutritional value. This is not overstating the risk, since first-generation GM crops and foods have proven unexpectedly toxic or allergenic (see "*The risks of consuming GM foods*", page 32). We don't know if gene-edited crops and foods will be different, as no one has done the required studies in animals or humans.

Gene editing is genetic modification

The gene-editing procedure is undeniably a GM process that gives rise to GMOs. This was confirmed in a 2018 European Court of Justice ruling that stated that gene-editing techniques (called in the case "new mutagenesis" techniques) pose the same risks as older GM techniques and fall under current GMO regulations. So in the EU, products of these new techniques must be subjected to safety checks and labelling.[40]

However, a well-funded lobby of GMO industry representatives, joined by genetic engineering scientists, many of whom are dependent on the GMO industry for funding, is trying to get the law changed. They want gene-edited crops and foods to be exempted from the GMO regulations and the accompanying safety checks and labelling. This would pose huge risks to consumers and the environment.

"Understanding of uncertainties and risks regarding genome editing is necessary and critical before a new global policy for the new biotechnology is established."[36]

S. Biswas and colleagues on their research finding that CRISPR gene editing "may be not as precise as expected in rice"

Many scientific studies are not objective

MYTH Extensive objective scientific studies confirm the safety of GM crops and foods.

FACT Many studies on GM crop and food safety are not objective.

We depend on scientists at public universities and institutes to be objective and stick to the evidence. However, many academic institutions and their affiliated scientists have come to rely on money from the agricultural biotechnology industry for funding research, buildings and departments, and therefore cannot be regarded as independent. In addition, many scientists and public bodies themselves own patents on GM crop technology.[41] These facts must be borne in mind when evaluating the claims about GM technology made by scientists associated with these institutions.

Hidden sponsorship

Some proponents of GM technology have been exposed as receiving money from the industry without disclosing these links. In one case, in 2014 the biotech company Monsanto (now owned by Bayer) approved a grant for US$25,000 to allow University of Florida scientist Dr Kevin Folta to travel to give public talks promoting GM. "I am grateful for this opportunity and promise a solid return on the investment," Folta wrote in an email to a Monsanto executive.[42] But Folta repeatedly denied having any Monsanto funding.[43] Emails show that he tried to hide the grant so that it was not "publicly noted".[44]

Few honest brokers

"Newly arriving biotechnologies are beginning to force us all – scientists, policy makers, and the public – to confront questions of extraordinary difficulty. We will urgently need scientists to act as 'honest brokers' to help educate, enrich debate, and inform policy ... but we have lost them ... The key CRISPR [a gene-editing technique] pioneers at both the University of California, Berkeley, and the Massachusetts Institute of Technology have started their own companies, where rewards will be profits. As an honest broker, the scientist should be the first one to point out that their job is ... to use the tools of science for the rewards their employer seeks and for which their employer rewards them. It is those rewards that should be compared to risks worth taking, not the rewards of the imaginary scientist whose overriding concern is human health or food supply."

Glenn Davis Stone, Professor of Anthropology and Environmental Studies, Washington University, St Louis, Missouri [45]

Taking control of the food supply

A key element of the jigsaw of the GM business is the control and assurance of profits that patent rules give to the companies that develop and market GM crops.

Traditionally, most of the seeds that farmers have used to grow our food crops have not been owned by anyone. Farmers have been free to save seed to replant. Around 1.4 billion people in the southern hemisphere rely on farm-saved seed.[46]

An ongoing cost to farmers

This ancient practice of seed saving is being undermined because the GM genes used in creating GM crops are patented and owned by agricultural biotech companies. The contracts farmers sign when they buy GM seeds forbid them from saving seed to plant the next year. They have to buy new seed each year – a significant cost to growers working to extremely tight margins. The GMO developer Monsanto has sued hundreds of farmers for replanting its patented seed.[47]

Patents block access to plant genetic material

Patents also enable GMO developer companies to block access by breeders to the genetic material. GM patents extend to seeds, plants, and any progeny derived from the GM plant, all along the chain of farm and food production.

GM seeds are far easier to patent than seeds of non-GM crops, because the "inventive step" necessary to satisfy patent offices is clear. The GM industry uses patents on GM seeds to consolidate its ownership of seed and control of food production.[48]

Profit not responsibility

In this context, even if the GM crop turns out not to perform better than non-GM crops, this is of no concern to the companies that own the patents. As the expert group ETC said, "The new technologies don't need to be socially useful or technically superior (i.e. they don't have to work) in order to be profitable. All they have to do is chase away the competition and coerce governments into surrendering control. Once the market is monopolized, how the technology performs is irrelevant."[49]

> ***"Some GM foods may be healthy, others not; every genetic modification is different. But every GM food becomes dangerous – not to health, but to society – when it can be patented. Right now, the driving force behind the development of new genetic crop modifications is the fact that they possess the potential to be enormously profitable."***
>
> Frederick Kaufman, author of *Bet the Farm: How Food Stopped Being Food* [50]

Current regulation offers scant protection

MYTH GM foods are strictly tested and regulated for safety.

FACT GMO regulations are not strong enough to protect health and environment.

Some regulation is better than none and it is vital that we keep GM foods and crops, including gene-edited ones, regulated and labelled. However, GMO regulations across the world vary and lack the rigour needed to protect health and environment. For example, safety tests on GM foods are undertaken by companies that stand to profit from selling them. The tests are too weak to prove safety, especially regarding long-term consumption.

The US Food and Drug Administration (FDA) first allowed GM foods onto world markets in the early 1990s in spite of its own scientists' warnings that genetic engineering is different from conventional breeding and poses special risks.[51,52,53,54,55,56]

The myth of substantial equivalence

In many countries, GM foods are approved by regulators as "substantially equivalent" to non-GM crops. But when this assumption is tested scientifically, GM crops are often found to have unexpected differences.[57,58,59,60,61,62,63] These differences could make the GM food more toxic or likely to produce allergic reactions than the non-GM parent.

Risks have been ignored

Jonathan Latham, PhD, and Allison Wilson, PhD, co-founders of the Bioscience Resource Project, have published research pointing to risks of genetic modification that have been ignored by regulators.[33] Dr Latham commented, "Our research shows that regulators are colluding with GMO companies … to lower the safety bar so as to enable commercialisation."[65]

> *"[Regulators] are ignoring evidence of harm, and … are adopting risk assessment procedures that fall well below acceptable scientific standards."*
>
> Jonathan Latham, PhD, co-founder of the Bioscience Resource Project

A pseudo-scientific concept

Erik Millstone, Professor of Science Policy at the University of Sussex, and colleagues have written, "The concept of substantial equivalence has never been properly defined … Substantial equivalence is a pseudo-scientific concept because it is a commercial and political judgment masquerading as if it were scientific. It is, moreover, inherently anti-scientific because it was created primarily to provide an excuse for not requiring biochemical or toxicological tests."[64]

Safety research is in the hands of GM companies

MYTH Safety research on GMOs is carried out by independent experts.

FACT Governments have made those who stand to profit from the sale of GMOs responsible for ensuring their safety.

People often assume that governments and their independent agencies rigorously test and ensure the safety of the foods we eat. But this is not the case with GM foods. GMO developer companies are allowed to conduct their own safety tests, which

> ***"The huge arrogance of the companies developing GMO crops and their determination to destroy the line of accountability which links the developer to the product is breathtaking."***
>
> Sir Jonathon Porritt, former Director of Friends of the Earth and founder of Forum for the Future

regulatory agencies review. Putting the GMO industry in charge of ensuring the safety of GM foods and crops could be likened to leaving the fox in charge of the henhouse.

Vested interests in charge of monitoring

In Europe, the European Food Safety Authority (EFSA) has emphasized that the GM industry is responsible for ensuring the safety of its products and that the EFSA does not carry out its own research.[66] In the US, the Food and Drug Administration (FDA) has delegated responsibility for ensuring the safety of GM foods to the companies with a vested interest in selling these products.

"Ultimately, it is the food producer who is responsible for assuring safety." US FDA[7]

"Monsanto should not have to vouchsafe the safety of biotech food. … Assuring its safety is the FDA's job." Philip Angell, Director of Corporate Communications, Monsanto[68]

"It is not foreseen that EFSA carry out such safety studies as the onus is on the GM industry applicant to demonstrate the safety of the GM product in question."
European Food Safety Authority[66]

Obstacles to independent safety research

Scientists who wish to undertake objective research into the safety of GM foods are often hampered by the GM companies and even suffer persecution if they identify risks.

In-depth food safety studies on GM crops and foods carried out by scientists independent of the GMO industry are rare. They are hampered by:

- Lack of funding for research.
- Difficulty of obtaining the relevant GM seeds, which are under patent protection of the GMO companies, and their non-GM parent varieties for comparison, which are often not commercially available.[69,70]
- Persecution of scientists who have managed to carry out such research and have found risks from the GMO tested. They have suffered blocks to career advancement and withdrawal of funding.[71,70,72,73]

Hidden from the public

Claims that the climate for independent researchers has improved in recent years remain unproven[74,75.] Researchers have to sign restrictive agreements with the GMO company whose products they are examining. No examples of these agreements are in the public domain, so the public cannot see what limitations are imposed on researchers.[75]

> ***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.***
>
> *Scientific American*[76]

Punished for objective research

The Italian researcher Manuela Malatesta and her team carried out studies that found that Monsanto's GM soy disturbed the functioning of the liver, pancreas and testes of mice.[77,78,79,80]

After Malatesta published her papers, she was forced out of her job at the university and could not obtain further funding for her research. She said, "Research on GMOs is now taboo. You can't find money for it ... People don't want to find answers to troubling questions. It's the result of widespread fear of Monsanto and GMOs in general."[81]

The risks of consuming GM foods

MYTH GM foods are safe to eat.

FACT Some GM crops and foods have had toxic or allergenic effects on laboratory and farm animals.

There are no safety studies in humans on the health effects of GM foods. But animal studies reveal worrying risks. Some peer-reviewed studies on laboratory rodents (considered by scientists to provide an indication of human health risks) and farm animals have found toxic and allergenic effects in GM-fed groups, [82] including:

- Altered blood biochemistry.[83,84,85]
- Changes in organ weights.[79,86]
- Multiple organ damage.[87]
- Potential effects on male fertility.[87]
- Immune responses[84,88,89] and abnormal allergic-type reactions.[90]
- Enlarged lymph nodes.[89]
- Disturbed function of the liver, pancreas, and testes.[77,78,80,75]
- Unexplained liver ageing.[91]
- Liver and kidney damage.[92,93,94]
- Liver enlargement.[95]
- Digestive disturbances.[96]
- Excessive growth of gut lining and other intestinal abnormalities.[97,98,78]
- Altered gut bacteria.[84]
- Stomach lesions and unexplained deaths.[99,100,101]
- Severe stomach inflammation and heavier uteruses.[103]
- Hormonal disruption.[92]
- Increased premature deaths linked to higher body weight and pituitary gland tumours.[102]

"Most studies with GM foods indicate that they may cause hepatic, pancreatic, renal, and reproductive effects and may alter haematological [blood], biochemical, and immunologic parameters, the significance of which remains to be solved with chronic toxicity studies."

Artemis Dona, University of Athens Medical School, and I.S. Arvanitoyannis, University of Thessaly School of Agricultural Sciences

The long view is missing

Most feeding studies with GMOs are short- or medium-term. Nonetheless some have revealed changes in GM-fed animals that could develop into serious disease in the longer term. We need long-term studies and studies of effects over several generations to ensure that commercial GM foods are safe, but no regulators anywhere in the world require such studies.

Significantly unscientific?

The industry, allied scientists, and regulators often dismiss findings of toxicity in animal feeding studies on GMOs by claiming they are "not biologically significant", "not relevant", or "not adverse". However, these terms have not been defined in the context of feeding studies with GMOs and are scientifically meaningless.

Lack of labelling

Claims that Americans have eaten millions of GM meals with no ill effects are unscientific. No epidemiological studies have been done to find out if GM foods are affecting the health of Americans. What is more, GM foods are not labelled as such in the US, so there is no way of tracing who has eaten them in order to identify their possible effects. What is known is that human health and life expectancy in the US are declining.[104,105] GM foods and the pesticides used with them cannot be ruled out as one cause among many. Over 300 scientists have concluded that there is no consensus on GM food safety.[106,107]

No studies on animal fed the new gene-edited crops and foods have been published, so claims of safety for these new foods cannot be substantiated. Sixty-one scientists signed a statement warning that "unexpected molecular changes could result in the production of novel toxins and allergens".[108]

> *"The agri-food industry is overwhelmingly opposed to mandatory [GMO] labelling … Food companies …[and] biotech companies … spent over $100 million to defeat … initiatives [to label GMOs]."*
>
> Bain C and Dandachi T (2014). Sustainability 2014(6):9456-9476

Flawed research

MYTH Extensive animal research shows GM crops are safe.

FACT The flaws in this research make its conclusions unreliable.

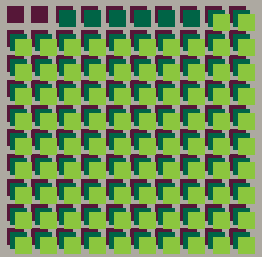
The results of one of the key studies on which GM proponents rely were published in 2014.* Led by former Monsanto scientist Alison Van Eenennaam, the research spanned a period of 29 years, before and after the introduction of GM feed in 1996. The study is claimed to show that data from over 100 billion farm animals confirm GM crops are safe. However, the study has many flaws, including:

- It was uncontrolled for many variables, including escalating antibiotic use in livestock, which can mask health problems.
- No information is given on how many of the animals in the study were eating GM feed, how much, and for how long.
- Of the 100 billion animals studied, 98 per cent were poultry and 92 per cent were 49-day-old broiler chickens.
- Animal health was not measured. Only livestock performance parameters such as carcass weight, pus in milk, and mortality rate were recorded.

*Eenennaam AL Van, Young AE. Prevalence and impacts of genetically engineered feedstuffs on livestock populations. *Journal of Animal Science* 2014;92(11):4255-78

Study dominated by immature poultry

KEY
- Total animals studied
- Poultry
- 49-day-old broiler chickens



Livestock performance is not a marker of health

Veterinarian Dr Ena Valikov commented on this study: "Livestock production is not a marker of health – because the goal of livestock production is minimizing inputs and maximizing production … regardless of costs to the animal's health or longevity. For the rest of us, who aren't slaughtered at 49 days, the goals are completely different."

Outside of controlled animal feeding studies, no meaningful data is available that could be used to assess the health effects of GM feed on livestock. Dr Valikov has written, "Veterinary health data has been collected by the FSIS (US Food Safety and Inspection Service)[109] and it shows remarkably high rates of malignant lymphoma in livestock. But appropriate data was only collected for five years: 1998–2002. So there are no long-term data useful in analyzing long-term impacts of GMOs on livestock health."[110]

Broiler chickens are not humans

Broiler chickens are irrelevant models for assessing human or even mammalian health risks as they have different digestive systems and metabolism. What's more, 49 days in a broiler chicken is too small a fraction of a chicken's natural lifespan (5-7 years) to give long-term data, even in chickens.

A toxic relationship

MYTH GM crops reduce pesticide use.

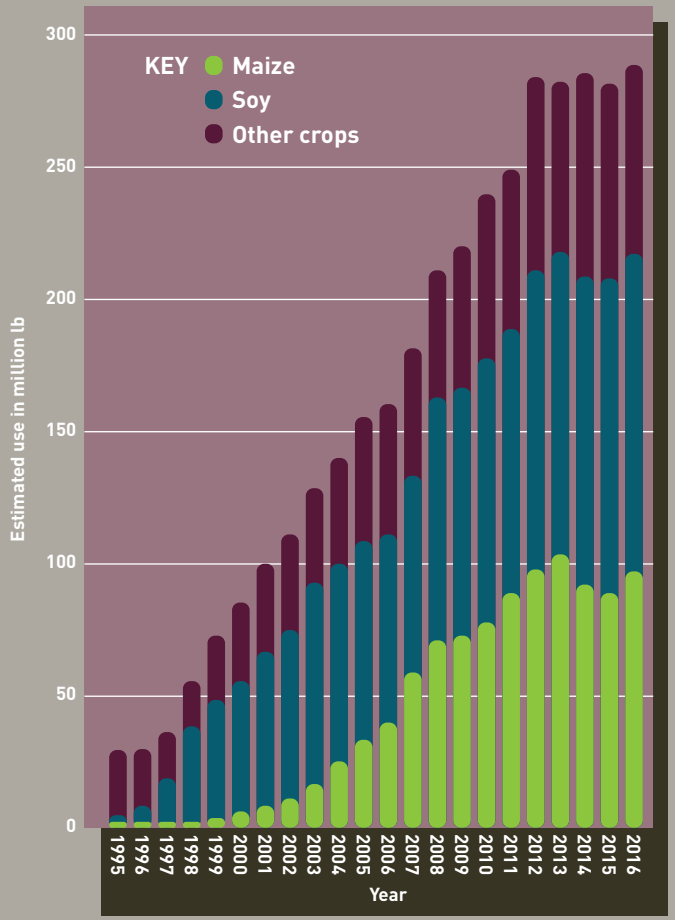
FACT GM crops increase pesticide use.

Genetic modification and increased pesticide use go hand-in-hand. Most GM crops are tolerant to herbicides, allowing widespread use of chemicals that are potentially dangerous to humans and the environment. Over 99 per cent of all commercialized GM crops are engineered to tolerate one or more herbicides, or to have an insecticidal effect, or both.[111] The most widely grown GM crop is Roundup Ready soy,[112] engineered to survive being sprayed with the glyphosate-based herbicide Roundup. The genetic modification enables farmers to spray the field liberally with Roundup, killing all plant life except the crop.

Massive increase in glyphosate use

Globally, the use of glyphosate, a chemical that has been identified as a potential cause of cancer, has increased 15-fold since the introduction of GM glyphosate-tolerant crops. And glyphosate use in the agricultural sector rose a massive 300-fold from 1974 to 2014. Nearly 67 per cent of total agricultural glyphosate use in the US since 1974 occurred in the decade following the introduction of GM crops.[113] A cause for concern is the high levels of glyphosate residues increasingly found in GM crops,[114,115] in some cases above permitted limits.[116] The risks of GMOs cannot be separated from those of the pesticides with which they are grown.

US glyphosate annual usage



Pesticide National Synthesis Project, US Geological Survey

Superweeds and the chemical treadmill

Since GM glyphosate-tolerant crops were introduced, many weeds have become resistant to this herbicide, leading to glyphosate-resistant "superweeds".

The area of US cropland infested with glyphosate-resistant weeds was estimated at 61.2 million acres in 2012.[117] The industry's answer to glyphosate-resistant superweeds has been to develop "stacked-trait" (with multiple gene insertions) GM crop varieties. Such crops are designed to be resistant to multiple herbicides.

The risks of multi-herbicide tolerance

Dow's GM soybean is engineered to tolerate the application of glyphosate, glufosinate, and 2,4-D.[118]. But weed scientists warn that multi-herbicide-tolerant crops will increase 2,4-D use, provide the trigger for the spread of weeds resistant to both glyphosate and 2,4-D, and undermine sustainable approaches to weed management.[119]

In 2015 the US Department of Agriculture (USDA) approved Monsanto's GM soybeans and cotton, engineered to tolerate the new herbicide dicamba as well as glyphosate.[120] The USDA predicted that dicamba use will increase 88-fold and 14-fold for soybeans and cotton respectively, compared to current levels.[121]

Use of different herbicides will not solve the problem of resistant weeds but will exacerbate it. Weed species already exist that are resistant to dicamba,[122] 2,4-D,[123] and multiple herbicides.[124]

Dicamba and agricultural meltdown

In the US, the use of the herbicide dicamba rocketed in response to the increasing resistance of some weed species to glyphosate. The rise in dicamba use was made possible by the development of GM crops that are tolerant to it. Far from solving farmers' problems, widespread dicamba spraying has brought with it a whole new range of risks.

Livelihoods ruined

Dicamba herbicide sprayed on GM dicamba-tolerant crops is prone to drifting miles off-target, killing other crops and ruining farmers' livelihoods.[125] Commercial orchard trees and other trees and plants have been killed or damaged in spite of the fact that the herbicide formulations were supposed to be drift-resistant.[126,127] After thousands of incidents of dicamba-related crop damage were reported over several years,[128] in June 2020 a court nullified the US EPA's approval of dicamba, saying the agency had failed to assess the risks properly.[129]

Glyphosate: the untold story

MYTH Glyphosate herbicides are safe.

FACT A large body of evidence shows that glyphosate herbicides are not safe.

Industry and regulators have long claimed that glyphosate-based herbicides are safe. But these claims are based on industry's interpretations of its own tests, which are inadequate in many respects. However, objective analyses reveal that even industry's own tests on glyphosate show evidence of serious health risks, including cancer[132,133,134] and birth defects.[135]

Toxic combinations

Industry tests are performed on the "active" ingredient glyphosate alone, not on the complete herbicide formulations as sold, which are not tested for long-term toxicity. This is a problem because these formulations – the ones to which people and animals are exposed – are known to be far more toxic than the isolated "active" ingredient that is tested. This applies to glyphosate-based herbicides and many other pesticides.[130,131]

Chemical cocktails not tested for safety

Regulatory safety studies on which safety limits for exposure are based test only one chemical at a time. The problem with this approach is that research shows that mixtures of chemicals (including pesticides) deemed safe by regulators for each individual substance are toxic when combined, damaging the livers of laboratory rats.* Failure to test the effects of these mixtures is another way that regulations fail to protect us.

The impact of low doses

Safety tests carried out by pesticide manufacturers also fail to test the effects of exposure to low doses, which can be more damaging than the effects of higher doses.[130] This is especially true of hormone-disrupting chemicals, which can have effects at extremely low doses.[136] Studies have linked chemicals of this type with serious health problems, including diabetes, cancer, heart disease, and birth defects.[137] There is still scientific controversy over whether glyphosate-based herbicides are hormone disruptors at the doses likely to be experienced in the "real world", as the required tests have not been done.[138]

* Mesnage R et al (2020). BioRxiv https://doi.org/10.1101/2020.08.25.266528

Glyphosate link with cancer

In 2015 the International Agency for Research on Cancer (IARC) classified glyphosate as a probable human carcinogen based on "sufficient" evidence from animal feeding studies and "limited" evidence from human epidemiology studies. The studies suggest a link with a form of cancer called non-Hodgkin lymphoma (NHL).[139]

DNA damage

The IARC said there is "strong" evidence that glyphosate is genotoxic (damaging to DNA) and that this a mechanisms by which the chemical could cause cancer.[139] The US Environmental Protection Agency (EPA), on the other hand, has said that glyphosate is not genotoxic. Why the disagreement? An analysis shows that the EPA relied on unpublished industry studies, 99 per cent of which found that glyphosate is not genotoxic, whereas IARC relied on published studies, 74 per cent of which found that glyphosate is genotoxic.[140]

Arguments about evidence

Sources sympathetic to the agrochemical industry argue that recent data from the Agricultural Health Study (AHS) in the US show that glyphosate does not cause NHL and that an IARC scientist wrongly excluded this data from the agency's review.[141,142]

This argument is false for the following reasons:

- The IARC considers only published data and thus could not evaluate the recent AHS data, which was not published when it produced its report.
- A previous finding from the AHS of no link with NHL had already been published years before the IARC produced its report.[143]
- The IARC considered the earlier AHS finding, weighing it against other studies that did find a link between glyphosate and NHL.[139]

Alarmingly, the updated AHS data did find a possible link between glyphosate exposure and another form of cancer, acute myeloid leukemia (AML), albeit the association was not statistically significant.[144,145]

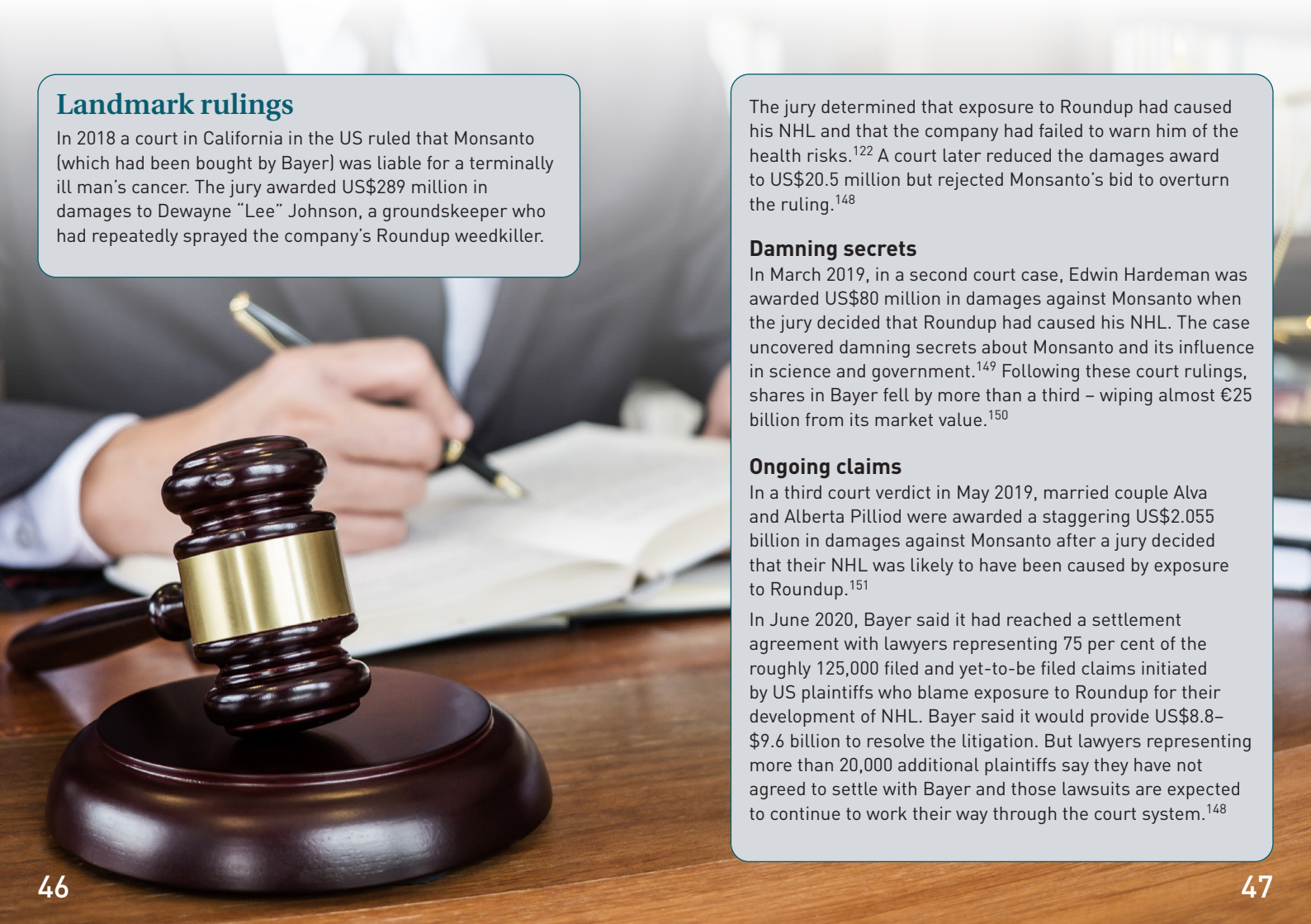
Recent findings

In 2019 a meta-analysis (a review of previously published independent research) found that people with high exposures to glyphosate-based herbicides have a 41 per cent increased risk of developing NHL. The findings ran counter to an assessment by the EPA that found no cancer concerns. The meta-analysis included the most recent update of the AHS in 2018. The authors pointed out that the results of the previous analyses of the AHS data were biased by the inclusion of people with very low exposure, which can dilute risk estimates. When people with high exposures are considered independently, a link between glyphosate herbicides and NHL is found.[146]

Manufacturers of glyphosate-based herbicides have been aware of the cancer risk of their products for many years, as internal Monsanto documents released in US cancer litigation show.[129]

Landmark rulings

In 2018 a court in California in the US ruled that Monsanto (which had been bought by Bayer) was liable for a terminally ill man's cancer. The jury awarded US$289 million in damages to Dewayne "Lee" Johnson, a groundskeeper who had repeatedly sprayed the company's Roundup weedkiller.



The jury determined that exposure to Roundup had caused his NHL and that the company had failed to warn him of the health risks.[122] A court later reduced the damages award to US$20.5 million but rejected Monsanto's bid to overturn the ruling.[148]

Damning secrets

In March 2019, in a second court case, Edwin Hardeman was awarded US$80 million in damages against Monsanto when the jury decided that Roundup had caused his NHL. The case uncovered damning secrets about Monsanto and its influence in science and government.[149] Following these court rulings, shares in Bayer fell by more than a third – wiping almost €25 billion from its market value.[150]

Ongoing claims

In a third court verdict in May 2019, married couple Alva and Alberta Pilliod were awarded a staggering US$2.055 billion in damages against Monsanto after a jury decided that their NHL was likely to have been caused by exposure to Roundup.[151]

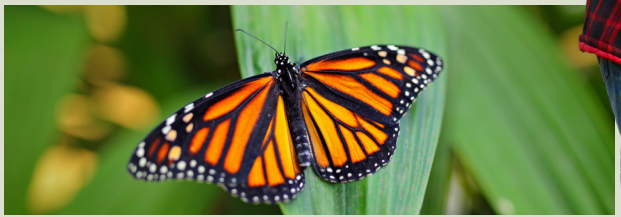
In June 2020, Bayer said it had reached a settlement agreement with lawyers representing 75 per cent of the roughly 125,000 filed and yet-to-be filed claims initiated by US plaintiffs who blame exposure to Roundup for their development of NHL. Bayer said it would provide US$8.8–$9.6 billion to resolve the litigation. But lawyers representing more than 20,000 additional plaintiffs say they have not agreed to settle with Bayer and those lawsuits are expected to continue to work their way through the court system.[148]

Association with other diseases

Scientific concerns about the health effects of glyphosate herbicides are not confined to cancer. A molecular profiling analysis of the tissues from rats fed a very low and realistic dose of Roundup showed that they suffered from non-alcoholic fatty liver disease (NAFLD). This is the first study to find a direct causative link between the low doses of Roundup likely to be ingested in the "real world" and a serious disease.[152,153]

Threat to monarch butterflies

Monarch butterfly numbers in the US declined by around 80 per cent in the decade leading up to 2015 and are now at risk of near-extinction.* The major reason for the decline is the spread of GM glyphosate-tolerant maize and soybeans. The herbicide sprayed on these crops has killed off the milkweed plants that are the monarch larvae's only food. It has been confirmed that the loss of milkweed – not other factors proposed by advocates of GM crops – is the cause of the decline.**



* Semmens BX and colleagues (2016), Sci Rep 6:23265

** Pleasants JM and colleagues (2017), PLOS One 12(7): e0181245

Other researchers have identified a link between exposure to glyphosate-based herbicides and an epidemic of chronic kidney disease among farmers in Sri Lanka, often with fatal results. The researchers suggest that glyphosate becomes damaging to the kidney when it mixes with metals in "hard" water, especially heavy metals such as arsenic and cadmium. The heavy metals can be naturally present in soils or added in pesticides and fertilizers. The researchers argue that glyphosate binds to these metals and carries them to the kidneys, resulting in tissue destruction.[156,157,158]

A study published in 2019 found a link between exposure before birth and in the first year of life to glyphosate-based herbicides and other pesticides and an increased risk of autism.[159]

In a separate study, glyphosate and Roundup were shown to alter the bacterial population in the gut and its biochemical function at low doses assumed to be safe by regulators. Results showed changes in the gut biochemistry that can lead to mutations in DNA, damage to cells and tissues, and diseases such as cancer.[160]

MONSANTO

The Monsanto Papers: a revealing cover-up

Internal documents, popularly termed the Monsanto Papers, from the glyphosate herbicide manufacturer Monsanto released during litigation arising from cancer cases in the US reveal that the company tried to cover up scientific evidence and suspicions – including within the company itself – that these herbicides can cause cancer. The documents appear to show that:

- Several months before the meeting at which IARC scientists decided to classify glyphosate as a probable carcinogen, Monsanto fully expected that IARC would find at least some cancer connections to glyphosate.[161]
- Even before the IARC decision was made, Monsanto enlisted teams of PR and lobbying experts, scientists and others to create what was designed to appear as a storm of "outcry" and "outrage" following the IARC classification.[161]
- Monsanto employees ghost-wrote scientific reviews purporting to show that glyphosate was safe. These were then attributed to academic scientists and used in regulatory assessments of the chemical.[162,163,164]

> *"You cannot say that Roundup is not a carcinogen … we have not done the necessary testing on the formulation to make that statement."*
>
> Monsanto toxicologist Donna Farmer [168]

- An official at the US Environmental Protection Agency, Jess Rowland, seemingly colluded with Monsanto in an effort to halt another agency's investigation of glyphosate's health effects. Rowland wrote in an email to a Monsanto employee, "If I can kill this I should get a medal."[163] The same official may have influenced regulatory assessment in the EU of the chemical.[165]
- Monsanto orchestrated a smear campaign to obtain the retraction of a study[92] led by Professor Gilles-Eric Séralini that showed adverse health effects of Roundup and a GM maize engineered to tolerate it. The editor of the journal that published and then retracted the study had entered into a contract with Monsanto shortly before the retraction campaign began.[166,167] The study was later republished by another journal.[92]

GM Bt: carefully targeted pest control or super toxin?

MYTH GM Bt crops contain toxins that only target certain pests.

FACT GM Bt crops contain a "super toxin" that affects many species.

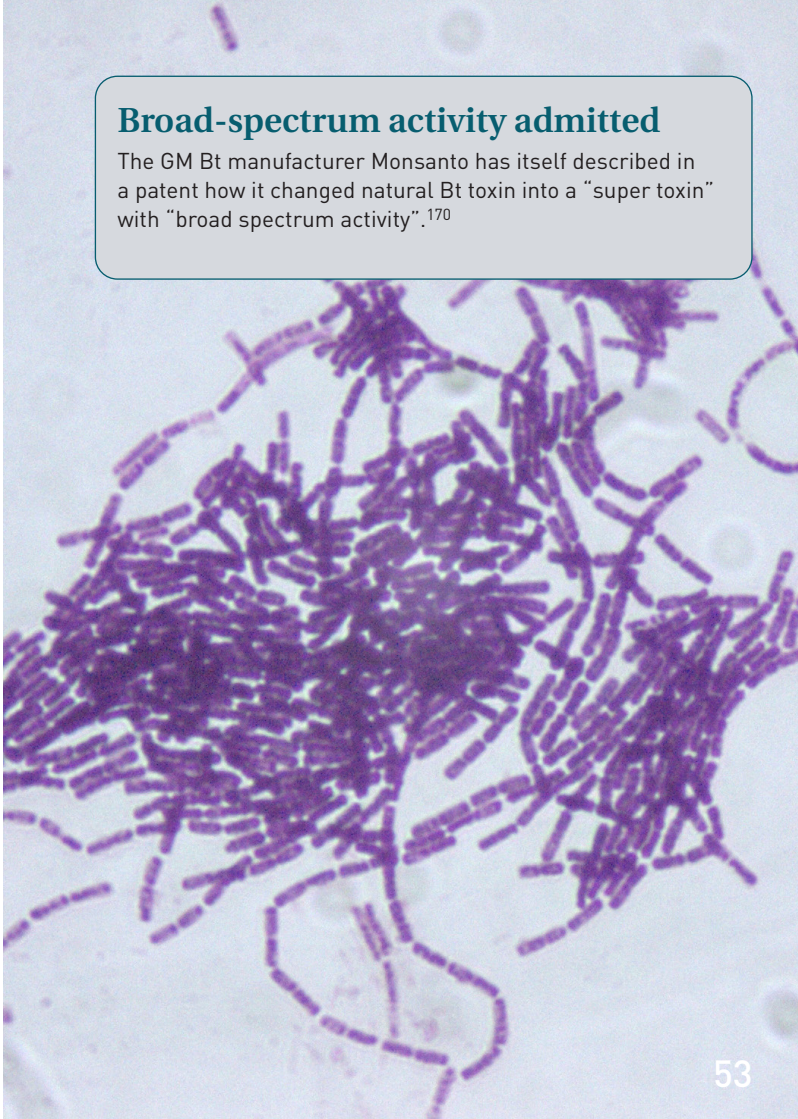
GM Bt crops have been genetically engineered to express (produce) insect-killing (insecticidal) toxins in their cells so that pests that eat the plants will die. The insecticidal toxins are produced by a gene derived from the natural soil bacterium *Bacillus thuringienisis*. Natural Bt is used by conventional and organic farmers as an insecticidal spray.

According to the GMO industry, the toxins in GM Bt crops are natural proteins that are toxic only to certain insect pests. Therefore, they claim, these insecticides can be safely eaten by other species, including humans. However, this is not the conclusion of a peer-reviewed analysis of the documents accompanying the commercial approval of 23 Bt-containing GM crops. The analysis showed that:

- GM Bt toxins differ greatly from their natural equivalents in ways that cause GM Bt proteins to be more toxic.
- GM Bt toxins are active against many more species than natural Bt toxins.[169]

Broad-spectrum activity admitted

The GM Bt manufacturer Monsanto has itself described in a patent how it changed natural Bt toxin into a "super toxin" with "broad spectrum activity".[170]



Toxic effects on wildlife and mammals

GM Bt crops and the insecticidal toxins they are engineered to contain have been found to have toxic effects far beyond the pests they were designed to control.

Among the species that can be harmed by these crops are butterflies, beneficial pest predators, bees, aquatic organisms, and beneficial soil organisms.[171,172,172,173,174,175,176,177,178,179]

Harmful to mammals

When GM Bt crops have been fed to mammals in feeding trials, they have been shown to have adverse effects, including:

- Toxic effects or signs of toxicity in the small intestine, liver, kidney, spleen, and pancreas.[180,93,96,181,87]
- Disturbed functioning of the digestive system.[96,87]
- Altered weight gain compared with controls.[180,83]
- Male reproductive organ damage.[87]
- Blood biochemistry disturbances.[83]
- Immune system disturbances.[88]

These results are worrying because in most regions of the world, including Europe, GM Bt crops such as maize and soy are fed to farm animals in large quantities. In addition, in many countries these crops are present in human food. The fact that some GM Bt crops have been found to have adverse impacts on mammals in animal feeding trials means that they could also have adverse impacts on humans. This is especially true of trials involving rodents, which are accepted as valid models for assessing risks to humans.

The beautiful swallowtail butterfly is one of the species harmed by GM Bt insecticides.

"Our published work on the toxicology of insect-resistant GMOs provides a … route by which the toxins contained in them could … cause harm to many organisms. This includes mammals and therefore humans."

Jonathan Latham, PhD, co-founder, Bioscience Resource Project[169]

Long-term failure

MYTH GM Bt crops reduce insecticide use.

FACT GM Bt crops do not reduce the use of insectides, but simply change the mode of application.

GM Bt crops are promoted as reducing the use of chemical insecticides. But the technology has simply changed the type of insecticide and the way in which it is delivered – from sprayed on, to built-in. What is more, the amount of Bt insecticide produced by Bt crops is generally far greater than the amount of chemical insecticide spray that these crops displace.[182]

Recipe for resistance

Bt crops produce the Bt toxin for their entire lifetime, exposing pests to the toxin over a prolonged period. This is a recipe for rapid evolution of resistance, since only the most resistant pests survive, reproduce, and pass on their resistance genes. For this reason, GM Bt crop technology sometimes enjoys short-term success in controlling pests but this is soon undermined by the emergence of pests resistant to the toxin.[183,184,185,186,187,188,189,190]

"The insect will win. Always bet on the insect if there is not a smart deployment of the trait."

Elson Shields, entomologist, Cornell University[186]

The human cost

In India, GM Bt cotton has suffered widespread failure as it has fallen victim to attack from pests, including the bollworm that the crop was engineered to kill.[191,192,193] The human cost has been severe. Farmer suicide rates in regions of India that rely on rain for irrigation have been found to correlate with increases in Bt cotton adoption (Bt cotton is water-thirsty). The high cost of patented GM seeds and chemical insecticides, which farmers resorted to in order to try to control pests, were cited as factors.[181]

Dr Keshav Kranthi, former director of the Central Institute for Cotton Research, stated that the solution to India's cotton farmer crisis lies in proven sustainable and low-input farming methods. These include the careful selection of suitable seed varieties, soil-building with organic matter, biological pest control, crop diversity and rotation, and the planting of legume crops to increase soil nitrogen content.[195]

Conclusion

Scientific research and real-world farming experience show that GM crops and foods have not delivered on their promises. They have not increased yields or reduced toxic chemical inputs. Instead they have presented farmers with new challenges of controlling herbicide-resistant superweeds and Bt-resistant superpests. GM crops have not been shown to be safe to eat and existing research shows that some of them pose health risks. They provide no solutions to world hunger or the major environmental challenges of our time: climate change, chemical pollution, and the energy crisis.

Complexity underestimated

The latest round of promises made for gene-edited crops will also prove hollow. The GM approach treats genes as isolated units of information with predictable outcomes, even when moved from one organism to another unrelated organism. But in reality, gene organization is not random and gene function is a complex, finely regulated and interconnected network, consisting of many layers of molecular systems.

Furthermore, it is now known that highly desirable characteristics such as high yield or resistance to disease are complex in nature and have at their basis the balanced functioning of the entire complement of genes of the organism, a phenomenon known as omnigenics.[196,197] Manipulating one or a few crop or animal genes by genetic modification techniques (including gene editing) in order to try to achieve a given outcome is thus doomed to fail.

Failure to address real problems

Genetics are only part of the solution to food and agriculture problems. We do not need more drought-resistant, high-yielding, or disease-resistant crops, as many such crops already exist. What we need are drought-resistant, productive, and disease-resistant agricultural systems that function as an integrated whole. Low-input agroecological systems have been proven to deliver safe and abundant food while keeping seeds within the control of farmers and free from patent restraints.

Further information and reading

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Andrew Rowell, *Don't Worry (It's Safe to Eat): The True Story of GM Food, BSE and Foot and Mouth*. Routledge, 2003.

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Jeffrey Smith, *Genetic Roulette: The Documented Health Risks of Genetically Engineered Foods*. Yes! Books, 2007.

Michelle Perro and Vincanne Adams, *What's Making Our Children Sick? How Industrial Food Is Causing an Epidemic of Chronic Illness, and What Parents (and Doctors) Can Do About It*. Chelsea Green, 2017.

To keep up to date with the latest information, sign up for GMWatch's free newsletters at gmwatch.org

GMWatch provides news and comment on genetically modified foods and their associated pesticides. www.gmwatch.org

The Soil Association and our many partners desire an agroecological future, in which our soils are regenerated so that health is the outcome for plants, animals and humanity. We seek to work with and learn from nature with science, not to manipulate species further. If this is your philosophy too, do join our 'from the ground up' movement for change. Connect with thousands of like-minded people in our active communities on facebook, Twitter and Instagram #SoilAssociation, and visit our website for more ways to get involved www.soilassociation.org.

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GMO
MYTHS & FACTS

Written by Claire Robinson, Editor, gmwatch.org

"Human science continues to astonish us with its progress. However, beyond the wisdom of the scientific discovery by humans, is the wisdom of nature – holding an entire planet in balance for millennia. How many times have our breakthroughs come with unintended consequences? Einstein said that insanity is repeating the same thing over and over again and expecting different results. Yet once again a new discovery (gene editing) is being promoted as a safer form of genetic modification and as a way to reduce pesticide use – but are we really any wiser or more ethical in how we will use these powerful technologies? This booklet reveals how GM has been used in hugely damaging ways and why we should take our time to carefully weigh the potential of genetic engineering technologies against the reality of how these techniques have been used to date."

Helen Browning, Chief Executive, The Soil Association