



Are GMOs Toxic?

Understanding Glyphosate Toxicity: An Interview with Genetic Engineer Thierry Vrain

As genetically modified organisms (GMOs) continue to enter the food chain, it's important for consumers to learn about Roundup Ready crops — and how the glyphosate sprayed on them may be toxic to our health.

Interview by Hannah Kincaid
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A high-clearance sprayer applies Roundup herbicide on glyphosate-resistant marestail in a Mississippi no-till cotton field. The application failed and the weeds survived.

Photo by AgStock Images

Monsanto's Roundup Ready crops are engineered to be herbicide tolerant, specifically when sprayed with Roundup. Now that the World Health Organization's cancer research arm has designated Roundup's active ingredient, glyphosate, as "probably carcinogenic to humans," consumers need to fully understand how the chemical works on plants and, in turn, impacts human health. For in-depth answers about glyphosate's toxicity and more, we turned to molecular biologist and retired genetic engineer Thierry Vrain.

MOTHER: *When and why did you start researching glyphosate?*

Thierry Vrain: I went to graduate school in North Carolina in the 1970s, where I was trained as a soil biologist — a nematologist, to be precise. Nematodes are microscopic worms in the soil that feed on the roots of plants and cause considerable yield loss for many types of crops. In school, I learned about agriculture and the damage caused by all sorts of pests and pathogens, such as nematodes, insects, and fungal diseases. I learned to deal with those pests by sterilizing soil or spraying pesticides. Halfway through my career, it became obvious that perhaps we could intervene at the molecular level to make crops naturally resistant to pests, so I learned molecular biology and became a genetic engineer. When I became head of a molecular biology department, I took it as my responsibility to educate people and try to assuage their fears about genetic engineering.

I retired 12 years ago and started gardening as a serious hobby. After gaining that hands-on experience, I realized how much damage pesticides cause to the living environment of the soil. I

learned all sorts of things that I wasn't taught in graduate school. For example, I learned that not only pesticides, but also regular fertilizers damage communities of microorganisms in soil. I became "organic," so to speak.

At this point, I started reading scientific research showing a problem with genetic engineering. Rats and mice fed genetically engineered, Roundup Ready grain were getting sick. At first I couldn't figure it out. My knowledge of the engineering technology made it clear to me that this should be safe. As I explain in my TEDx talk, "[The Gene Revolution, the Future of Agriculture](#)," I couldn't understand why adding a gene from one species to another could be toxic because this DNA technology is used every day in many research labs around the world to create a variety of transgenic animals and plants, to study their biology, and to advance various fields of knowledge. Only two years ago did I realize that the problem lies not with genetic engineering technology itself, but with the herbicide that's sprayed on all Roundup Ready crops. Again, I took it as my responsibility to educate people.

MOTHER: *When was this herbicide invented, and for what purpose?*

Vrain: Roundup is the herbicide in question, and its active ingredient is glyphosate. Glyphosate is a very small molecule, an analog of glycine, which is one of the 20 amino acids that make up all proteins of all living organisms. This molecule was invented in the 1950s and patented in 1964 by Stauffer Chemical Co. in the United States. Stauffer Chemical was in the business of selling products that could clean mineral deposits off industrial pipes and boilers. Think of your electric kettle at home. After boiling water repeatedly over the course of a few months, you can see whitish mineral deposits on the walls of your kettle. Industries that use boiling water all the time must chemically remove the deposits every so often. The deposits are called "scales," and the chemicals that remove them are called "descaling agents." Glyphosate was invented as a descaling agent because it binds to all sorts of minerals and makes them unreactive, stripping them from the pipes. In biology and chemistry, we call this type of agent a "chelator," and the binding of minerals is called "chelating."

Somebody promptly figured out that glyphosate kills all bacteria and plants, and that there's a lot more money to be made using this chemical as an herbicide rather than as a descaling agent. That's when the chemical corporation Monsanto bought the rights to the molecule and patented it in 1969 as a nonselective herbicide.

MOTHER: *How does glyphosate's chelating ability affect the way it interacts with plants?*

Vrain: Unlike animals and humans, bacteria and plants make their own proteins because they're capable of synthesizing all 20 amino acids required as the building blocks of proteins. Bacteria and plants make three complex amino acids (we call them "aromatic amino acids") in a small biochemical pathway called the "Shikimate Pathway." One of the enzymes of that pathway is called "EPSPS" for short. EPSPS is a protein with an atom of manganese that must be there for it to function properly.

As a descaling agent, glyphosate enters the bacterial or plant cells and steals the atom of manganese from the EPSPS enzyme, rendering it unable to synthesize aromatic amino acids. If

some of these building blocks are missing, the bacteria and plants can't synthesize the proteins, and they promptly die.

MOTHER: *How heavily is glyphosate used in the United States?*

Vrain: When molecular biology and genetic engineering technologies became mainstream in the 1980s, somebody figured out they could engineer agricultural crops to be glyphosate resistant. When we engineer crops to be glyphosate-resistant, farmers can spray them with the herbicide and they'll survive, even while the unwanted surrounding plants — the weeds — ultimately perish.

A handful of major crops are now glyphosate-resistant. Developers have trademarked them as "Roundup Ready." The technology has revolutionized weed management in industrial agriculture. In 2013, farmers in the United States used glyphosate-resistant soybeans on 93 percent of all planted soybean acreage, corn on 85 percent of all corn acreage, and cotton on 82 percent of all cotton acreage. These glyphosate-resistant crops are usually sprayed twice at the beginning of the crop cycle with three-fourths to 1-1/2 pounds (depending on plant height) per acre. In recent years, many species of weeds have adapted and become resistant, requiring higher and higher dosages of glyphosate to be killed.

The use of glyphosate for chemical drying of non-engineered grain and seed crops has also grown exponentially in the past 15 years. This is not widely known. Some farmers who grow grains and seeds (such as cereals, beans, sunflowers, and hemp) now commonly spray a formulation of glyphosate to kill their crops just before harvest. This process also kills any weeds that might have popped up during the growth of the crop. This is called "chemical drying" or "dessication." It makes for a much easier harvest of grains and seeds.

MOTHER: *What are the current allowable amounts of glyphosate in food and water, and how do they compare to the levels at which scientists are detecting harmful effects?*

Vrain: We know very little about the residual amounts of glyphosate in food crops for human and animal consumption. Most other pesticides and herbicides are closely monitored by government agencies in Canada and the United States, but for some reason glyphosate residues have not been monitored closely. What we do know is that the legal levels allowed by the Environmental Protection Agency and Health Canada have increased significantly in the past few years — presumably to accommodate the new reality. The allowable levels are now well above parts per million (ppm). Every single crop has allowable levels: sugar at 10 ppm, soybean and canola at 20 ppm, cereals at 30 ppm, nongrass animal feed at 400 ppm. Residue levels that were once considered extreme are now seen as normal.

A large number of published scientific studies — mostly done outside the United States — show that as little as 1 ppm of glyphosate will kill almost all bacteria — particularly beneficial bacteria — in the gut of animals; that endocrine disruption starts at 0.5 ppm; and that even just a few ppm can cause oxidative stress, chronic inflammation, DNA damage, and many other disruptions in mammalian organ cells and tissues. Last year, the World Health Organization asked an international team of 17 senior toxicologists from 11 countries to review the status of several

agricultural chemicals, including glyphosate. Their verdict regarding glyphosate's toxicity was that the scientific literature contains enough convincing evidence to classify it as a probable carcinogen.

MOTHER: *Monsanto, the company that owned the glyphosate patent, claims that humans can digest glyphosate in our food and water and it won't accumulate in our bodies. Is this true?*

Vrain: Recent scientific studies clearly show that glyphosate doesn't degrade easily in soil or in humans and animals. A German study suggests that glyphosate accumulates in all organs (liver, kidneys, intestines, heart, lungs, bones, and so on) of animals and people eating food products made from Roundup Ready crops.

Monsanto and the North American government regulatory agencies have promoted glyphosate as the safest herbicide for 40 years. It was assumed at the time of its registration that it couldn't affect animals because the Shikimate Pathway (where it impairs protein synthesis) is present in plants and bacteria but not in animals. However, the past 10 years have brought enormous progress in our understanding of the pre-eminent role of the microbiome in animal physiology. In humans, it turns out that the 100 trillion bacterial cells that live in our intestines — and that *do* contain the Shikimate Pathway — play an absolutely essential role in the health of most of our organs.

MOTHER: *We were surprised to learn that glyphosate is also patented as an antibiotic. What are the effects this has on human health and the soil food web?*

Vrain: We've known for decades that glyphosate is a powerful antibiotic, but it was only patented as one in 2010. I call glyphosate an antibiotic masquerading as an herbicide. Aside from its function as an endocrine disrupter and the multitude of other documented nefarious effects it has on human physiology, I think the most immediate concern about glyphosate's toxicity is its damaging effect on the human microbiome.

I don't remember seeing much research on the effects of glyphosate in the soil environment, other than the usual industry-sponsored (and reassuring) results. Plenty of anecdotal evidence, however, shows that damaging soil microbiology leads to slow desertification.

MOTHER: *How do you recommend we move forward to prevent this toxic herbicide from causing any more damage?*

Vrain: Roundup has become the most successful agricultural chemical in the past 40 years. It's extremely useful in all kinds of weed-management applications. Because it was originally labeled as innocuous to humans and animals, Roundup has been heavily used, and it's time to reconsider its place in the market. In light of glyphosate's toxicity, we must strictly regulate the use of the herbicide Roundup, abandon chemical drying of grain and seed crops, and recall Roundup Ready technology.

How to Avoid Glyphosate

If you're concerned about glyphosate toxicity, you can follow some basic guidelines when sourcing your food. Steer clear of processed foods and buy ingredients that are either clearly labeled "USDA Certified Organic" or come from a trusted local grower who doesn't use herbicides. Certified Organic crops can't be sprayed with glyphosate at any stage of the growing, harvesting, or drying processes, and none of the ingredients in USDA Certified Organic foods are allowed to be genetically engineered. The USDA Certified Organic standards for meat, eggs, and dairy require that livestock are fed 100-percent-organic feed and forage.

For more information, browse our collection on [The Dangers of Glyphosate Herbicide](#).

Thierry Vrain is an organic gardener and retired genetic engineer. For more information about glyphosate's toxicity and its use on genetically modified crops, we recommend watching Vrain's presentation to the American College of Nutrition on the [nutritional implications of GMOs](#).