

Can Genetically-Engineered Foods Explain the Exploding Gluten Sensitivity?

by Jeffrey M. Smith, Executive Director,
Institute for Responsible Technology

Research support by Sayer Ji, GreenMedInfo.com |
Dr. Tom O' Bryan, thedr.com | Tom Malterre, MS CN,
nourishingmeals.com | Stephanie Seneff, PhD
<http://people.csail.mit.edu/seneff/>



Can Genetically Engineered Foods Explain the Exploding Gluten Sensitivity/Celiac Epidemic?

“Based on my clinical experience, when I remove genetically modified foods as part of the treatment for gluten sensitivity, recovery is faster and more complete. I believe that genetically modified organisms (GMOs) in our diet contribute to the rise in gluten sensitivity in the U.S. population.”

—Emily Lindner, MD, Internist

The explosion of awareness about gluten sensitivity is hard to miss these days. Whether walking down supermarket aisles or ordering in restaurants, “gluten-free” proclamations call out in ever-increasing numbers. Pizza crust, hotdog buns, and cookies are offered with rice flour, corn meal, anything but wheat and its close relatives, like rye, barley and spelt, that contain the dreaded gluten.

Technically, gluten refers to any of the more than 23,000 distinct proteins in wheat, and the term “gluten related disorders” describes a wide spectrum of problems associated with its consumption.¹ Wheat is not the only grain of concern, as there are gluten-like proteins known as gliadins and glutenins found in most other cereal grains (see chart below). Only some of these, however, are linked to reactions. The most well known conditions linked to gluten sensitivity are celiac disease and wheat allergy, in part because they are both specific immune responses that can be unequivocally confirmed through modern diagnostic techniques. Celiac disease, which may be called an extreme sensitivity, is quite dangerous. Those with celiac disease can experience adverse effects when exposed to gluten in the parts-per-million range levels and research shows that when it goes undiagnosed, it is associated with a nearly four-fold increased risk of death from all causes.²

Unfortunately, celiac disease and other forms of gluten related disorders are often overlooked or misdiagnosed, because the symptoms are so varied. They can affect cardiovascular, neurological, and skeletal systems, to name but a few³; in fact, there are over 300 health conditions and/or symptoms linked to gluten sensitivity, as confirmed by peer-reviewed studies.⁴

Why is Wheat Now Dangerous for So Many?

Celiac disease prevalence in Finland doubled in the last two decades, even when ruling out confounding factors such as better detection rate. The growth in the U.S. is even worse. According to one 2009 study, celiac disease has increased more than four-fold in the United States during the past 50 years.⁵ A 2010 study pushed that figure to a five-fold increase in celiac disease prevalence just since 1974.⁶

The same study found the dramatic uptick was “due to an increasing number of subjects that lost the immunological tolerance to gluten in their adulthood.”⁶ Clearly, there is an environmental component to this trend. It is important to clarify that wheat is not a genetically modified organism (GMO). The process of genetic modification involves the transfer of DNA from one species, such as a bacteria, virus, or fish, into that of another, such as corn, soy, or tomatoes. With

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~ Emily Linder, MD, Internist

genetic modification, scientists can breach species barriers to create a new organism that could never be produced in nature. This process is very different than traditional breeding practices such as hybridization. Wheat has been hybridized over the years. Some experts blame the hybridization of wheat for the increase in gluten sensitivity:

One theory popularized by the 2011 publication of Dr. William Davis’ *New York Times* best-selling book *Wheat Belly*, is that the increase in the

incidence of celiac disease might be attributable to an increase in the gluten content of wheat resulting from wheat breeding. This view was echoed in a 2012 study published in the journal *BMC Medicine*⁷:

“One possible explanation is that the selection of wheat varieties with higher gluten content has been a continuous process during the last 10,000 years, with changes dictated more by technological rather than nutritional reasons.”

A 2013 review of historical data commissioned by the U.S. Department of Agriculture, however, found no clear evidence of an increase in the gluten content of wheat in the United States during the 20th century, and only a slight change in the 21st century. They did concede that an increase in the per capita consumption of wheat and gluten

Food	Total protein	Gliadins (% of total protein)	Glutenins (% of total protein)
Wheat	10-15	40-50	30-40
Rye	9-14	30-50	30-50
Oats	8-14	10-15	~5
Corn	7-13	50-55	30-45
Rice	8-10	1-5	85-90
Sorghum	9-13	>60	
Millet	7-16	57	30
Buckwheat			High

Adapted from: Pizzorno JE, Murray MT, eds. *Textbook of Natural Medicine*. 2nd ed. New York: Churchill Livingstone; 1999:1601.

“ There are over 300 health conditions and/or symptoms linked to gluten sensitivity, as confirmed by peer-reviewed studies. “

might play a role.⁸ Additional environmental factors studied to play a role include: timing of gluten exposure,⁹ breast-feeding duration,¹⁰ the composition of the intestinal microbiota,¹¹ and cesarean birth.¹²

Dietary Allergens, Environmental Toxins, and GMOs

One of the most common explanations for the alarming increase in gluten-related health issues is both that detection of gluten problems has improved, and that more practitioners are looking for it; hence, the greater numbers. While better detection and the new “popularity” of the disorder are certainly contributing, there is an accumulating body of research indicating a third factor is at play, namely, the exposure of the U.S. population to environmental toxins and other food allergens whose combined influence is triggering the increase in the overall susceptibility to gluten. Support for this notion is found in the increased rates of related disorders over the past decade or two. These include autoimmune problems such as allergies and asthma, as well as gastrointestinal disorders such as Crohn’s disease, irritable bowel syndrome (IBS) and acid reflux (GERD).

Here, we will present evidence that strongly suggests that one significant addition to the American diet—genetically modified (GM) food—is a major contributor to gluten sensitivity reactions, and also interferes with complete and rapid recovery. Also called genetically modified organisms (GMOs), these are crops that have had foreign genes inserted into their DNA, usually from bacteria or viruses, to confer a particular trait. There are nine GM food crops currently being grown for commercial use; the six major ones are soy, corn, cotton (used for cooking oil), canola (also used for cooking oil), sugar beets (used for sugar production), and alfalfa (used as animal feed). All six are engineered to be herbicide tolerant, i.e. to survive spray applications of weed killer. They thus contain high residue levels of these extremely toxic, endocrine-disrupting and DNA-damaging agrichemicals. Some corn and cotton varieties are also equipped with genes that produce a toxic insecticide call Bt-toxin (from *Bacillus thuringiensis* soil bacteria). There are also zucchini, yellow squash, and papaya varieties that have viral genes designed to help them ward off certain viral infections.

Based on animal feeding research, case studies, and the properties of these crops, GMOs are linked with four types of disorders that are known to impact gluten reactions:

1. Leaky gut (aka ‘intestinal permeability’)
2. Impaired digestive capacity (reduced enzymes, damage to microvilli)
3. Gut bacteria dysbiosis (overgrowth of pathogenic microbes)
4. Immune/allergenic response

Leaky Gut

Poking Holes in the Intestinal Walls

It is well known that a significantly higher percentage of patients diagnosed with celiac disease have leaky gut,¹³ whereby the junctures

between the cells lining the intestinal wall (enterocytes) open up, allowing contents of the intestines to enter the bloodstream. (Technically, anyone who consumes gluten—whether a celiac sufferer or not—is susceptible to increased intestinal permeability. That’s because the protein class in wheat known as alpha-gliadin can provoke the release of zonulin from our bodies, which can promote intestinal permeability to unhealthy levels.¹⁴)

When the intestines are intact and functioning properly, usually only tiny byproducts of digestion are ushered appropriately into the bloodstream for assimilation. Approximately 90% of proteins are fully broken down into smaller “peptides,” with the remaining 10% capable of stimulating an antigenic response.¹⁵ With gaps in the intestinal walls, however, a far larger percentage of undigested food particles (macromolecules), gut bacteria, and even consumed chemicals, can all enter the bloodstream and wreak havoc.

An example of the protective aspect of the immune system is that it can launch an attack on the undigested proteins, treating them as invaders. This will result in a number of inflammatory reactions and symptoms of a hypersensitized immune system. Second, some of these proteins will exhibit the phenomenon of ‘molecular mimicry,’ where the person’s immune system may attack a protein sequence in undigested wheat, for example, that resembles a sequence that also exists in our body’s own tissue. This sets up the groundwork for a wide range of autoimmune conditions, whereby the immune system starts to attack parts of the body, losing ‘self-tolerance.’

Celiac disease is one such example of this immune system “friendly fire,” but in truth, there are literally hundreds of possible side effects and symptoms that can result from this process.

GM Corn Creates Small Holes in Human Cells

When considering the role of GMOs in “punching holes in the gut,” the most obvious candidate is the GM corn *designed* to produce Bt-toxin. That’s because the toxin is designed to create holes. It’s not supposed to create holes in *human* cells. Rather, it is *supposed* to limit its destructive effects by targeting certain insect species, in which it breaks open small pores in the cells of their digestive tract and kills them.¹⁶

When Bt-corn was introduced into our diet in 1996, the biotech companies and their supporters in the U.S. Environmental Protection Agency (EPA) (which categorized these corn plants as *registered pesticides*) promised that the toxin was only dangerous to certain insects—it had no effect on humans or mammals. This assumption, however, was directly contradicted by several peer-reviewed published studies, and even by the statements of the EPA’s Science Advisory Panel.¹⁷

The study most clearly related to the risk of leaky gut was published in February 2012.¹⁸ Researchers “documented that modified Bt toxins [from GM plants] are not inert on human cells, but can exert toxicity.” In concentrations that are generally higher than that produced in average Bt corn, Bt-toxin disrupts the membrane in just 24 hours, causing

fluid to leak. The authors note, "This may be due to pore formation like in insect cells." Thus, the main assumption used as the excuse to allow pesticide-producing corn into our diet appears to be totally false. Bt-toxin *does* interact with human cells and may be boring small holes in our intestinal walls.

The other primary assumption touted by regulators was that Bt-toxin would be fully broken down by the digestive processes in our stomach. But a 2011 Canadian study conducted disproved that one as well. They discovered that 93% of the pregnant women tested had Bt-toxin from genetically engineered corn in their blood. And so too did 80% of their unborn fetuses.¹⁹

If the Bt-toxin had entered the bloodstream through holes that it created, it is likely that bacteria and food particles also got through and caused problems. Bt-toxin's presence in fetuses is of greater concern. The toxin may be disrupting cellular integrity throughout their system. And since fetuses do not have a fully developed blood-brain barrier, the hole-poking toxin may be active in their brains as well.

The authors of this Canadian study were faced with a question, "Why did so many of their subjects have Bt-toxin in their blood?" The toxin is expected to quickly wash out of our bloodstream. Therefore, the consumption of Bt-toxin must be quite frequent to explain why 9 of

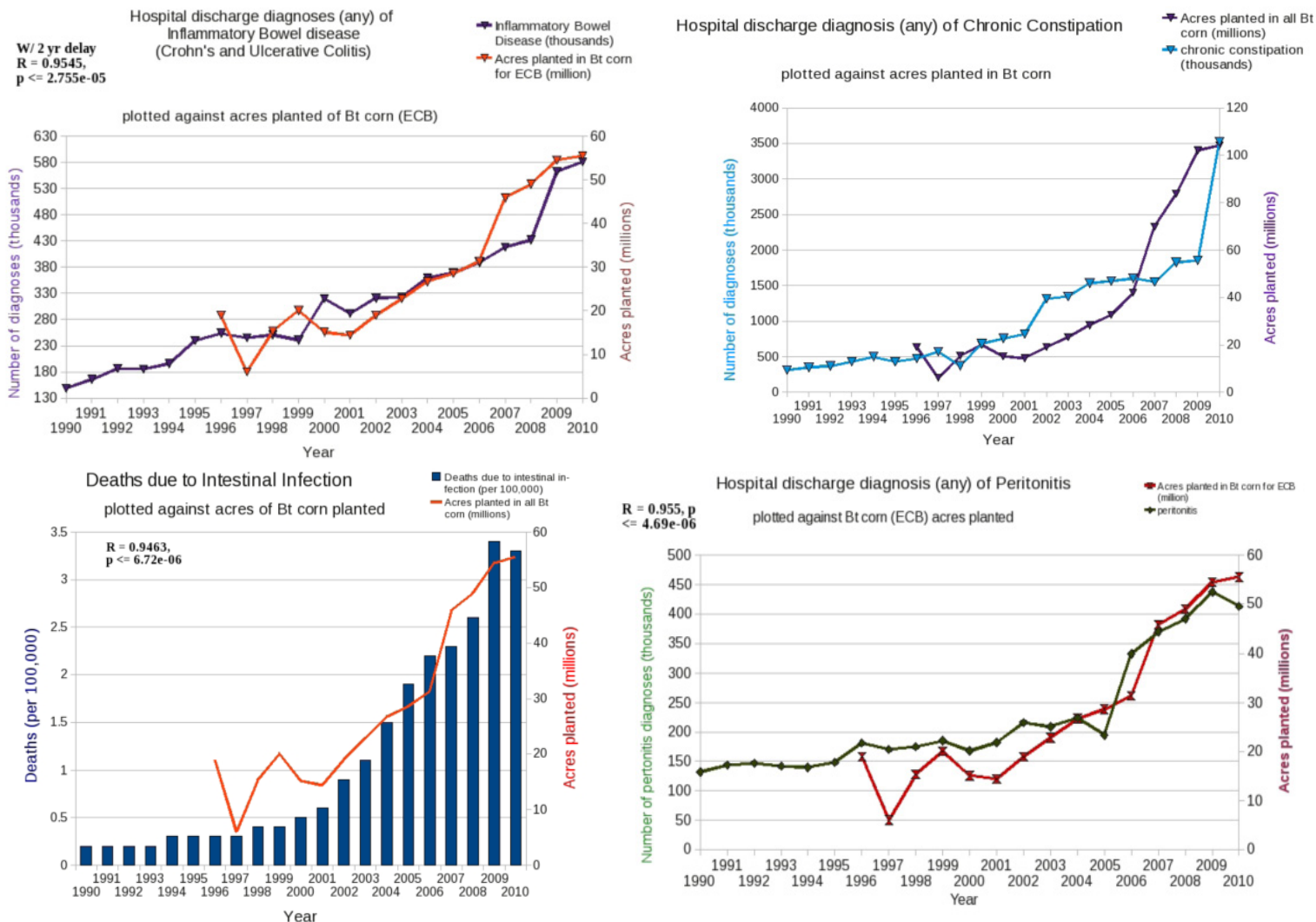
10 subjects to still have it in their blood. But this was Canada. And unlike Mexico, they don't eat corn chips and corn tortillas every day. They *do* eat lots of corn *derivatives* like corn sweeteners, but these highly processed foods no longer have the Bt-toxin present and therefore, could not be the source.

But livestock in North America do eat Bt corn as a main component of their diets. And Canadians eat the meat and dairy products of these corn-fed animals every day. The authors of the study, therefore, speculated that the source of the Bt-toxin in the blood could have been the meat or dairy. This would mean that the Bt-toxin protein remains intact through the animals' entire digestive process and then again through the humans' digestive process. While this may be true, there's another possible explanation with very serious consequences for those who eat GMOs.

Living Pesticide Factories Inside Us

In spite of numerous claims by the biotech industry that it would never happen, research confirmed that part of the DNA "transgene" inserted into GMO crops can actually transfer into the DNA of our gut bacteria.²⁰ Published in *Nature Biotechnology* in 2004 by a team of British scientists, they found that part of the gene from the herbicide-tolerant Roundup Ready (RR) soybean had integrated into the DNA of the intestinal flora of three out of seven subjects tested. The transfer of

Correlation between the rise of Bt corn in the US diet and GI tract disorders.



the RR gene had occurred before the subjects came to the research facility, apparently from consuming GM soy in some previous meal(s). The percentage of subjects with the integrated GM genes may have been higher if the study had been conducted in the United States. This was done in the UK, however, where the intake of GM soy is but a fraction of that eaten in North America.

In the original, longer paper about this research was an important fact—confirmed by the authors of the study to be true (that, for some reason never made it into the published version): the gut bacteria that contained part of the Roundup Ready gene were not killed when exposed to Roundup’s active ingredient, glyphosate. In other words, the gut bacteria were herbicide-tolerant. This suggests (but doesn’t yet prove) that the transferred genes from GMOs continue to function after they have integrated into our gut bacteria. If so, we may have GM proteins continuously being produced inside our intestines long after we stop eating GMOs.

The funding for this research was cut off, so the researchers never did test whether the Bt gene in corn likewise transfers. But this might provide a far more plausible explanation why so many subjects tested positive for Bt-toxin. The Bt-toxin genes could have transferred from corn chips or corn tortillas into gut bacteria, where they produced the toxin on a continuous basis inside the intestinal tract. Then, it could have altered the permeability of the cell walls (“poked holes”), entered the bloodstream, and then also traveled through the placenta into the unborn fetuses of pregnant test subjects.

Bt corn and Gluten Sensitivity

If leaky gut is a precursor and a contributing factor to the many types of gluten sensitivity, then the introduction of Bt corn into the U.S. diet may be responsible for increasing the number of reactive eaters. It also may help explain why a range of gastrointestinal and inflammatory disorders have also risen sharply after GMOs were introduced (see charts).

On the other hand, if the leaky gut is being caused by conditions such as celiac disease, then Bt corn may be exacerbating the problems, possibly converting asymptomatic people (those without symptoms) into those who suffer acutely.

In either case, removing Bt corn from the diet would make sense in the treatment, and possibly prevention of this debilitating disease.

In addition, leaky gut is exacerbated by each of the other three disorders also linked to GMOs, described below: impaired digestion, disrupted gut bacteria, and increased allergen exposure.

Impaired Digestion

If our digestive system is not functioning properly, then food particles are not broken down as quickly or as completely. One obvious result is poor absorption of food. If a person is not gaining sufficient nutrition from the foods they consume, their overall health, including their immune system, can suffer.

With poor digestion, proteins can remain intact for longer than normal periods in the gastrointestinal (GI) tract. This can result in the larger, undigested food particles becoming the “food” of pathogenic gut bacteria, leading to their overgrowth. This further compromises digestion and immunity. When protein putrefies, it can also release

excess hydrogen sulfide (as toxic as cyanide gas) which irritates and inflames the mucous membranes. Undigested proteins also have a greater likelihood of provoking autoimmune reactions, in which the immune system attacks parts of the body, and which can contribute to upsetting the delicate balance between the innate (Th1) and adaptive (Th2) poles of immunity, also known as Th2-dominance, a type of immune hypersensitization where formerly harmless foods provoke harmful immune responses.

If the leaky gut remains unchecked, the constant antigenic challenges presented by these larger food particles entering the bloodstream will continue to foment inappropriate antibody responses, inflammation, and the development of more serious autoimmune disease.

Celiac Disease Damages Gut Wall

One of the debilitating side effects of celiac disease is the flattening of the microvilli along the intestinal walls. These cells are what absorb broken down food into the bloodstream for use by the whole body. Normally, they stick out like tiny fingers, dramatically increasing the surface area that can be used for digesting. (The total surface area of the intestinal villi of a healthy human being is equivalent to a tennis court.)

In celiac disease patients, the immune system adversely responds to gluten proteins causing destruction in the microvilli, and a filling in of the crypts between them, resulting in a flattened, highly dysfunctional surface. Because the surface area for nutrient absorption is drastically reduced and/or functionally disabled, celiac disease patients often suffer from a variety of disorders related to poor digestion and malnutrition.

To make things worse, when the wall of the intestines are irritated (in the case of celiac disease or in general) the body produces less of a substance called CCK (cholecystokinin). This, in turn, reduces the digestive enzymes produced by the pancreas, as well as the bile produced in the liver. Without sufficient levels, digestion is slowed down, particularly of proteins. Thus, gluten sensitivity carries a one-two punch: reducing digestion by damaging cell walls, and exacerbating nutrient malabsorption by reducing digestive enzymes and bile.

This can become a vicious cycle if the larger food particles result in bacterial overgrowth, which in turn, can further irritate the lining of the intestines, further lowering digestive capability directly, and through reduced CCK levels.

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GMOs Can Damage GI Tract

As discussed above, Bt-toxin was found to poke holes in human cells. It is certainly possible that this can disrupt the digestive capability of the gut lining, as well as lower CCK levels. A study on mice also looked at the impact of Bt-toxin on the microvilli and discovered a real problem.

Using both natural Bt-toxin from bacteria, as well as that produced in an experimental GM crop (potato), the toxin damaged the microvilli of mouse intestines (ileum). Some microvilli were broken off and discontinuous; others were shortened.²¹ This is very similar to the type of damage that gluten proteins cause to the intestines.

The high levels of glyphosate-based herbicides in Roundup Ready

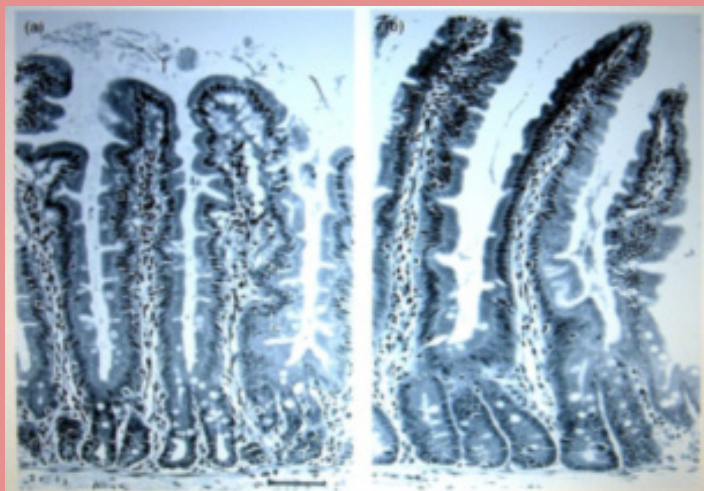
30 years, she said, “You can extrapolate that the *same thing may be occurring in babies clinically*. They are not digesting their food. They are malabsorbing. . . . And I’m seeing that commonly now.” Digestive issues are skyrocketing among her patients and around the nation. In fact, according to U.S. hospital discharges and ambulatory admissions records data, inflammatory bowel syndrome skyrocketed since the introduction of GMOs. Is this coincidence or an indication of cause-and-effect?

Livestock Ulcers and Corroded Intestines

Howard Vlieger, an Iowa farmer and farm consultant, asked a local slaughterhouse to save the stomachs of pigs—including those that had been fed with GMO soy and corn and others raised on non-GMO soy and corn. The results were dramatic. The GMO-fed stomachs

Rats fed genetically engineered potatoes suffered from potentially precancerous cell growth in their digestive tracts.

Intestinal Wall



Non-GMO

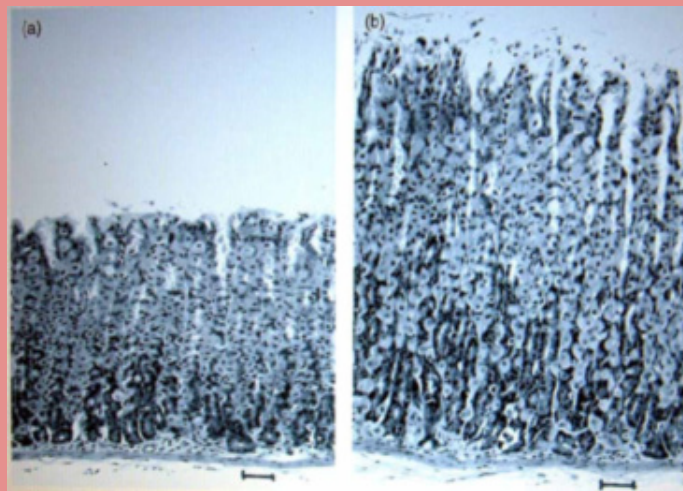
GMO

crops may also directly damage the structure and function of the gut wall. A study on glyphosate exposure in carnivorous fish revealed remarkable adverse effects throughout the digestive system,²² including “disruption of mucosal folds and disarray of microvilli structure” in the intestinal wall, along with an exaggerated secretion of mucin throughout the alimentary tract.

Another study using GM potatoes also caused severe disruption of the cells lining the digestive tract of rats in just 10 days.²³ Damage included potentially precancerous growth and abnormal cell architecture. The foreign gene inserted into the potato *did* produce a pesticide, but *not* the Bt-toxin. Instead, it was outfitted with a gene from a snowdrop plant that produced an insecticide call GNA lectin. The big revelation from the study, however, was that the lectin itself was not the cause of the damage to the intestines and stomach. When other rats were fed the lectin itself, no such damage took place. This research lays the blame squarely on the unpredicted side effects of the process of genetically engineering a crop. In other words any GMO crop, irrespective of what gene is inserted, can theoretically cause this type of profound damage to the digestive tract.²⁴

When California pediatrician Michelle Perro saw photos of the rats’ damaged digestive tract, she was reminded about a trend she is now seeing in her practice.” Based on her experience treating children for

Stomach Lining



Non-GMO

GMO

were inflamed, discolored, and had multiple ulcers. The non-GMO stomachs were healthy. He later worked with a team of scientists, who reproduced the results in a controlled, peer-reviewed study.²⁵

Similarly, Danish pig farmer Ib Borup Pedersen reported that when he switched his pigs from GM soy to non-GM soy feed in April 2012, deaths from ulcers and bloat disappeared entirely during the next year. By contrast, he had lost 36 animals over the previous two years to these maladies. (His animals also recovered from chronic diarrhea, increased conception rate and litter size, eliminated birth defects, and reduced their need for antibiotics by 2/3.)

Some butchers in the U.S. also see a marked difference between the organs of cattle fed GM versus non-GM feed. Instead of the healthy, intact intestines that they see in the non-GMO animals, the GMO-fed ones are thin and corroded, and tear easily. And the changes are not just in the intestines and not just in cattle. Dr. Ronald Anders, an Ohio livestock veterinarian, confirms that based on autopsies, “There is a big difference in the liver and the intestinal tract on these animals on GMOs,” including cows, pigs, sheep, horses, and even dogs on a corn-based diet. “The livers and intestines were extremely bad on a lot of these animals,” he said.

This type of damage to the structural integrity of the intestinal wall

“Leaky gut is exacerbated by each of the other three disorders also linked to GMOs, described below: impaired digestion, disrupted gut bacteria, and increased allergen exposure.”

might directly reduce its capability to digest nutrients. Furthermore, the unhealthy gut lining may also reduce the production of CCK, which will then lower bile and digestive enzyme production in the pancreas. Consumption of GMOs, however, might damage the pancreatic cells directly, leading to lower digestive capability.

Roundup Ready Soybeans and Reduced Digestive Enzymes

Pregnant mice were fed GM soybeans, and their offspring continued on the diet for eight months. Compared to controls fed non-GMO soybeans, the pancreas suffered a profound reduction in digestive enzyme production.²⁶ Alpha-amylase, a major enzyme that degrades carbohydrates, was 77% lower among two-month old mice pups, and remained 75% and 60% lower in months five and eight. Young mice (one month) also had reduced amounts of a protein digesting enzyme precursor (zymogen), which is essential for healthy breakdown of the proteins in food.

Nearly all GMO soybeans are Roundup Ready, engineered to survive otherwise deadly doses of Roundup herbicide. As a result, Roundup Ready (RR) soybeans (as well as RR corn, cotton, canola, sugar beets, and alfalfa) end up with physiologically significant amounts of Roundup absorbed into the plant tissues and deposited into the food portion. When analyzing the dangerous impacts of RR soybeans, it is unclear whether the primary causative factor is the genetic engineering of the plant or the high Roundup content in the food, but their individual toxicities may work in concert and synergize.

An analysis of the properties and effects of glyphosate, the active ingredient in Roundup, shows how this toxin may contribute to many of the problems discussed in this paper. For example, carnivorous fish exposed to glyphosate showed decreased activity of protease, lipase, and amylase—important proteins involved with the digestion of proteins, fats, and carbohydrates—in the esophagus, stomach, and intestine.²⁷ Glyphosate also has profoundly harmful effects on the bacteria living inside our intestines.

Gut Bacteria Dysbiosis

Healthy Gut Bacteria is Essential

Bacteria living inside us play a critical role in digestion, immunity, detoxification, and even the production of nutrients (e.g. the entire B group of vitamins is produced through their activity). Together, they function like another essential organ. In fact, some researchers in the field have suggested we reclassify ourselves as “meta-organisms” as there are about 10 times the number of bacteria cells in our digestive tract as there are

human cells in our entire body. In other words, we are more “them” by count than “ourselves.” Our relationship with our internal bacteria plays an immensely important role in our health.

A proper balance of bacteria supports not only many aspects of our physical health, but also our mental health. The so-called “gut-brain axis” depends on the health of the flora residing in our gastrointestinal tract. As much as 95% of our serotonin, for instance, is synthesized in our gut through the bacterial conversion of the essential amino acid L-tryptophan.

One of the hallmark features of gluten sensitivity is gastrointestinal symptoms such as gas, bloating, constipation, diarrhea, and cramping—all of which indicate an imbalance in the gut flora, as well.

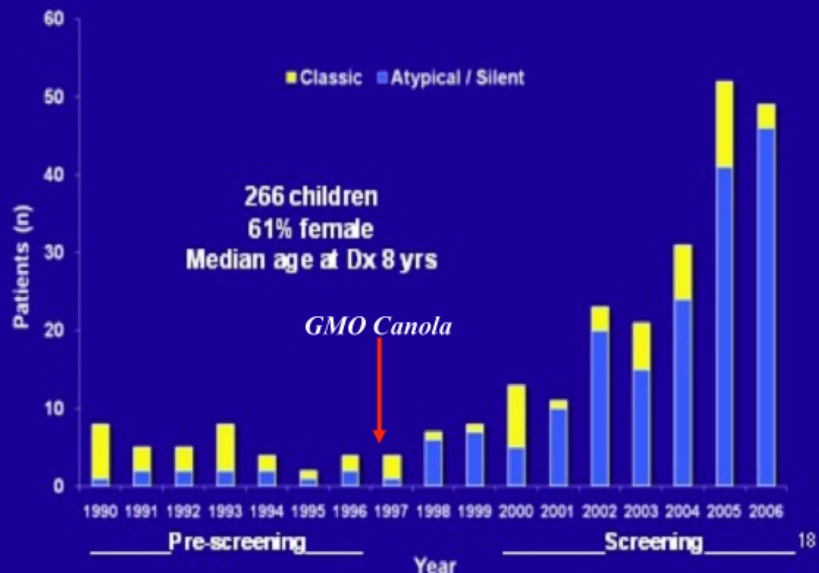
In fact, gluten sensitive individuals often have documented imbalances in their gut flora. This is especially true for those with celiac disease.^{28,29,30,31} While we do not know whether the gut flora imbalance precedes the sensitization to gluten, or vice versa, it is likely that both processes play a role.

GMOs May Compromise Intestinal Flora

Glyphosate was patented as a broad spectrum biocide (literally ‘life-killing’ agent). In other words, it’s a very powerful antibiotic. In tiny amounts, it can significantly reduce the population of the healthy bacterial varieties in the digestive tract and promote overgrowth of dangerous pathogenic bacteria according to research with poultry³² and cattle.³³

The introduction of Roundup Ready Canola (and the use of Roundup on Canadian farms) appears to correlate with childhood celiac diagnoses in an Alberta hospital.

Children Diagnosed with Celiac Disease at Alberta Childrens’ Hospital



The implications for health may be quite profound and complex. In celiac patients, for example, the healthy *Bifidobacterium* strains can affect certain components of the immune system called cytokines. The cytokines that provoke inflammation are reduced by the *Bifidobacterium* bacteria, while the type that is anti-inflammatory (IL-10) is increased.³⁴ But *Bifidobacterium* is one of the types of bacteria that is easily killed by glyphosate.³² The result could be a generalized increase in inflammation, which is now recognized as the basis for numerous diseases.

On the other hand, “the highly pathogenic bacteria” such as those that produce Salmonella or botulism poisoning “are highly resistant to glyphosate.”³² Furthermore, some of the healthy bacteria that are killed normally keep some of the pathogenic bacteria in check. Researchers in Germany, for example, suggest that glyphosate use kills lactic-acid producing bacteria in the gut of cattle, allowing the bacteria that produce deadly botulism to flourish. This might explain the increase in chronic botulism in cattle.³³ ³⁵ (Cases of sudden infant death syndrome are also linked to the botulism toxin.)^{36,37}

In addition to the risk of producing acute toxins, such as the one that causes botulism poisoning, bacterial pathogens can activate the potent signaling molecule called zonulin. Zonulin, as described above, can induce a breakdown of the tight junctions in cells lining the gut, leading to leaky gut.³⁸ Indeed, some of the same bacterial growth stimulated through glyphosate exposure, e.g. *Clostridium botulinum*,³⁹ *Clostridium perfringens*,⁴⁰ and *Salmonella* infections,⁴¹ have been found to increase intestinal permeability.

Gut Bacteria on the Farm

Livestock veterinarian Dan Skow says that coincident with the time that GMOs were introduced, the balance of the good bacteria inside livestock was thrown way off. He says, “Now what set this off and why these disruptions of the balance to the microscopic flora in the intestinal tract? I’m personally suspicious—there’s a lot of impact from the GMOs.”



Butchers have noted that livestock fed on GMOs have a different smell. According to Purdue Professor Emeritus Don Huber, “The pigs fed GMOs have a very dramatic difference in their microflora. [It] has a terrible odor to it compared to the normal microflora because of that changed bio-environment.” Similarly, the organs and tissues are discolored, possibly due to the proliferation of this different flora

Ronald Anders, DVM, who has been treating animals since 1982, says “I see more problems in the digestive tract [of GMO-fed animals] than I see with animals not on the GMOs.” He specifically saw a huge increase in overgrowth of *clostridium perfringens* type A in livestock within a year of the introduction of RR soy and corn in 1996. This condition, which affects the liver, has resulted in sudden deaths of pigs and cows, as well as chronic conditions.

The bacterial overgrowth from glyphosate may be just one of the reasons why Dr. Anders says, “If we’ve switched from a genetically modified grain to one that is not genetically modified, we’ve seen dramatic improvements in their health.” Both the immune system and digestive systems are much healthier in animals on non-GMO feed.

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A village in Andhra Pradesh India lost all 13 buffalo after they grazed on Bt cotton plants for a single day. Natural cotton plants did not have any negative effects over the previous seven years.



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Dead Sheep, Buffalo, and Cows

While it is clear that Roundup residues in GM crops can damage the gut microflora, there is preliminary evidence suggesting that Bt-toxin might be a similar culprit—especially in animals. In India, farmers allow sheep, goats, and buffalo to graze on cotton plants after harvest. When genetically engineered Bt cotton was introduced into the country, the results were tragic. Thousands of animals died; even more suffered from a variety of disorders.⁴²

Renowned Indian biologist P. M. Bhargava, PhD, suggests that the Bt-toxin produced in the cotton plant kills the cellulose-digesting bacteria

certain insects when gut bacteria were present.⁴³ When bacteria were first removed by administering antibiotics, the toxin was no longer lethal. The authors suggest that Bt-toxin can cause “otherwise benign gut bacteria to exert pathogenic effects.” The mechanics of how this happens, and whether it also impacts humans, is not known. It might be a direct impact on the bacteria; transfer of the Bt-toxin gene to the gut bacteria (which might dramatically increase the amount of toxin produced); or simply the transport of healthy bacteria through the “leaky gut” created by the Bt-toxin, where it then becomes toxic.

Immune and Allergic Response

Immune Shift to Gluten Sensitivity

As discussed at the beginning of this article, it is thought that there must be an environmental trigger to initiate gluten sensitivity. The only study to date that has been able to effectively trigger the onset of

“ While there is insufficient research to prove that GMO consumption causes gluten sensitivity, the evidence does show how it might, at least, exacerbate the symptoms, or contribute to the conditions that might lead to the development of sensitivity to gluten. Instead of waiting for more research, many clinicians are now prescribing non-GMO diets to their gluten-sensitive and -intolerant patients, as well as those with a variety of other disorders.”

normally found in the animals’ rumen. The rumen is a compartment in the digestive tract of these “ruminants” where specialized bacteria break down the plant matter before it travels to deeper chambers of their multi-compartmentalized stomachs.

This would explain why autopsies of the dead sheep revealed shriveled intestines, and an autopsy of a dead buffalo showed undigested food in the rumen—at least three days after consumption. According to Bhargava, since the cellulose was never broken down, the food never made it into the intestines.

U.S. agriculture consultant Marc Tainio reports that when his client, who was raising miniature cattle (three feet high) switched from non-GMO to GMO corn feed, he may have come across the same issue. He said the animals “weren’t able to process the food correctly, and they would bloat up and die.” The farmer quickly lost about 90% of his herd, but was able to save the rest by switching back to non-GMO corn.

An unpublished study by the India-based Navdanya organization also found a significant reduction in soil bacteria over three years in fields where Bt cotton was planted, compared to natural cotton. This supports the theory that Bt-toxin, which is produced even by the roots of the plants, is a natural enemy of certain types of bacteria and therefore a “natural antibiotic.”

If those types of bacteria were only found in ruminants, it may not be a problem for humans; we don’t have ruminants. On the other hand, the Bt-toxin may interact with other gut bacteria to cause harm. This appears to be the case in insects; a study showed that Bt-toxin only killed

gluten sensitivity was done in mice in 2011.⁴⁴ The study showed that retinoic acid, a metabolite of vitamin A, activated a specific immune response to gluten under inflammatory conditions in the gut. It turns out that glyphosate, the primary herbicide used on GMO crops, increases retinoic acid activity.⁴⁵ This was found in a study in frog embryos that showed glyphosate caused birth defects by increasing activity of this vitamin A metabolite. If glyphosate activates retinoic acid, and retinoic acid activates gluten sensitivity, this could be critical information in understanding the environmental trigger for celiac onset.⁴⁶ Eating genetically modified foods increases our exposure to glyphosate and may result in gluten related disorders.

Direct Exposure to Allergens

Sensitivity to gluten is just one of many immune reactions to food that is on the increase. According to the Centers for Disease Control and Prevention (CDC) statistics (see graph below), hospital-confirmed extreme food allergies have been steadily increasing over the past 15 years. It is well known that, if a person is experiencing an allergic reaction to one substance, they can become more vulnerable to reactions from other potential triggers, a phenomenon referred to as “antigenic load”. At low levels of stimulation, the immune system can remain quiet. But once the allergen load reaches a critical threshold, the person may react to many things that were tolerated before that point.

GMOs as Allergens

If GMOs either provoke allergic responses or somehow damage the immune system (immunotoxic), their entrance into our food supply in large quantities could boost allergic reactions to other non-GMO foods. Determining whether a GMO is allergenic, however, can be very difficult. The foods contain genes and their proteins from bacte-

ria and viruses that have never been part of the human food supply in the past. People aren't usually allergic to a food until they have eaten it several times. It would, therefore, be difficult to know in advance if the new foreign protein was an allergen.

Without a surefire method to identify allergenic GM crops, the World Health Organization (WHO) and others suggest examining the properties of the new protein to see if it shares characteristics with proteins that are known to trigger allergies.⁴⁷ One method is to compare the amino acid sequence of the protein with a database of allergens. If there is a match, according to WHO, the GM crop should either not be commercialized or additional testing should be done. Unfortunately, a section of the protein produced by Roundup Ready soybeans does match a sequence in a dust mite allergen; Bt-toxin protein matches an egg yolk allergen; and GM papaya protein also finds a match in the database.⁴⁸

The Bt protein also fails two other tests recommended by the WHO. The protein remains stable for too long when exposed to heat and to simulated stomach acid and digestive enzymes.⁴⁹ Thus, it shares the characteristic with many allergens of not being quickly degraded during digestion.

But GM Bt corn, as well as GM soy and papaya, were all introduced before WHO criteria were established. Furthermore, their criteria are recommendations, not requirements. Thus, in spite of the fact that these three crops fail the allergen tests, additional in-depth tests were not conducted to confirm allergenicity and the foods remain on the market.

If their foreign GM proteins trigger reactions, the danger is compounded by the fact that genes can transfer into the DNA of human gut bacteria and may continuously produce the protein from within our intestines. This could trigger reactions 24/7, permanently elevating the load on the immune system.⁵⁰

If the Roundup Ready soybean protein is an allergen, this might explain why soy allergies in the UK jumped by 50% just after GMOs were introduced in the late 1990s.⁵¹ The UK is one of the few nations to monitor allergy incidence each year, so we don't know the results in North America.

Bt-toxin as an Allergen, and Promoter of Reactions to Other Foods

In addition to failing the WHO allergy criteria, there are many other studies that implicate Bt-toxin as an allergen. In its natural state derived from soil bacteria, Bt-toxin has triggered immune responses in mice⁵² and in farm workers,⁵³ and allergic- and flu-like symptoms in hundreds of exposed citizens.^{54, 55}

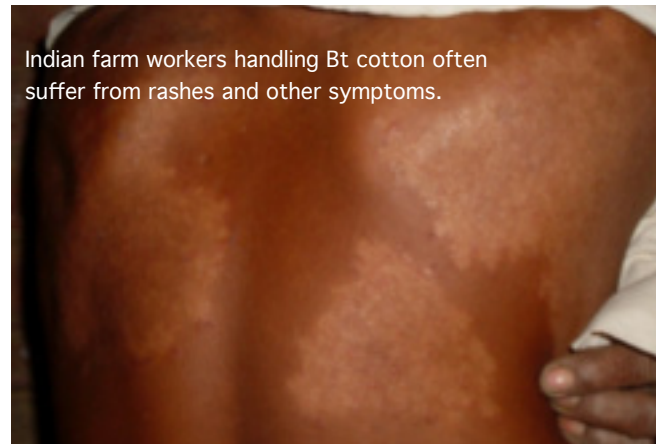
The Bt-toxin is produced in GM corn by inserting the toxin-creating gene from the natural soil bacteria. It is not the same, however, as the spray version. It's far worse. It's designed to be more toxic, it's produced in concentrations that are thousands of times greater than the spray, and it doesn't wash off or biodegrade in sunlight—like the natural version does. It is no wonder that an Italian government study showed that mice fed Bt corn had dramatic immune responses.⁵⁶ Furthermore, thousands of Indian farm workers who harvest Bt cotton are also experiencing allergic-and flu-like symptoms.⁵⁷

When scientists exposed mice to natural Bt-toxin, not only did they react to the toxin directly, afterwards, their immune systems were triggered by substances that formerly did not cause a response.⁵⁸ This illustrates how exposure to one GM food might cause an increase in allergies to many natural foods.

Genetic Engineering Produces Unexpected New or Increased Allergens

Irrespective of which foreign gene is inserted into a plant, the very process of insertion, followed by cloning that cell into a plant, causes massive collateral damage to the plants' *natural* DNA.⁵⁹ There can be hundreds or thousands of mutations throughout the DNA, and these, in turn, can introduce new allergens or toxins, or elevate levels of existing harmful proteins. Neither GMO companies nor federal regulators screen for most of these types of unexpected side effects, and even if they did, the complexity of possible allergens and allergic reactions produced would make a truly comprehensive and accurate assessment virtually impossible.

After Monsanto's Bt corn was on the market, independent scientists decided to take a look at the impacts of the insertion process on the expression of natural genes in the corn plant.⁶⁰ They found 43 proteins that had been inadvertently increased, decreased, newly introduced, or were completely missing. One of the newly-introduced proteins that is



Indian farm workers handling Bt cotton often suffer from rashes and other symptoms.



not found in the natural corn variety is called gamma zein—a known allergen. This means that the corn sold on the U.S. market has an unlabeled new allergen that might be provoking reactions in sensitive consumers.

In a 1996 study by Monsanto in the *Journal of Nutrition*, scientists acknowledge an increase by 27% of a known soy allergen called trypsin inhibitor.⁶¹ Since trypsin is a major enzyme produced by the pancreas and used in the breakdown of food proteins, an inhibition of trypsin activity could result in greatly increasing the length of time that allergenic proteins from our diet remain undegraded in our digestive tract. This would allow more time to provoke allergic responses.

The 27% increase was found in raw soybeans. Trypsin inhibitor is usually degraded substantially by cooking. In Monsanto's study, they did cook soybeans and compare the composition of selective components. But for some reason, they chose not to include the results in the paper. When an enterprising medical writer discovered the missing data in the Journal archives, we learned why Monsanto may have conveniently overlooked it. The trypsin inhibitor was hardly broken down at all. As a result, it was as much as seven times higher in the cooked GM soy compared to the non-GM version of the identical variety of soybeans.⁶²

Other scientists discovered that GM soybeans contain a unique, unexpected protein that was able to bind with IgE antibodies, suggesting that it may provoke dangerous allergic reactions. The same study revealed that one human subject showed a skin prick immune response only to GM soy, but not to natural soy.⁶³ The results of this research, however, must be considered preliminary, as the non-GM soy control was a "wild" type and not easily comparable to the GM variety. The ideal control soy would have been the same *natural* soy variety as that which had been genetically engineered (isogenic). The authors would have used that if it were available, but Monsanto consistently refuses requests by scientists to use their soybean varieties for research purposes.

Harmless Proteins Can Turn Harmful in GMOs

Australian scientists at the Commonwealth Scientific and Industrial Research Organization (CSIRO) produced a genetically engineered pea with a gene from the kidney bean.⁶⁴ The gene produces an anti-nutrient (alpha-amylase inhibitor) that interferes with the digestive system of the pea weevil larvae, causing them to starve to death. These bug-killing peas passed all the studies that are usually conducted on GMOs before regulators wave them onto the world market.

But the developers of the peas decided to do one more test that no GM food developer had done before or since. They supplemented mice diets with GM peas, non-GM peas, or kidney beans, then subjected the animals to a battery of tests. Only mice fed GM peas had an immune response to GM protein. In addition, the mice fed the GM peas started to react to egg albumin, while those fed non-GM peas or kidney beans did not.⁶⁴

The findings suggest that GM peas might cause allergies in humans, as well as promote reactions to a wide range of other foods. According to Judy Carman, an epidemiologist and the director of The Institute of Health and Environmental Research in Australia, "If a GM food was introduced onto supermarket shelves and caused an immune reaction, it would be very difficult to find the culprit, particularly if it caused reactions to other, different foods, as this GM pea was found to do."

What is fascinating about this research is that the "identical" protein found in its original state—in the kidney bean—did not provoke reactions. It was only after the gene was transferred into the peas and the

protein was produced in that new environment that it became harmful and potentially deadly. The scientists later discovered that the sugar molecules that often attach to proteins had a subtle difference in their shape. Since sugar attachments are known to trigger reactions, they blamed the mice reaction on this unpredicted side effect of genetic engineering.

No other GM crop is evaluated for the presence or changes in sugar chains. Any of them might be provoking allergic responses, as well as enhancing reactions to other foods formerly considered harmless.

Apply the Precautionary Principle Now: Avoid GMOs

We have seen how gluten sensitivity and celiac disease involve a combination of inflammatory and other immune responses, altered gut bacteria, as well as destruction of intestinal integrity. We have further seen that genetically modified foods may trigger immune reactions, impair gut bacteria, and damage gut integrity and digestive capacity.

While there is insufficient research to prove that GMO consumption *causes* gluten sensitivity, the evidence does show how it might, at least, exacerbate the symptoms, or contribute to the conditions that might lead to the development of sensitivity to gluten. Instead of waiting for more research, many clinicians are now prescribing non-GMO diets to their gluten-sensitive patients, as well as those with a variety of other disorders. Reports from the clinicians and from patients are encouraging.

Although 64 countries either ban GMOs outright or require mandatory labeling, the United States is not one of them. To avoid GMOs in America, consult **NonGMOShoppingGuide.com** or download the free iPhone app ShopNoGMO. It contains over ten thousand products that have been third-party verified as meeting the standards of The Non-GMO Project. In addition, avoiding GMOs can be accomplished by purchasing organic products, buying brands that say Non-GMO on the label, or avoiding the "at-risk" ingredients. These include derivatives of soy, corn, cottonseed and canola oil, sugar from sugar beets, papaya from Hawaii or China, zucchini and yellow squash.

The Institute for Responsible Technology (IRT) is collecting experiences from practitioners and consumers who eliminate GMOs. Please share results with IRT at healthy@ResponsibleTechnology.org.

Jeffrey M. Smith is the author of the #1 international GMO bestseller Seeds of Deception and Genetic Roulette, Director of the award winning film Genetic Roulette—The Gamble of Our Lives, and Executive Director of the Institute for Responsible Technology. He regularly presents on GMO health issues at medical conferences worldwide, testifies before government bodies, and is a frequent guest on popular shows, including Dr. Oz and BBC World Service.

Sayer Ji, author and founder of GreenMedInfo.com, the most widely referenced natural medicine database

Tom Malterre, MS, Certified Nutritionist, author, and physician educator. WholeLifeNutrition.net

Tom O'Bryan, DC, CCN, DACBN, theDr.com

Stephanie Seneff, PhD, Senior Research Scientist, MIT

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