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The Troubling Role of Glyphosate in COVID-19

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STORY AT-A-GLANCE -

- Your body substitutes glyphosate for glycine, and in so doing, poisons your body's machinery for creating proteins
- In normal physiology, processes in your mitochondria ensure deuterium depletion. If your mitochondria are damaged by glyphosate, they're not going to be able to eliminate the deuterium properly and the buildup of deuterium may contribute to chronic disease
- Glyphosate may play an important role in cases of severe COVID-19. If you've accumulated a lot of glyphosate in your tissues, your immune cells will be impaired, making it difficult to clear the virus
- To avoid glyphosate exposure, the most important strategy is to eat certified organic foods whenever possible, and eat/drink more sulfur-containing foods, organic grass fed milk and butter, glacier water, animal fats and probiotic foods
- To help mitigate the toxic effects of glyphosate, you can take an inexpensive glycine supplement

This article was previously published February 28, 2021, and has been updated with new information.

In this interview, Stephanie Seneff, Ph.D., a senior research scientist at MIT, reviews the health impacts of glyphosate. She has just finished writing a book about glyphosate called "Toxic Legacy: How the Weedkiller Glyphosate is Destroying Our Health and the Environment," which is expected to be published in June 2021.

For years, glyphosate was assumed safe and claims of toxicity were vehemently denied. But in recent years, studies on glyphosate have been demonstrating toxicity even at very low levels. Seneff also believes glyphosate exposure may be a key player in cases of severe COVID-19, which we'll unravel in this interview.

Glyphosate's Mechanism of Action

The "gly" in glyphosate actually stands for the amino acid glycine. The glycine amino acid in glyphosate has a methylphosphonate group attached to its nitrogen atom, which is responsible for its effects and toxicity.

After studying the research literature on glyphosate, Seneff has reached the conclusion that your body sometimes substitutes glyphosate for the amino acid glycine when it is constructing proteins, and this can have devastating consequences in some cases. The proteins created with glyphosate instead of glycine simply don't work because glyphosate is much larger than glycine and also negatively charged, and as a result this alters important physical characteristics.

Monsanto's own research, dating back to the late 1980s, shows that glyphosate accumulates in various tissues, even though they claim it doesn't.[1] The Monsanto researchers proposed that it was "incorporated into" the proteins in the tissues. This is not widely appreciated, even in the natural health community.

Now, if you have a distorted analog of glycine (in the form of glyphosate), the protein constructed from it is not going to work like it's supposed to. In her book, Seneff details the amino acids in proteins that are most susceptible to damage because of what she calls a "glyphosate susceptible motif."

> *"It's really fascinating biology and so terrifying when you think of the potential consequences, if I'm right,"* she says. *"It matches so well with all the diseases that are going up dramatically in our society that I really think I'm onto something huge here."*

An aromatic amino acid called EPSP synthase is a critical enzyme that almost surely gets disrupted by glyphosate through this mechanism of substituting for glycine. This gets a bit technical, but it is important. The plant version of EPSP synthase binds a phosphate group in its substrate phosphoenolpyruvate at a site where there is a highly-conserved glycine residue (highly conserved usually means that it is critical for proper function).

It has been shown experimentally that, if you change the DNA code so that the glycine is substituted by an amino acid called alanine (one extra methyl group), the enzyme becomes completely insensitive to glyphosate at any concentration. It also takes a hit on phosphate binding because of the extra methyl group, but you can tweak another amino acid nearby to fix this problem, while still keeping its insensitivity to glyphosate.

Researchers from Dow-Dupont did exactly this to a maize version of EPSP synthase using CRISPR technology and were able to create synthetically a version of the maize's own EPSP synthase that was completely resistant to glyphosate. The title of this paper is: "Desensitizing Plant EPSP Synthase to Glyphosate: Optimized Global Sequence Context Accommodates a Glycine-to-Alanine Change in the Active Site."[2]

The shikimate pathway is the pathway that produces aromatic amino acids, which are essential to humans as we cannot create these amino acids in our body. The argument is we're not susceptible to glyphosate because our cells don't have EPSP synthase — in fact, they don't have the entire shikimate pathway.

However, our gut microbes do have that pathway, and they use it to make essential amino acids for the host. So, our gut microbes are indeed affected by glyphosate, and when they're damaged, our health can suffer in any number of ways.

But what might be an even more devastating problem with glyphosate is the way it probably messes up a large number of proteins that bind phosphate at a site where there is at least one, and often three, highly conserved glycine residues. Glyphosate slips its methylphosphonate group into the spot that is supposed to be where phosphate from the substrate fits snugly. Phosphate can't bind because glyphosate is in the way.

The arguments for why glyphosate specifically disrupts proteins that depend on glycine for phosphate binding are described more fully in a paper Seneff published together with colleagues arguing that glyphosate is a major factor in kidney failure among young agricultural workers in Central America.[3]

The Importance of Deuterium

Laszlo Boros is a professor of pediatrics at UCLA and an expert on deutenomics, "the science of autonomic deuterium discrimination in nature."[4] After reading one of Seneff's papers, he contacted her, suggesting she look into deuterium.

> *"I was blown away, and I immediately saw the connection to glyphosate,"* she says. *"This was a year ago in December, and I've just been reading everything I can on deuterium since then and hooking it to glyphosate. It's just astonishing what I found, even, ultimately, [linking it] to COVID-19.*
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> *It's been quite a year for me in terms of major breakthroughs in my understanding of how metabolism works and how it's getting messed up by glyphosate, and then how that's causing us to not be able to effectively deal with COVID-19."*

In normal physiology, your cells, specifically the mitochondria, function to help deplete your body of deuterium. Deuterium is a naturally occurring isotope of hydrogen. If you didn't already know, deuterium is also known as heavy hydrogen, because it has a neutron in addition to the proton and electron in the hydrogen atom.

Provided your cell is healthy, it has deuterium-depleting enzymes and organelles that help remove deuterium from your cells. If your mitochondria are damaged by glyphosate, they're not going to be able to eliminate the deuterium properly.

Deuterium is like iron in the way that it's both essential in the right amounts and toxic in excess. Hydrogen is the smallest atom and by far the most common atom in your body. Deuterium, being a heavy hydrogen, has one extra neutron, in addition to the normal proton and electron that regular hydrogen has.

Now, your cells are surrounded by structured water, which is negatively charged and contributes to your body's energy production by supplying deuterium-depleted hydrogen to lysosomes and mitochondria. The structured water is maintained by sulfates, which makes sulfate extremely important for health. Sulfate is made dysfunctional by glyphosate, which in turn destroys structured water, resulting in impaired energy production in the cell.[5]

> *"The mitochondria have [a] membrane, which has a part inside the membrane that's really, really important,"* Seneff says. *"That's where you have those protons, and you really don't want it to be deuterons. This is what Laszlo brought home to me."*

How Your Body Creates Deuterium-Depleted Water

Endothelial NOS (eNOS) makes nitric oxide (NO), and for every molecule of NO that it makes, it produces two molecules of water, which are deuterium depleted. Stephanie believes the NO created by eNOS may act as a signal that deuterium-depleted water has been created. Interestingly enough, deuterium-depleted water is also created during the inflammatory process.

> *"The inflammation is there for a good reason, and the reason is to produce deuterium-depleted water,"* Seneff says. *"It's all because the mitochondria are failing in their task of producing their own deuterium-depleted water, which they get in part through the structured water from the sulfate [and] through enzymes that are highly skilled at choosing hydrogen over deuterium …*
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> *NADH and NADPH are also fascinating. I've been chasing them through all the proteins. They are interesting because they are the carriers of that wonderful hydrogen that's not deuterium. When you trace what's doing what, where, you realize that the cytoplasm is producing NADH and handing it over to the mitochondria.*
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> *The mitochondria then take that H [hydrogen atom] off and throw it into the intermembrane space. So, the whole process ends up with the intermembrane*

space being assured that this is H [hydrogen] and not D [deuterium].

This is crucial because then those protons, once they build up, come back through the ATPase [ATP synthase] pump. If they are deuterons, they are going to wreck the pump … You release reactive oxygen species [that] break it, and of course, then you can't make ATP."

For clarification, the ATP synthase pump works like a mini-motor. When a hydrogen atom with one proton goes through it, it works flawlessly and generates ATP. If deuterium enters it, which has one neutron and one proton, making it twice the weight of hydrogen, it breaks that motor.

Interestingly, deuterium is everywhere, naturally, but your body has developed an intricate way to make it harmless by trapping it in the structured water, where it's beneficial, as it actually supports the creation of structured water.

Problems arise when you cannot make enough structured water to sequester it all. Then, the deuterium gets loose, causing mitochondrial dysfunction, impairing energy production and contributing to chronic disease.

Glyphosate Damages Health in Many Ways

As noted by Seneff, glyphosate harms your health in a number of ways. For example, she cites a recent paper showing it causes endocrine disruption, which can lead to breast cancer, reproductive issues, obesity and thyroid problems.[6]

Another paper shows glyphosate sensitizes cells to be more receptive to cancer after exposure to other chemicals.[7] "Glyphosate makes everything else more toxic than it would otherwise be," Seneff says. "It disrupts your defense system against toxic chemicals." Other research shows epigenetic and generational effects, even when no apparent problems can be found in the first generation exposed.[8]

> **“ I think [COVID-19] is mostly about glyphosate. If you've accumulated a lot of glyphosate in your tissues,**

> **you're not going to do well with COVID-19, and that's because [your body] is trying to repair the mitochondria in the immune cells so that the immune cells can actually clear the virus. If they can't make ATP, they can't do their job, and the virus flourishes. ~ Stephanie Seneff, Ph.D.”**

Glyphosate also impairs flavoproteins — proteins that bind flavins. Many of these proteins play a crucial role in transferring hydrogen from NADH or NADPH to other molecules, essentially supporting the delivery of pure hydrogen to the mitochondria. Flavoproteins have a characteristic GxGxxG motif at the site where they bind phosphate in the flavins. The 'G' stands for glycine and the 'x' is a wildcard — any amino acid, including glycine.

This means they have at least three susceptible glycines at this critical region of the protein. Flavoproteins are molecules that facilitate the transfer of protons and electrons, and know how to avoid deuterium, by exploiting a special feature of hydrogen called proton tunneling.

All of them can be expected to be disrupted by glyphosate. A critical flavoprotein is succinate dehydrogenase, and several papers have shown it is adversely affected by glyphosate, Seneff says. It is the only enzyme that plays a role in both oxidative phosphorylation and the citric acid cycle in the mitochondria.

In addition to aromatic amino acids, the shikimate pathway is essential for riboflavin synthesis, and riboflavin, a B vitamin, is the main precursor to flavins. This means that riboflavin deficiency can be triggered from glyphosate exposure as well. Glyphosate also causes damage by:

- Increasing calcium uptake in cells, which causes toxicity to neurons
- Interfering with the ability to take glutamate out of your synapses

- Making manganese unavailable — This in turn disrupts and prevents glutamate from being turned into nontoxic glutamine after it's removed from your synapses. The enzyme responsible for the conversion is also highly dependent on glycine, which could be replaced by glyphosate

Deuterium-Depleted Water May Be Central to Metabolism

According to Seneff, it appears deuterium-depleted water plays a central, hitherto unappreciated role in metabolism, as your body has so many ways to create it. For example, deuterium-depleted water is created through:

- Fatty acid synthesis and metabolism — The enzymes that synthesize fatty acids incorporate hydrogen that is carried by NADPH. This hydrogen atom has been carefully selected to be assured not to be deuterium. Interestingly, lipoxygenase is a protein expressed during conditions of stress, and according to Seneff, it has the greatest ability to select protons over deuterons of any protein.

  It is highly upregulated in severe COVID-19 infection. It appears the virus triggers an increase in lipoxygenase because the virus captures linoleic acid (LA) in pockets in the viral membrane. However, lipoxygenase is not a flavoprotein, and it also doesn't bind heme — this makes it resistant to damage from glyphosate. So, its activation becomes an alternative pathway to fix the mitochondrial deuterium problem.

  SARS-CoV-2 picks up the omega-6 LA as it crosses the cellular membrane, and the LA then triggers the production of lipoxygenase that modifies the LA into leukotrienes — signaling molecules that bring in damaging macrophages.

  But deuterium-depleted water is also produced in this process, by yanking two hydrogen atoms out of the fat and combining them with oxygen to make water. Note that this is just yet another way that excess LA damages your body, but with an ulterior motive that we often fail to appreciate.

- Sterol synthesis and metabolism — including cholesterol, vitamin D, cortisol, and sex hormones.

- Aromatic amino acid derivatives — including melatonin and neurotransmitters such as dopamine and serotonin, as well as thyroid hormone.

"All these molecules that go through these complicated steps are all focused on delivering deuterium-depleted water to the mitochondria," Seneff says. "I mean, it's an absolute obsession that the cell has." She goes on to review how processes that may appear to have nothing but harmful effects are actually an effort to heal the body. This, for example, seems to be the case in COVID-19:

> *"I believe that whatever biology is doing, it's doing it for a good reason. There may be damage, but there's a good reason why you need that damage in order to survive long term. It's trying to fix a problem that's very serious, and that's what I think is happening with [SARS-CoV-2].*
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> *Not only does it induce this lipoxygenase, which produces deuterium-depleted water, it then creates this inflammatory environment, which brings in the platelets and the macrophages, the immune cells and the stem cells. All these are having a big party in there in all this fluid that's building up inside the lungs.*
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> *Meanwhile, it also increases the production of hyaluronic acid. Hyaluronic acid is able to trap deuterium-depleted water. It makes structured water. So, you get structured water inside the alveoli of the lungs, and then you get fluid water in the interstitial spaces.*
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> *The blood vessels are leaky, the capillaries are leaky. Everything's coming out of the capillaries into this interstitial space where there's this fluid water, and you've got this lipoxygenase making deuterium-depleted water.*
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> *So, you're producing this environment of deuterium-depleted water, inviting the macrophages to come in, and the platelets release their mitochondria … the stem cells also come in and release their mitochondria, and then macrophages sweep up the mitochondria — and all this is happening in the interstitial space in the lungs where the fluid is. This is why you cannot breathe. You're drowning.*

Maybe one of the most important things platelets do is hang on to mitochondria that they can deliver to the macrophages under conditions of stress. So, what happens is all these mitochondria get released in that interstitial space, and the macrophages induce this macropinocytosis, where they actually sweep up the water and everything that's in it and bring it inside the macrophage, including the mitochondria.

It's actually been shown that platelets can release mitochondria into the environment, and macrophages can take them up and use them as perfectly functioning mitochondria. It's astonishing. So, what they're doing is restoring the mitochondrial health to the immune cells."

Glyphosate Damage May Be a Factor in Severe COVID-19

As explained by Seneff, your immune cells are impaired by glyphosate, so the older you are, the more likely you've been exposed to glyphosate for decades and therefore have poorly functioning immune cells. Interestingly, Seneff points out that the comorbidities of COVID-19 — obesity, diabetes and high blood pressure — are also diseases whose prevalence is going up dramatically over time, exactly in step with glyphosate usage on core crops.

"So, I think it's mostly about glyphosate," she says. *"If you've accumulated a lot of glyphosate in your tissues, you're not going to do well with COVID-19, and that's because [your body] is trying to repair the mitochondria in the immune cells so that the immune cells can actually clear the virus. If they can't make ATP, they can't do their job, and the virus flourishes."*

The key take-home message here is that this is yet another reason to clean up your diet to make sure you're not exposed to glyphosate. It basically wrecks your immune cells, and the cascading damage that takes place in severe cases of COVID-19 appears to be your body's response to salvage or repair those poorly functioning immune cells.

Dietary Recommendations

The answer to this problem is, first of all, to eat certified organic foods whenever possible. "We won't buy it if we can't find certified organic, and we've really seen health improvements since we've started doing that," Seneff says. "I really swear by it, and I try to get all my friends to do the same. I think if you can eliminate glyphosate, you can really see great improvements in your health no matter what your problems are." Other dietary recommendations include eating/drinking more:

Sulfur-containing foods such as organic eggs and seafood	Organic grass fed milk and butter. Butter is one of the lowest deuterium foods available
Glacier water, which is naturally low in deuterium	Animal fats, which are also low in deuterium
Molecular hydrogen	Probiotics foods such as sauerkraut and apple cider vinegar

To help "push" glyphosate out of your body and mitigate its toxicity, you can take an inexpensive glycine supplement. I take between 5 and 10 grams a day. It has a light, sweet taste, so you can actually use it as a sweetener.

> *"It makes sense because it's basically going to outnumber the glyphosate molecules,"* Seneff says. *"Remember, glyphosate's going to compete with glycine in building the protein. If there's a lot of glycine around, then it's much less likely that glyphosate will get in there."*

Sources and References

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