Roundup and Autism: Why Correlation IS Causation This Time

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Outline

• Correlation between glyphosate and autism
• Glyphosate’s general mechanisms of toxicity
• Metal chelation, especially manganese
• Glyphosate’s potential substitution for glycine during protein synthesis: broad consequences
• Summary
Correlation between glyphosate and autism

THIS IS THE NEW CHILDHOOD IN AMERICA:
1 in 3 is overweight
1 in 6 has learning disabilities
1 in 9 has asthma
1 in 10 has ADHD
1 in 12 has food allergies
1 in 20 has seizures
1 in 54 males has autism
1 in 45!

50% (half) of all children have chronic illness or are overweight.

This is the NEW NORMAL in our country.

Are you concerned yet?! Because if you’re not, then you are not paying attention!
Roundup and GMO Crops

GMO Roundup-Ready corn, soy, canola, sugar beets
cotton, tobacco and alfalfa

What is glyphosate?

A Frightening Trend*

These numbers are for children who are 12 years old

A Frightening Trend*

AUTISM DIAGNOSES RISING
Almost 1.5% of US children are now diagnosed with autism, according to data from 11 regions in the United States.

Percentage of children with Autism in the US

Percentage of children with Autism in the US

If we stay the course, half the children born in 2032 will be diagnosed with autism – That will be 80% of the boys

Is glyphosate a major factor in the autism epidemic?
Autism Prevalence: 6 year olds

glyphosate is total of year indicated + 3 previous years
\[ R = 0.9972, \quad p \leq 2.366e-07 \]

R = 0.9972

* Figure 15, Seneff et al., Agricultural Sciences, 2015, 6, 42-70

Glyphosate’s general mechanisms of toxicity
Is Glyphosate Toxic?

• Monsanto has argued that glyphosate is harmless to humans because our cells don’t have the shikimate pathway, which it inhibits

• However, our gut bacteria DO have this pathway
  – We depend upon them to supply us with essential amino acids (among many other things)

• Other ingredients in Roundup greatly increase glyphosate’s toxic effects

• Insidious effects of glyphosate accumulate over time
  – Most studies are too short to detect damage

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Growth of GM Corn, Soy and Cotton in US, 1996-2012*

Another claim of Monsanto's has been that residue levels of up to 5.6 mg/kg in GM-soy represent "...extreme levels, and far higher than those typically found" (Monsanto 1999).

Soy Formula Linked to Seizures in Autism*

"There was a 2.6-fold higher rate of febrile seizures, a 2.1-fold higher rate of epilepsy comorbidity and a 4-fold higher rate of simple partial seizures in the autistic children fed soy-based formula"

*CJ Westmark, PLOSOne March 12, 2014, DOI: 10.1371/journal.pone.0080488.
Nutrients, Hormones and Neurotransmitters Disrupted by Glyphosate

- Vitamins:
  - Folate, niacin, cobalamin, vitamins A, K, and D
- Proteins:
  - Aromatic amino acids, glycine, methionine
  - Cytochrome P450 enzymes in the liver
- Minerals:
  - Iron, manganese, cobalt, selenium, zinc, sulfur
- Neurotransmitters:
  - Serotonin, melatonin, dopamine, thyroid hormone
- Melanin (skin tanning agent)
- Glutathione (antioxidant defenses)

Many of these deficiencies have been linked to autism.
**Glyphosate and Autism: Some Biological Mechanisms**

- Disruption of gut microbes\(^1\)
  - Children with autism suffer from many digestive issues
- Disruption of sulfur metabolism, glutathione deficiency, impaired methylation pathways\(^1\)
- Metal chelation (especially manganese)\(^2\)
  - Manganese deficiency leads to impaired mitochondrial function and glutamate toxicity in the brain
- Inhibition of pituitary release of thyroid stimulating hormone → hypothyroidism\(^3\)
  - Moms with hypothyroidism have 4-fold increased risk to autism in the fetus


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**Metal chelation, especially manganese**
Glyphosate Depletes Iron, Manganese and Zinc in Plants*

![Graph showing the depletion of iron, manganese, and zinc in plants with and without glyphosate.]


Severe Deficiency in Serum Cobalt and Manganese in Cows*

Cows at 8 different farms consumed GM Roundup-Ready corn and soy feed

All cows tested had glyphosate in the urine

*M. Krüger et al., J Environ Anal Toxicol 2013, 3:5*
Low Manganese in Teeth Linked to Autism*

- Studied lead, mercury and manganese levels in tooth enamel of shed primary teeth in 84 children
- Manganese accumulated after birth was down by 60% in autistic children
- *No other result was statistically significant*


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Lactobacillus Depends on Manganese!*

- Many lactic acid bacteria contain very high intracellular manganese levels
  - Scavenges toxic oxygen species, particularly superoxide
- Manganese deprivation suppresses growth


Lactobacillus levels are low in the gut in association with autism

Impaired Thyroid Function

- Low thyroid hormone in mother → 4-fold increased risk to autism in child*
- Thyroid hormone is derived from tyrosine, a product of the shikimate pathway
- Thyroid depends on selenium (chelated by glyphosate) to protect it from oxidative damage and for hormone activation
- Thyroid stimulating hormone (pituitary) depends on manganese


Glyphosate’s potential substitution for glycine during protein synthesis: broad consequences
What If Glyphosate Could Insert Itself Into Protein Synthesis???

Glyphosate is a synthetic amino acid analogue of glycine

Any proteins with conserved glycine residues are likely to be affected in a major way
What If Glyphosate Could Insert Itself Into Protein Synthesis???

Damaged proteins would slowly accumulate throughout the body over time, causing widespread pathologies.

Any proteins with conserved glycine residues are likely to be affected in a major way.

An Analogy: Multiple Sclerosis & Sugar Beets*

- Sugar beets contain an analogue of proline called Aze
- Remarkable correlation between MS frequency and proximity to sugar beet agriculture
- Myelin basic protein contains a cluster of proline residues that are absolutely essential for its proper function

Glycine, Methyl-folate and One-carbon Metabolism

• Glycine is a key source of methyl groups for the one-carbon cycle (methylation pathway) via the glycine cleavage system
• A glycine-rich region maintains shape and flexibility of glycine decarboxylase, a key enzyme in the glycine cleavage system*


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Celiac Disease and Prolyl Aminopeptidase

- Gluten intolerance and Celiac disease result from inability to break down gluten, which is enriched in proline*
- Prolyl aminopeptidase, the enzyme that breaks down proline-containing peptides, depends on manganese as a catalyst
- Prolyl aminopeptidase also contains a highly conserved GxSxGG motif plus two other regions with conserved glycines**
- Malabsorption due to celiac disease can lead to nutritional deficiencies and symptoms of autism***

**F Morel et al., Biochimica et Biophysica Acta 1999;1429: 501-505

Impaired GABA Receptor Activity and Autism

- Autism has been linked to a weakened response of the inhibitory GABA receptor to stimuli*
- The GABA receptor has a conserved glycine at the entrance to the first membrane-spanning domain that is essential for its function**

*CD Robertson et al., Current Biology 2016;26: 80-85
**BX Carlson et al., Mol Pharmacol. 2000;57(3):474-84
Summary

• Contrary to Monsanto’s claims, glyphosate is toxic to humans
• Mineral chelation, disruption of gut microbes, and inhibition of liver enzymes have broad consequences
  – Causes deficiencies in vitamins, minerals, amino acids, neurotransmitters, melatonin and antioxidants
  – Makes other toxic agents more toxic (synergy)
• Glyphosate may insert erroneously into protein synthesis
  – Multiple proteins with conserved glycines would be severely affected, causing widespread disease