

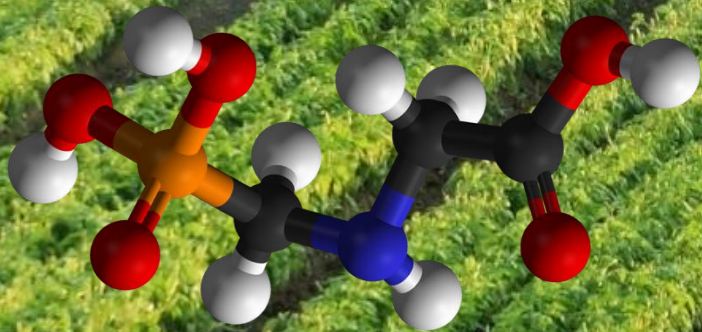
Toxic Legacy: How the Weedkiller Glyphosate is Destroying Our Health and the Environment

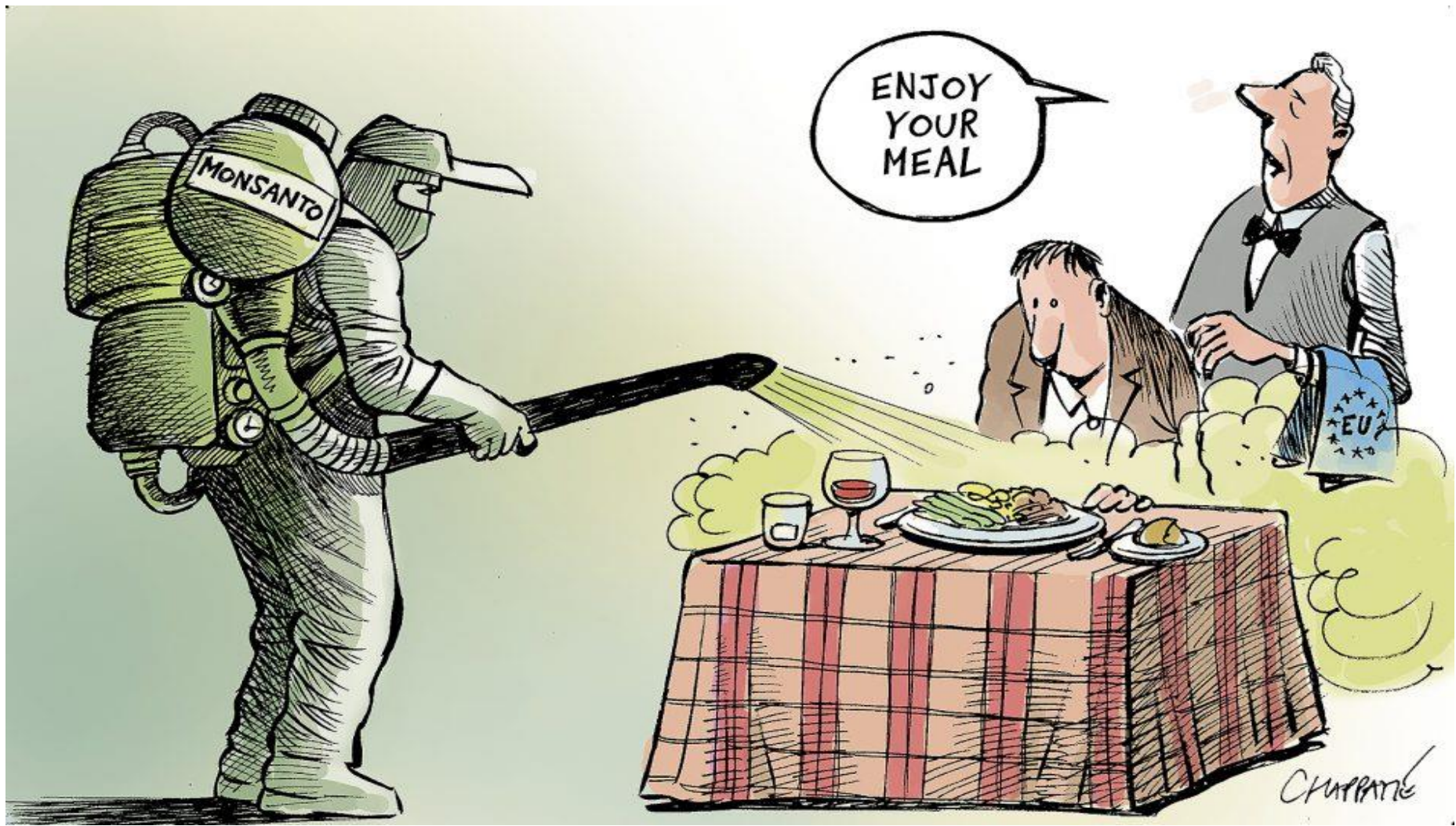
Stephanie Seneff

MIT CSAIL

Understanding Ag Webinar

June 10, 2021



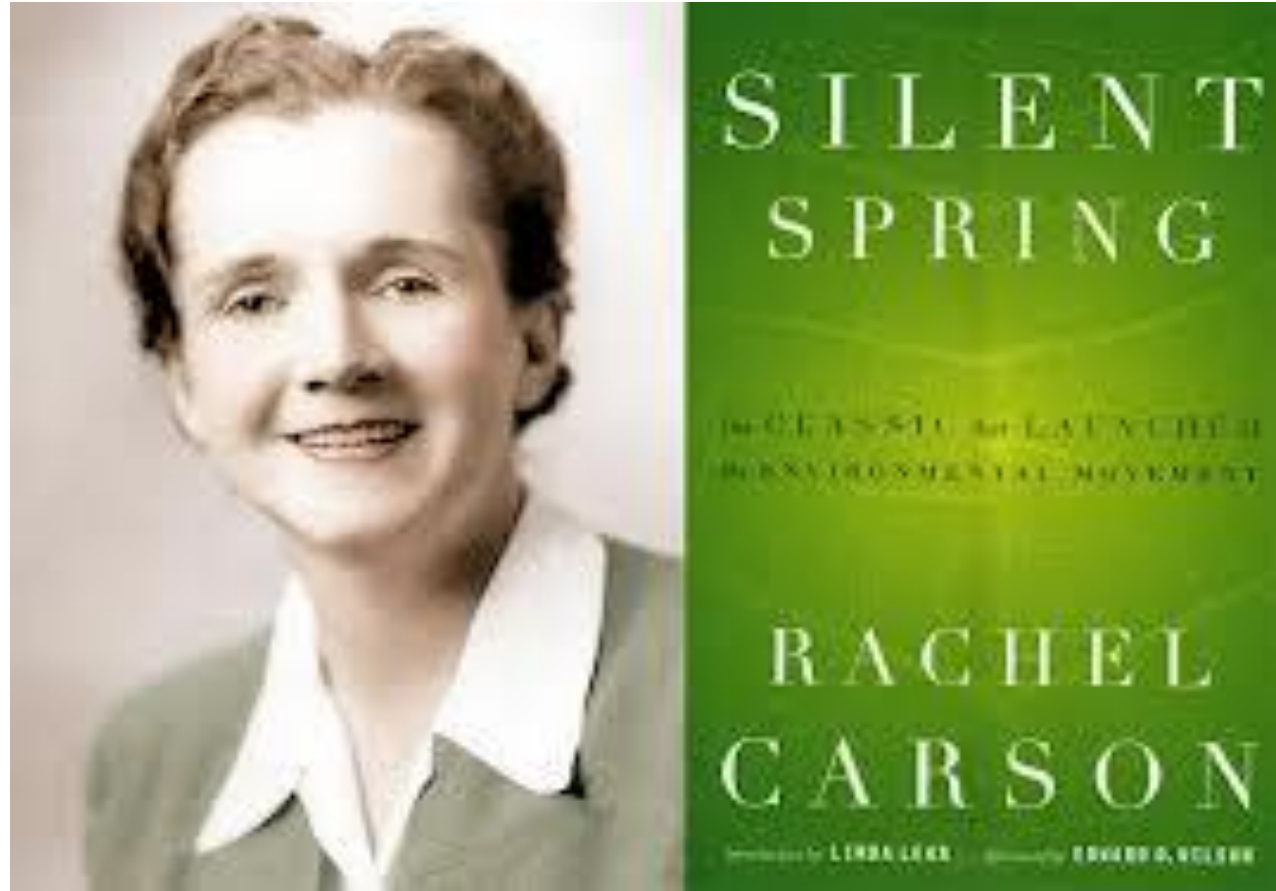


“The earth is not dying, it is being killed,
and those who are killing it have names and addresses.”

-- the late activist musician Utah Phillips.

Silent Spring (1962)

Rachel Carson argued that uncontrolled and unexamined pesticide use was harming and even killing not only animals and birds, but also humans.



Outline

- Introduction
- Evidence of Persistence and Toxicity
- Animal and Human Diseases
- Glyphosate and the Gut
- Glyphosate and Autism
- Glyphosate and Endocrine Disruption
- Transgenerational Effects
- How to Stay Healthy in a Toxic World
- Conclusion

Introduction

Roundup and GMO Crops

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

What is glyphosate?



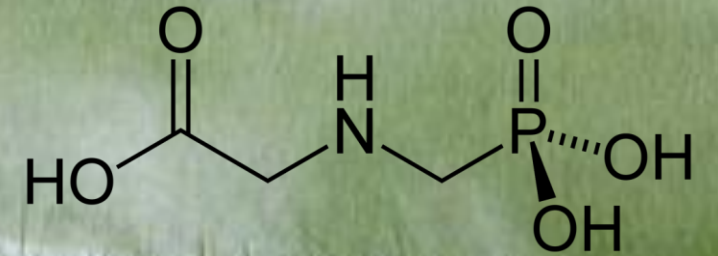
Roundup as a Desiccant/Ripener just before Harvest

Wheat, Oats, Barley, Rye, Sugar cane,
Beans, Lentils, Peas, Flax, Sunflowers,
Pulses, Chick Peas



A Brief History of Glyphosate

- Glyphosate is now the #1 herbicide in use in the U.S. and is increasingly used around the world
 - Patented by Monsanto as an herbicide in 1969
 - Introduced into the US food chain in 1974
- Came out from under patent in 2000
- Inhibits an enzyme in the *shikimate pathway* involved in synthesis of tyrosine, tryptophan and phenylalanine (the three *aromatic amino acids*)
- Huge expansion of GMO corn, soy, cotton and canola crops has led to sharp increases in the last two decades



Is Glyphosate Nontoxic?

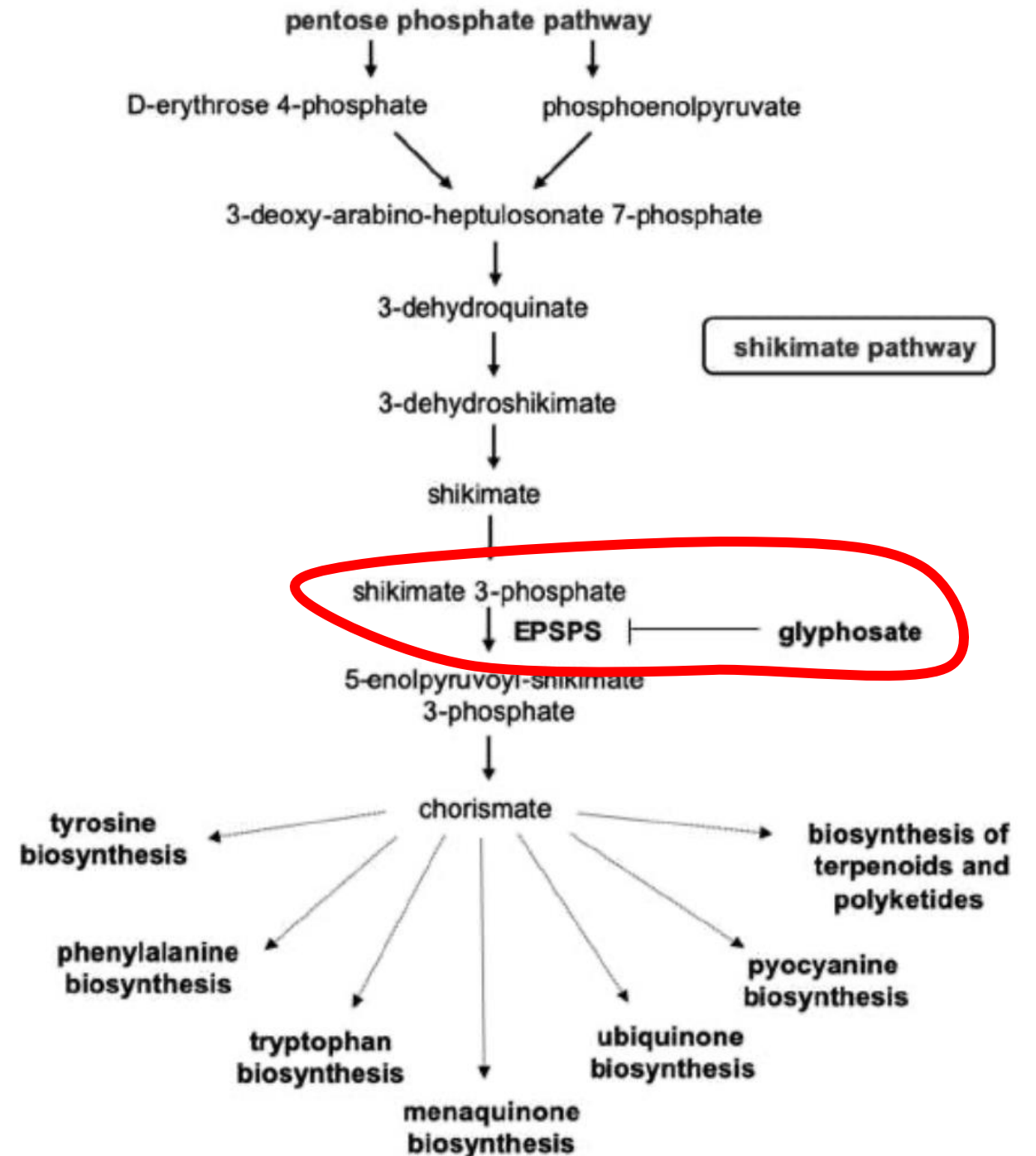
- Monsanto has argued that glyphosate is harmless to humans because our cells don't have the shikimate biological pathway which is the pathway glyphosate disrupts to kill plants
- However, our gut bacteria DO have this pathway
 - We depend upon them to supply us with essential amino acids produced through that pathway, and with many other nutrients such as vitamins and short chain fatty acids
- 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
- Recently, three successful lawsuits claiming that glyphosate caused non-Hodgkin's lymphoma are bringing public awareness to glyphosate's toxicity

Why did we not find this out long ago?

- The industry defined the rules for evaluating toxicity
 - The chemical could be evaluated only in isolation despite enhancing effects of formulations
 - If high levels appear safe, then no need to study lower levels (“the dose makes the poison”)
 - No need to study beyond three months in assessing damage to organisms
- Glyphosate is an endocrine disruptor
 - Low exposure levels are more toxic than higher levels
- Glyphosate is a “slow kill”
 - Accumulates in the body and takes time for symptoms to appear
- Many studies are coming out in the past few years showing diverse adverse consequences of low-dose exposures, even transgenerational

Evidence of Persistence and Toxicity

Glyphosate Blocks EPSP Synthase in the Shikimate Pathway in Plants*



*Figure 1 in Robin Mesnage et al. Environmental Health Perspectives 2021; 129(1): 017005.



Research paper

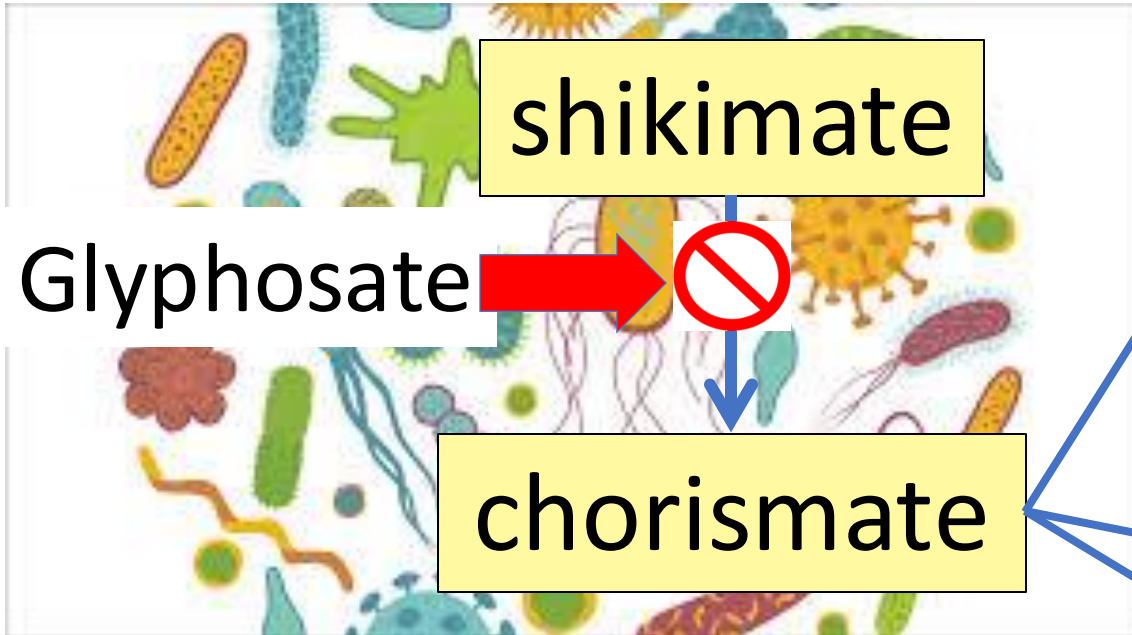
Classification of the glyphosate target enzyme (5-enolpyruvylshikimate-3-phosphate synthase) for assessing sensitivity of organisms to the herbicide

“A conservative estimate from our results shows that 54% of species in the core human gut microbiome are sensitive to glyphosate.” *

*Lydia Leino et al. Journal of Hazardous Materials 2021; 408: 124556.

Shikimate Pathway Disruption

Gut Microbes



Phenylalanine,
tryptophan, tyrosine



Dopamine, adrenaline,
serotonin, melatonin, melanin,
thyroid hormone

vitamin K

Several B
vitamins

Roundup Safety Claims Disputed*

“It is commonly believed that Roundup is among the safest pesticides. ... Despite its reputation, Roundup was by far the most toxic among the herbicides and insecticides tested. This inconsistency between scientific fact and industrial claim may be attributed to huge economic interests, which have been found to falsify health risk assessments and delay health policy decisions.”

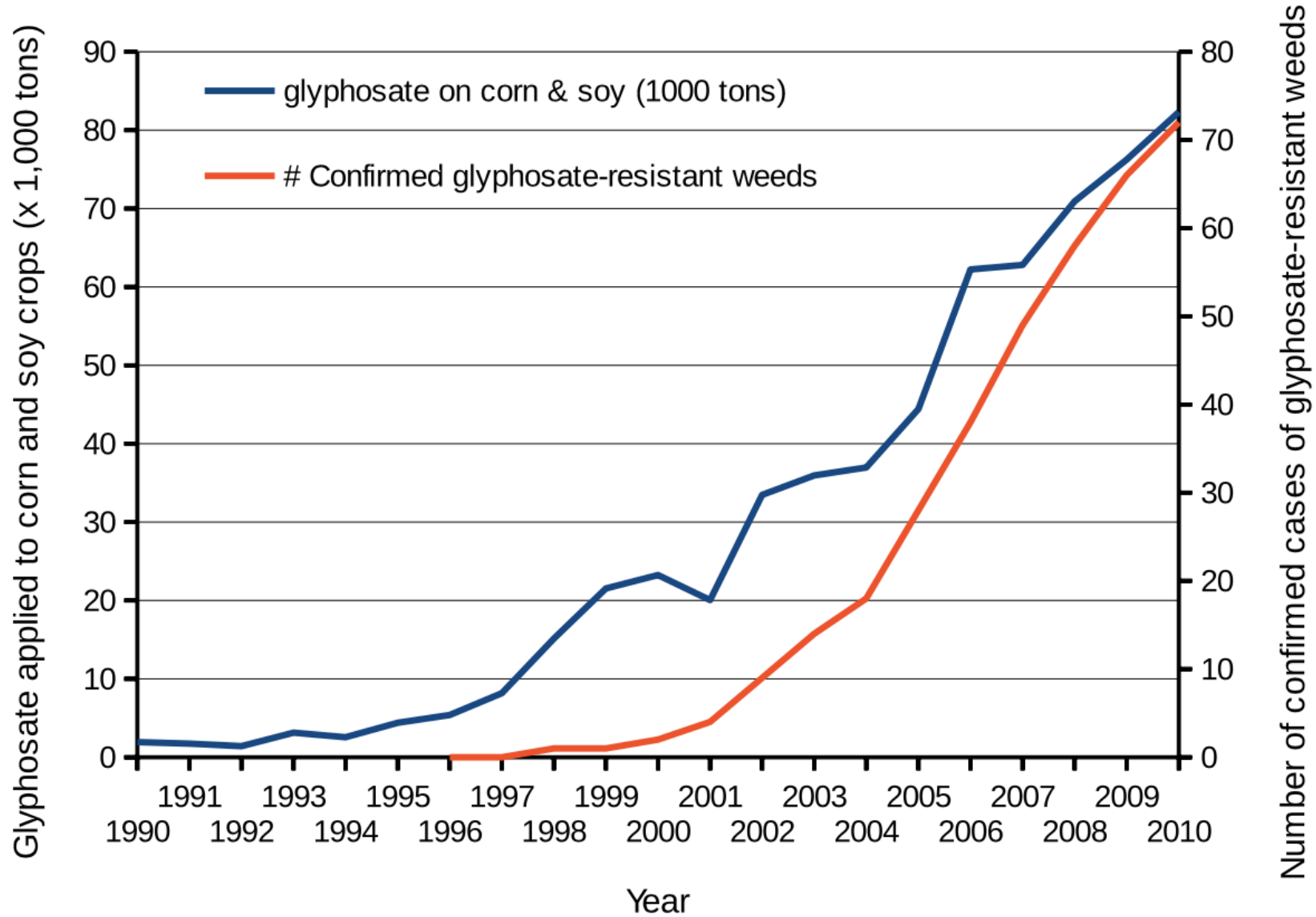
*R. Mesnage et al., Biomed Research International, 2014; 2014: 179691

Main Toxic Effects of Glyphosate*

- Kills beneficial gut bacteria and allows pathogens to overgrow
- Interferes with function of cytochrome P450 (CYP) enzymes in the liver
 - These enzymes serve many important roles, including making bile acids, activating vitamin D, detoxifying many toxic chemicals and breaking down prescription drugs
- Chelates (binds tightly to) important minerals like cobalt, manganese and zinc, making them unavailable to the cells
- Interferes with the synthesis of aromatic amino acids and methionine
- Disrupts sulfate synthesis and sulfate transport

Samsel and Seneff, Entropy* **2013, 15, 1416-1463

Glyphosate applications & Superweeds



Glyphosate usage increased dramatically over time, likely because of the emergence of glyphosate-resistant weeds

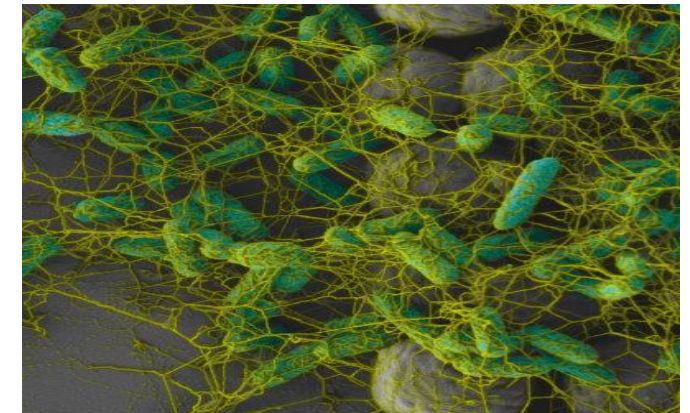
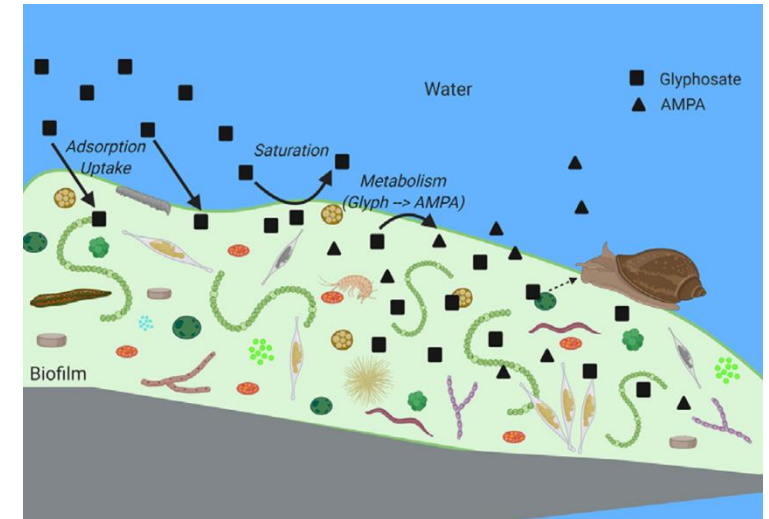
Figure 1: Glyphosate applications to corn, soy and cotton along with the advent of glyphosate-resistant weeds.

*Judy Hoy et al., Poultry, Fisheries & Wildlife Sciences 2015; 3(1): 1000132.

Glyphosate Accumulates in Biofilms*

- Glyphosate polluting waterways is rapidly adsorbed into biofilms
- Concentrations of glyphosate in biofilms were *two to four orders of magnitude higher* than those in the surrounding water
- Glyphosate appears to rapidly disappear from waterways but this is an illusion
- Juvenile fish and amphibians dwell in the biofilms

“We may be underrecognizing the potential ecological risk of contaminants, like glyphosate, that are bioconcentrating in biofilms and subsequently being consumed.”



*Laura Beecraft et al. Science of the Total Environment 756 (2021) 143993.

“Glyphosate remains in forest plant tissues for a decade or more” *

“We found that residues persisted for up to 12 years in some tissue types, and that root tissues generally retained glyphosate residues longer than shoot tissue types. We also found that samples from the colder, more northern biogeoclimatic zone investigated retained significantly higher levels of glyphosate for longer than samples collected from the warmer biogeoclimatic zone.”



*N Botten et al. Forest Ecology and Management 493 (2021) 119259.

“Glyphosate: Plasma and Bone Marrow Levels Following Intraperitoneal Injection”*

- Significant amounts of radiolabeled glyphosate were found in plasma and bone marrow following intraperitoneal injection in rats
- Glyphosate in bone marrow reached 340 ppm after 1/2 hour, and it remained at about that level throughout the duration of the study (10 hours)



*WP Ridley et al. Monsanto commissioned study ML-83-218; EHL No. 830109. 1983.

Glyphosate and Cancer*

- In April 2015, the World Health Organization's International Agency for Research on Cancer (IARC) identified glyphosate as a probable human carcinogen
- Three trials involving cases where glyphosate was claimed to cause non-Hodgkin's lymphoma resulted in a successful lawsuit
 - The plaintiffs were awarded \$25-80 million in each case
- In June, Bayer agreed to pay up to \$10.9 billion to roughly 125,000 people in thousands of lawsuits arguing Roundup was responsible for their non-Hodgkin lymphomas

*<https://sustainablepulse.com/2020/12/24/environmental-and-farming-groups-start-us-legal-action-in-attempt-to-ban-glyphosate/>

Animal and Human Diseases

Seminal Séralini Study: Mammary Tumors in Rats*

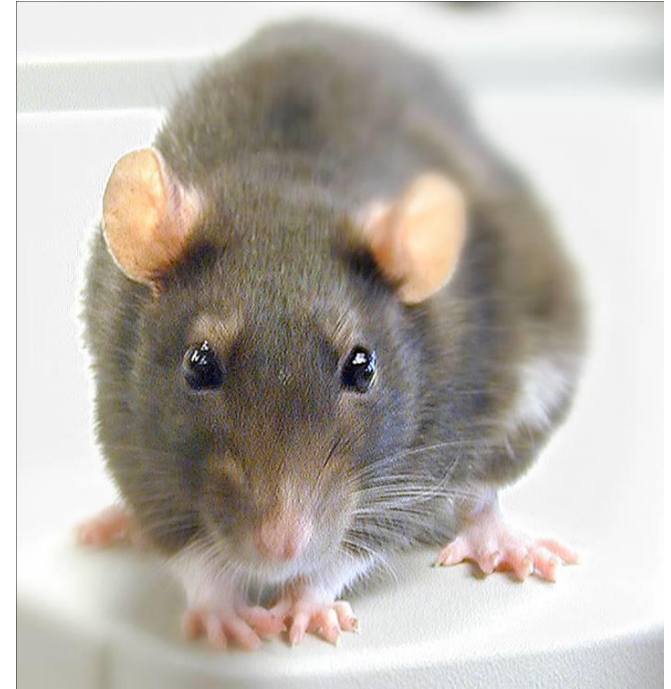
Rats exposed to Roundup over their entire lifespan at levels well below established safety limits



*GE Séralini et al. Environmental Sciences Europe 2014; 26: 14.

Conclusions from Séralini's Rat Study *

- Female rats had greatly increased risk of mammary tumors
- Males had significantly increased risk of liver and kidney disease
- Sex hormone disruption for both males and females
- Enhanced oxidative stress
- *Effects didn't become apparent until after 4 months*



*GE Séralini et al. Environmental Sciences Europe 2014; 26: 14.

Glyphosate-based formulations: Effect on honeybee behaviors*

Conclusions

“In this study, we provided new information on the influence of commercially formulated glyphosate at the recommended concentration on the behaviours of honeybees. Our findings showed that the **water responsiveness, sucrose responsiveness, learning and memory ability and climbing ability** of honeybees were affected by commercially formulated glyphosate **at or below the recommended concentration.**”



*Qi-Hua Luo et al., Scientific Reports 2021; 11(1): 2115.

Effect of Glyphosate on Water Flea Embryos*

- Water fleas are near the bottom of the aquatic food chain
- Tadpoles, salamanders, newts, aquatic insects and many types of small fish feed on water fleas
- When water fleas were exposed to concentrations of Roundup and glyphosate well below the approved regulatory threshold, they suffered from:
 - Embryonic developmental failure
 - Systemic inflammation
 - Collagen degradation
 - Impaired wound healing
 - Disrupted gut microbes
- The animals that eat the water fleas pick up glyphosate from their food
- Effects on water fleas propagate up the food chain



*Suppa et al. Microbiome (2020) 8:170.

Glyphosate Increases Malaria Spread through Mosquitoes*

- Melanin traps and kills invading pathogens
 - Melanin production rises in response to infection
 - Highly reactive molecules produced as intermediates in melanin synthesis destroy the invader.
- Glyphosate suppressed several enzymes involved in the synthesis of melanin
- Mosquitoes exposed to glyphosate were less able to control Plasmodium infections → better vectors for infection (malaria)



*Daniel FQ Smith et al. Plos Biology 2021 19(5): e3001182.

Ib Pedersen: Pig Farmer in Europe*

- Glyphosate was found in the lungs, liver, kidney, brain, gut wall and heart of 38 malformed euthanized one-day-old Danish piglets
- Highest concentrations were in the lungs and heart

“The summary of my findings is, without a doubt, that Roundup sprayed on crops is the direct reason for the increase in fertility problems, abortions and deformities in animals and as a farmer, knowing how nature works, I quite expect that people are already affected.”

“Glyphosate is everywhere.”

-- Ib Pedersen



* M Kruger et al. Detection of Glyphosate in Malformed Piglets J Environ Anal Toxicol 2014, 4:5



Research Article

Open Access

The High Cost of Pesticides: Human and Animal Diseases

Judy Hoy¹, Nancy Swanson² and Stephanie Seneff^{3*}

- The first author, Judy Hoy, runs a wildlife rehabilitation center in the Bitterroot Valley in Western Montana
- She has been tracking the dwindling numbers and decreasing health status of wildlife there for decades
- Dr. Nancy Swanson and I collaborated with her to compare health issues of the animals with those of humans in the United States

Changing Faces

The Consequences of Exposure to
Gene and Thyroid Disrupting Toxins



Judy Hoy

Scientist, Biologist, Naturalist and Wildlife Rehabilitator

Newborn white-tailed deer have severely damaged thymuses*



*Judy Hoy et al., Poultry, Fisheries & Wildlife Sciences 2015; 3(1): 1000132.

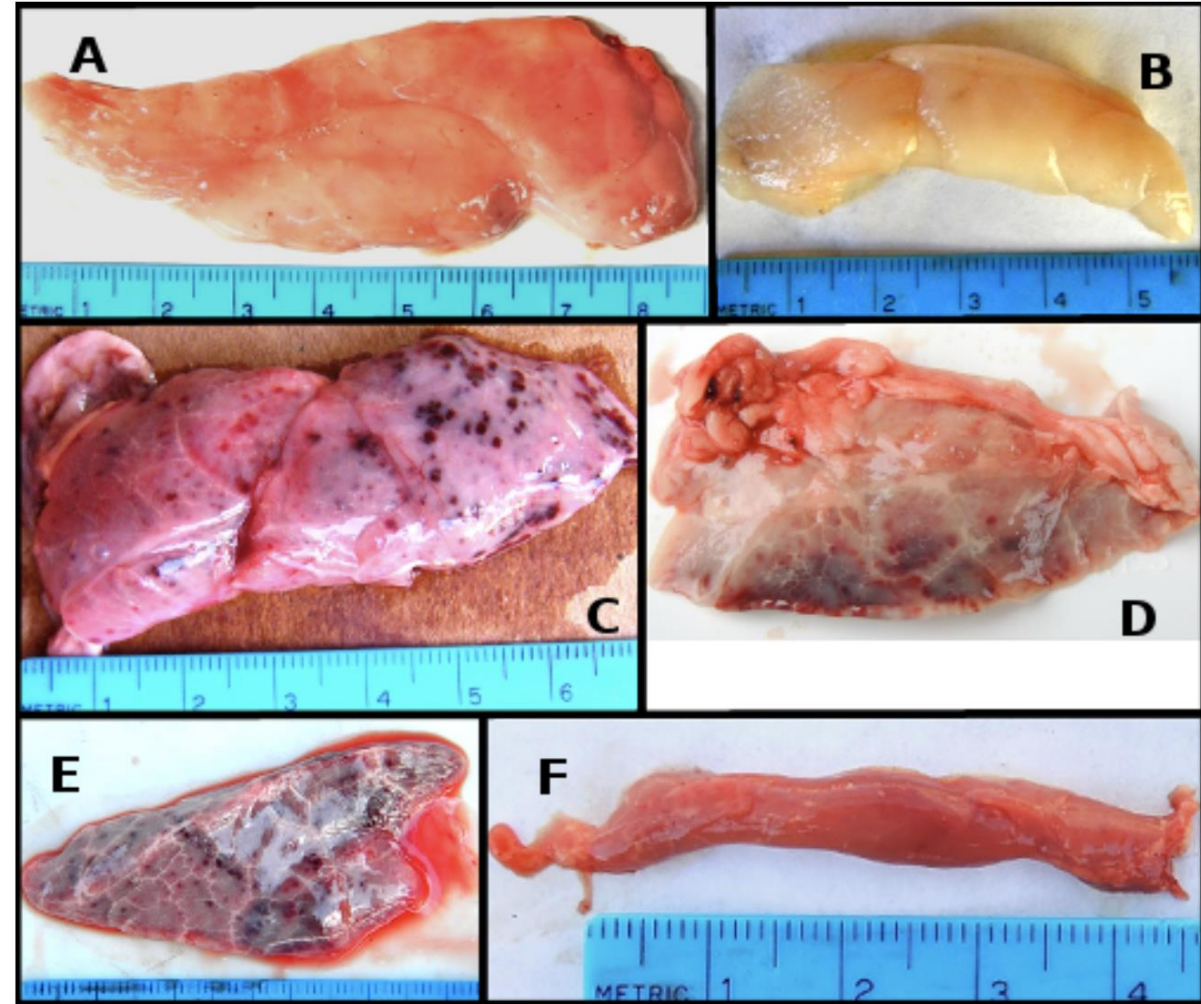


Figure 14: Newborn white-tailed deer thymus conditions. A and B. Normal thymus color and shape. C and D. Thymus with red spots throughout. E. Odd shaped, mostly red thymus. F. Undersized thymus, red throughout.

Some Correlations between Human Diseases and Glyphosate*

- Compared US government data on glyphosate usage and on human disease patterns over time from the 1998-2010 hospital discharge data
- Found striking correlations between the rise in glyphosate usage and the rise in multiple health issues in newborn babies:



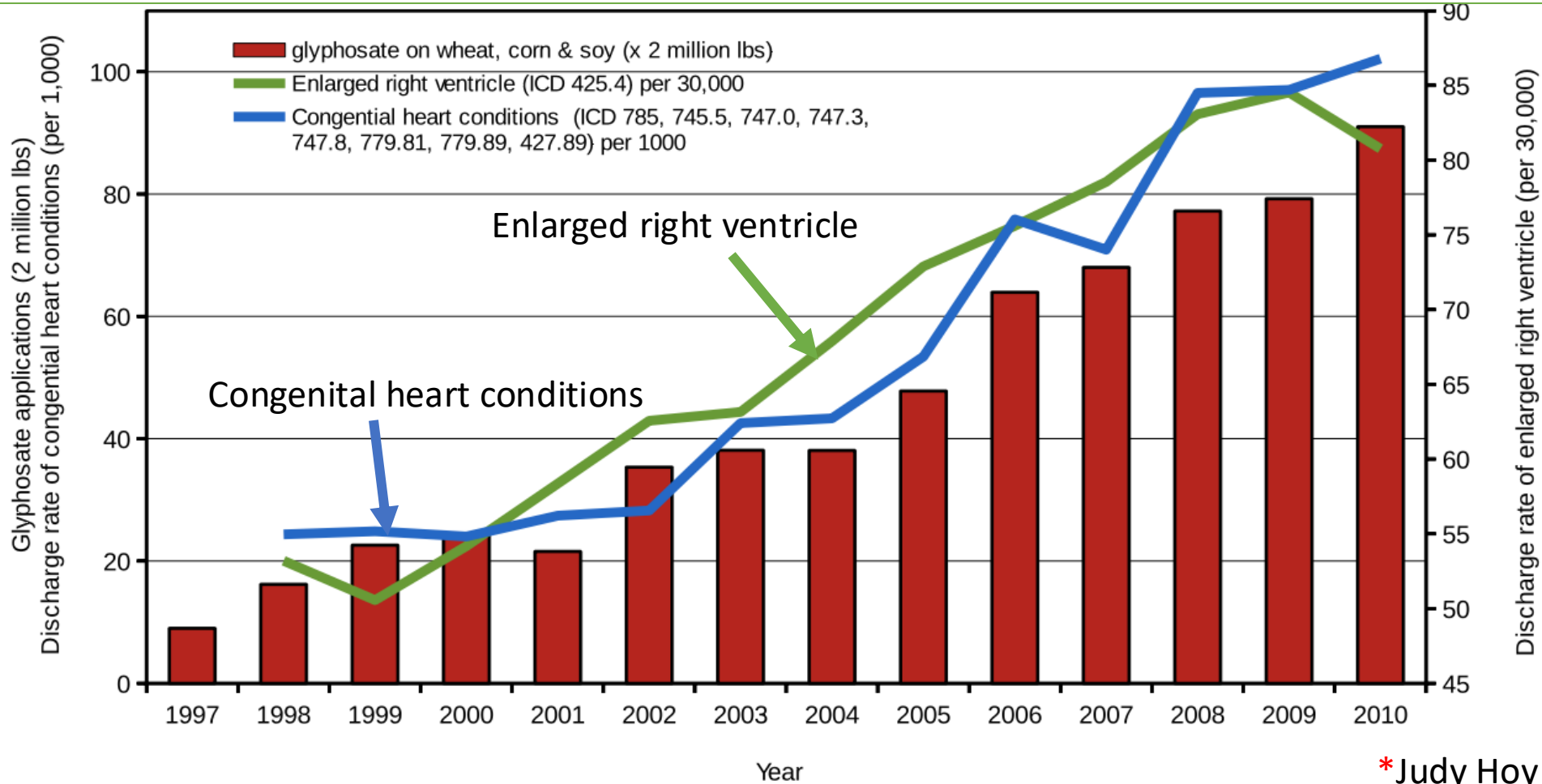
- | | |
|-------------------------------|--------|
| • head and face anomalies | R=0.95 |
| • blood disorders | R=0.92 |
| • skin disorders | R=0.96 |
| • metabolic disorders | R=0.95 |
| • genitourinary disorders | R=0.96 |
| • congenital heart conditions | R=0.98 |
| • lung problems | R=0.95 |

R is the correlation coefficient characterizing how similar the two curves are. 1.0 is the highest value it can take, representing a perfect match.

*Judy Hoy et al., Poultry, Fisheries & Wildlife Sciences 2015; 3(1): 1000132.

Congenital heart conditions (newborns) $p < 0.000009$
 enlarged right ventricle (adults) $p < 0.00003^*$

and



* Judy Hoy et al., Poultry, Fisheries & Wildlife Sciences 2015; 3(1): 1000132.

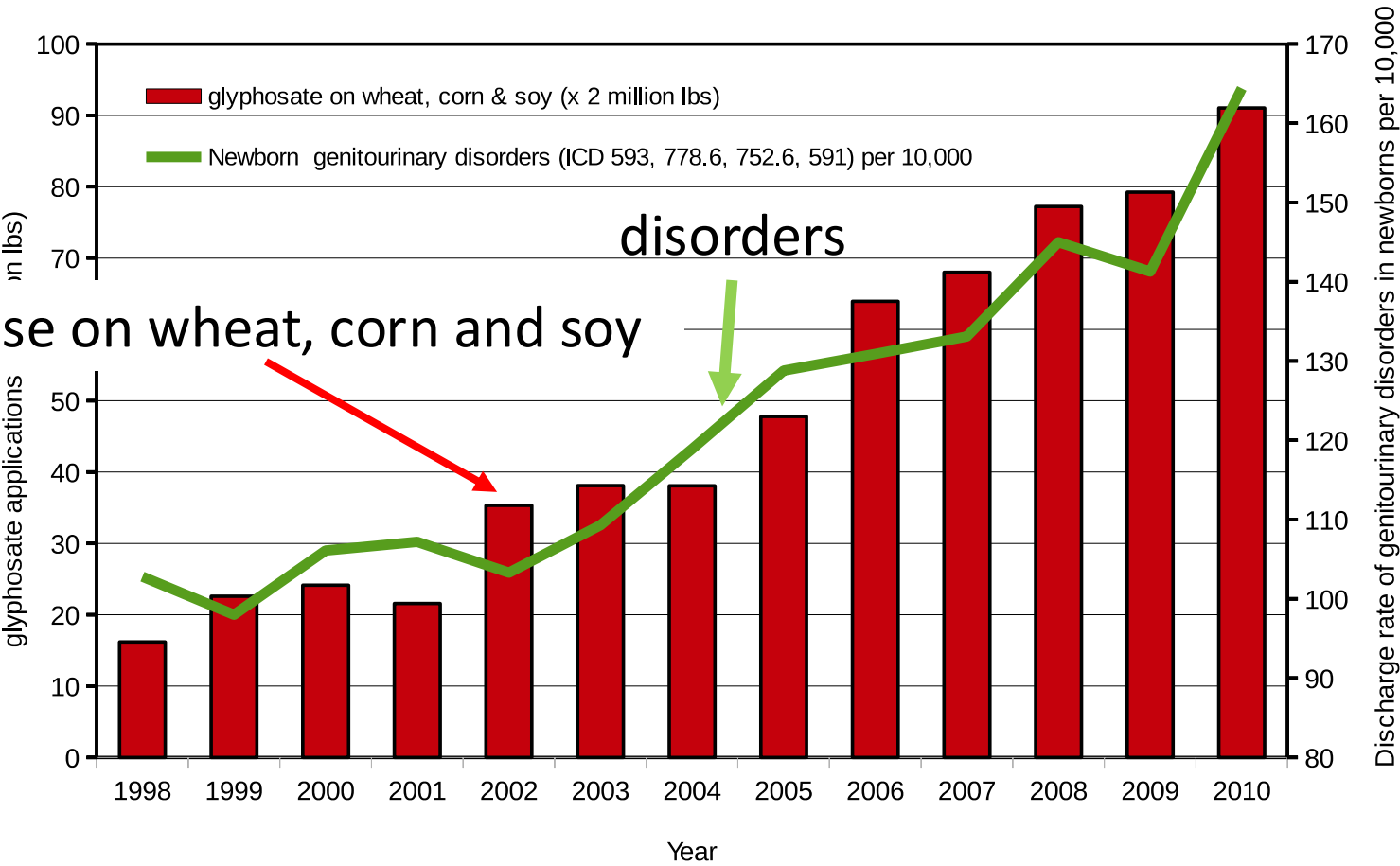
Glyphosate-Based Herbicides Potently Affect Cardiovascular System in Mammals: Review of the Literature

**Steeve Gress · Sandrine Lemoine · Gilles-Eric Séralini ·
Paolo Emilio Puddu**

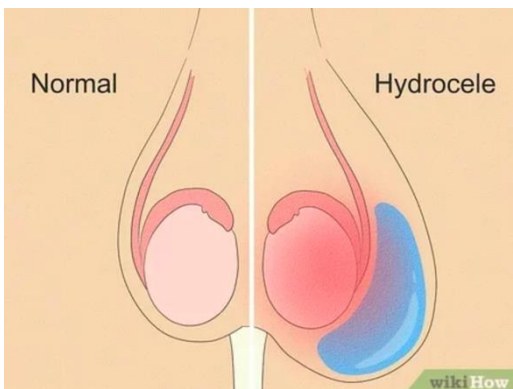
- Long-QT syndrome, atrioventricular block, arrhythmias in both humans and animals
- “In fatalities, the common symptoms were cardiorespiratory arrest, cardiovascular shock, hemodynamic disturbances, intravascular disseminated coagulation and multiple-organ failure”

Newborn Genitourinary Disorders (Hypospadias, Hydrocele, etc.) $p < 0.000024$

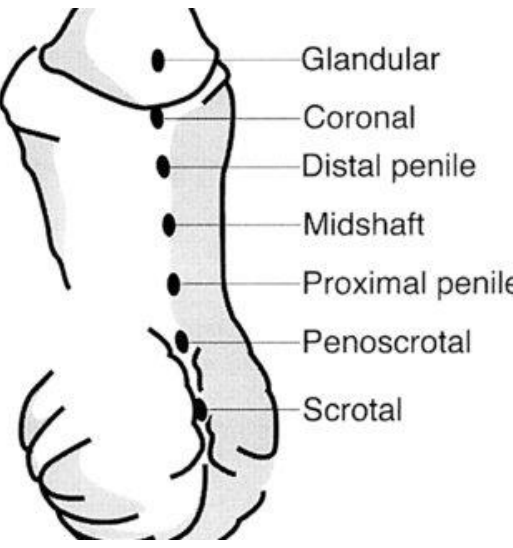
Glyphosate use on wheat, corn and soy



Swollen testicle



Urethra opening below the tip



Hypospadias

*Hoy et al., Poultry Fish and Wildlife Science 2015, 3:1

Is Glyphosate Causing an Epidemic in Fatty Liver Disease?

- Worldwide epidemic in fatty liver disease today*
- “Multiomics reveal non-alcoholic fatty liver disease in rats following chronic exposure to an ultra-low dose of Roundup herbicide”**
- Glyphosate correlated with fatty liver disease in humans***



Non-Alcoholic Fatty Liver Disease (NAFLD)



* Chris Estes et al. Hepatology 2018; 67(1): 123-133.

** Robin Mesnage et al. Sci Rep 2017; 7: 39328.

*** PJ Mills et al. Clinical Gastroenterology and Hepatology 2020;18(3):741-743.

Kidney Failure in Agricultural Workers*

- Agricultural workers in sugar cane fields in Central America and Sri Lanka are dying at a young age in record numbers from kidney failure
 - Second-most common cause of death in young men in El Salvador
- Attributed to toxic metals (arsenic, cadmium) + nitrates in well water + glyphosate**
 - Glyphosate chelates arsenic and then unloads it in the acidic environment of the renal tubules
- Glyphosate is synergistically toxic with paraquat to destroy the kidneys of agricultural workers in Sri Lanka***

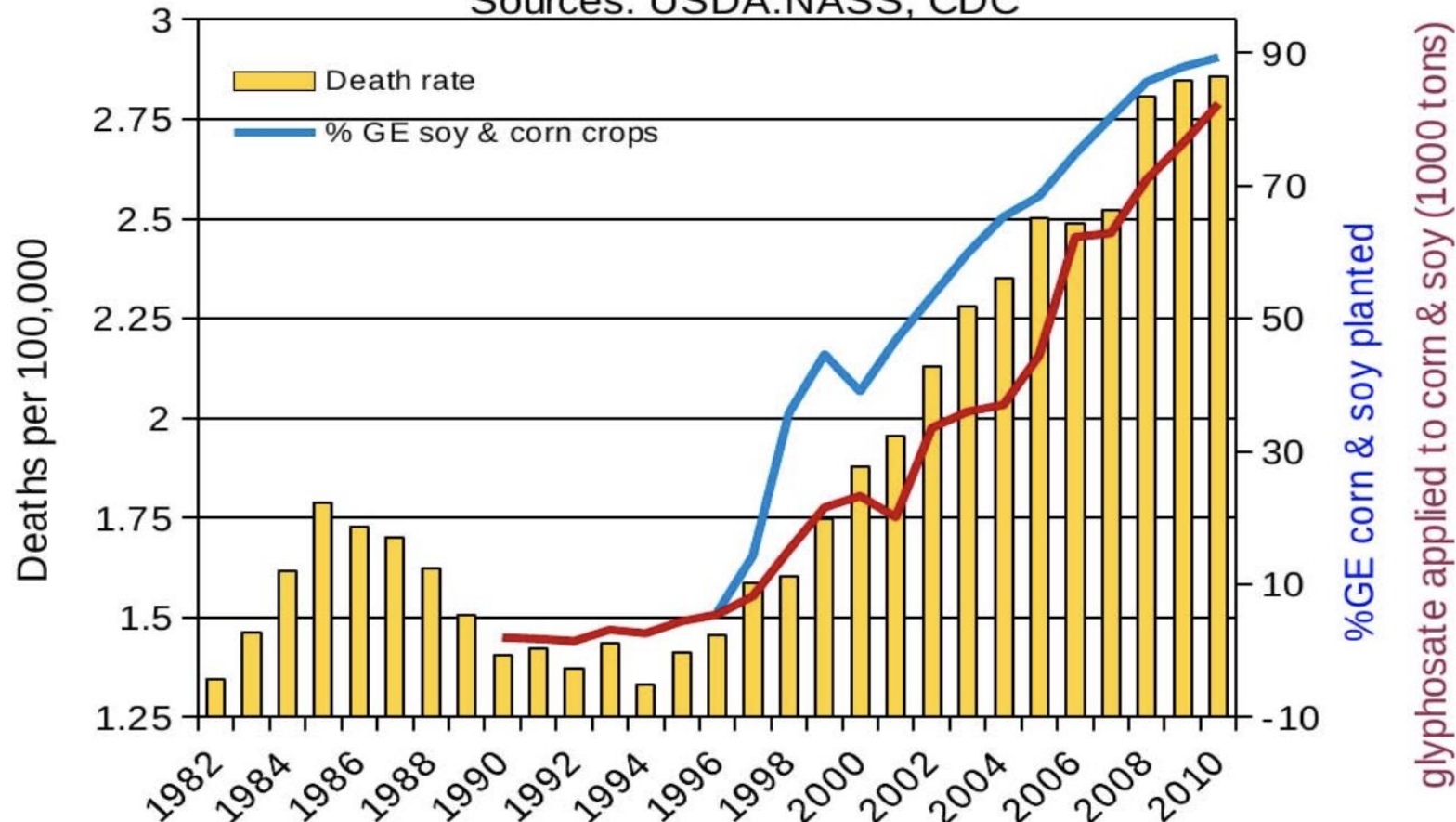
* CM Orantes-Navarro et al., Adv Chronic Kidney Dis 2017;24(2):101-106.

** C Jayasumana et al. Int. J. Environ. Res. Public Health 2014, 11, 2125-2147.

*** Sarath Gunatilake et al., Int J Environ Res Public Health 2019; 16(15): 2734.

U.S. Acute Kidney Disease Death Rate Plotted against Glyphosate and GMOs*

Age Adjusted Acute Renal Failure Death (ICD N17& 584)
plotted against %GE corn and soy planted ($R = 0.9674$, $p \leq 2.736e-06$)
and glyphosate applied to corn and soy ($R = 0.9775$, $p \leq 5.953e-09$)
Sources: USDA:NASS; CDC

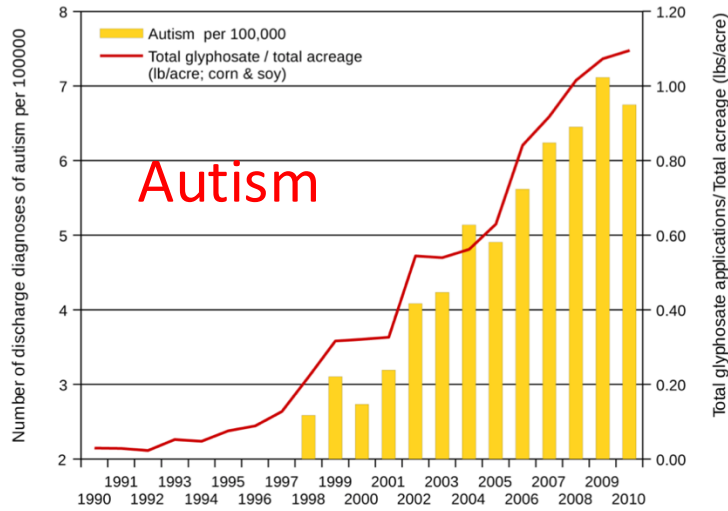


*Figure 19, NL Swanson et al. Journal of Organic Systems 9(2), 2014, p. 25.

Correlations between Glyphosate and Neurological Diseases*

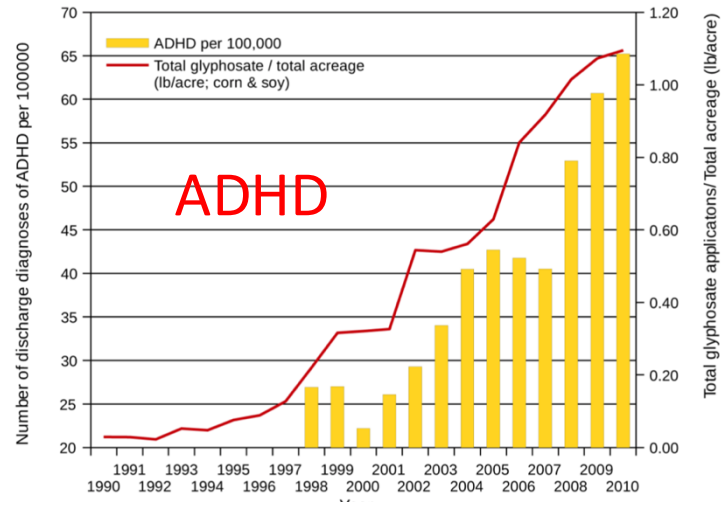
Hospital Discharge Diagnoses of Autism (ICD 299.0) & Glyphosate applied to corn & soy crops

R = 0.9824, p <= 9.569e-06
Sources: CDC; USDA



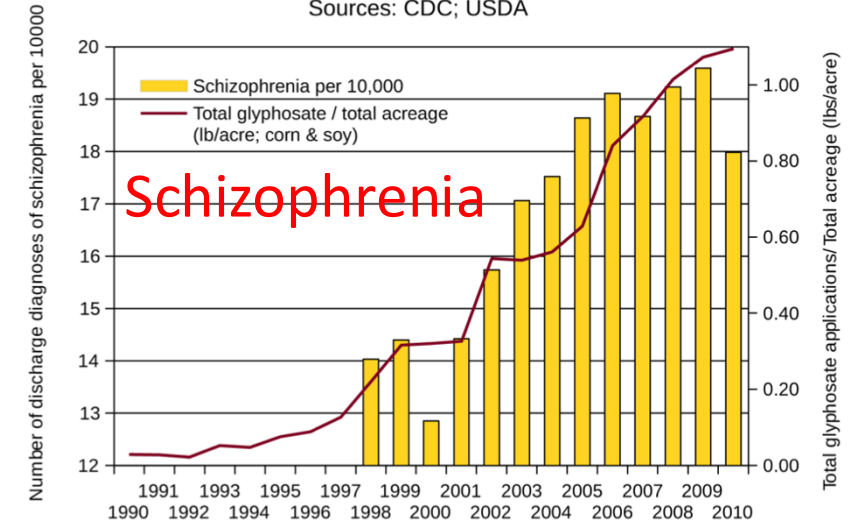
Hospital Discharge Diagnoses of ADHD (ICD 314.00-01) & Glyphosate applied to corn & soy crops

R = 0.9466, p <= 3.632e-05
Sources: CDC; USDA



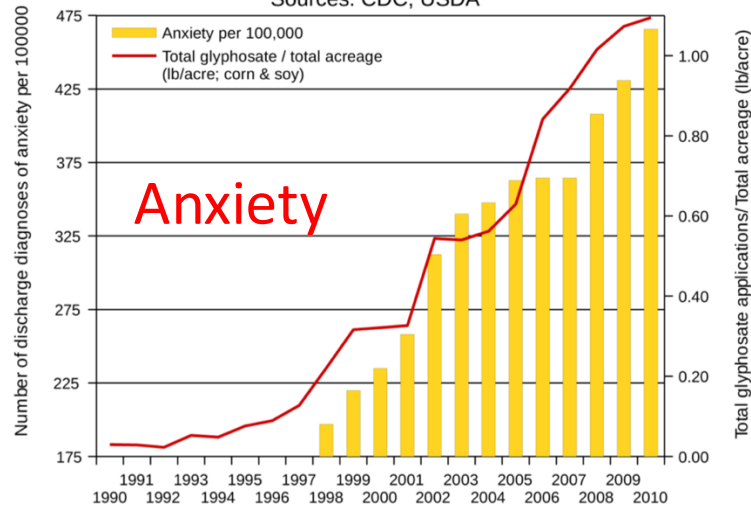
Hospital Discharge Diagnoses of Schizophrenia (ICD 295) & Glyphosate applied to corn & soy crops

R = 0.883, p <= 0.00025
Sources: CDC; USDA



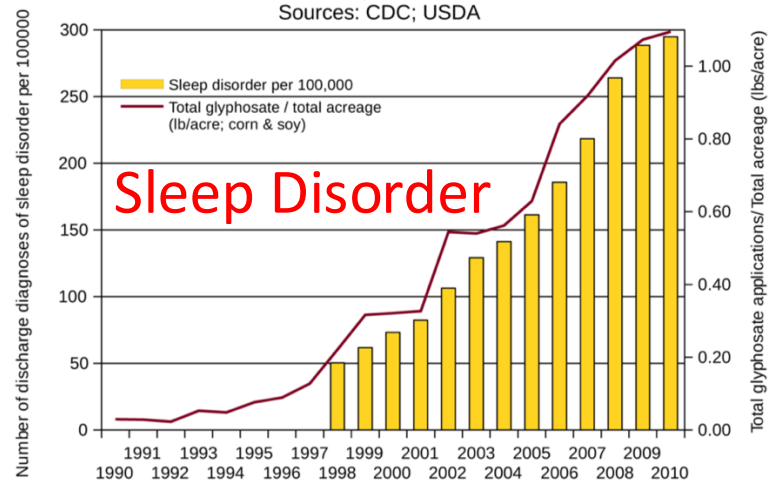
Hospital Discharge Diagnoses of Anxiety (ICD 300) & Glyphosate applied to corn & soy crops

R = 0.95, p <= 3.231e-05
Sources: CDC; USDA



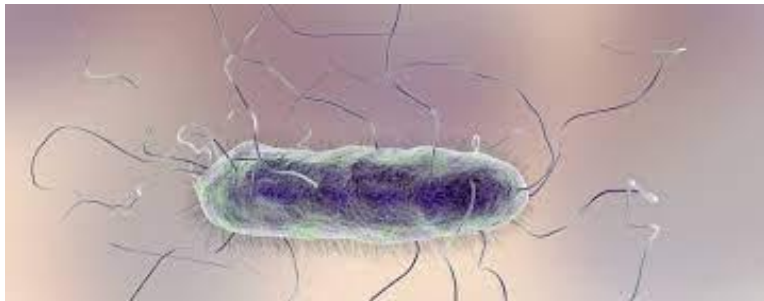
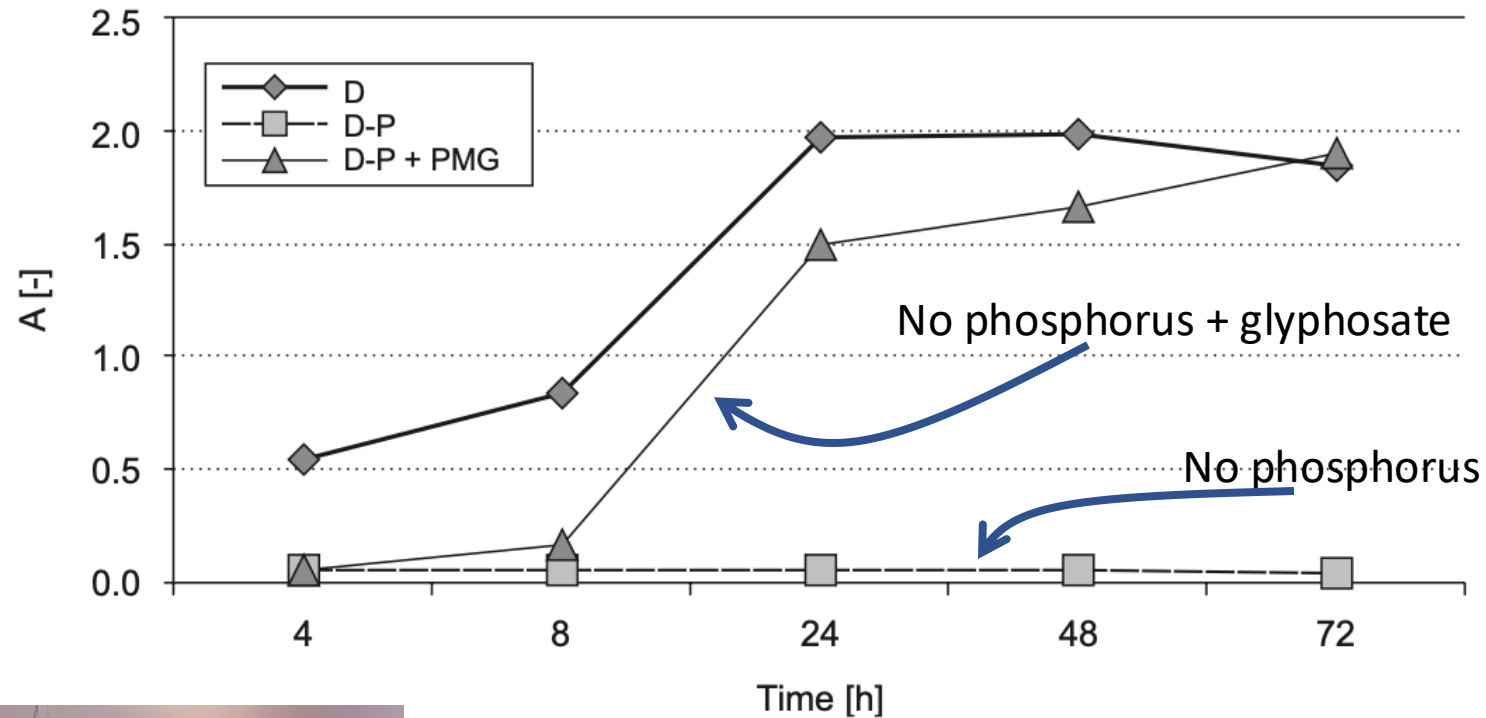
Hospital Discharge Diagnoses of Sleep Disorders (ICD 327, 780.50-59, 307.41-49) & Glyphosate applied to corn & soy crops

R = 0.9876, p <= 7.744e-06
Sources: CDC; USDA



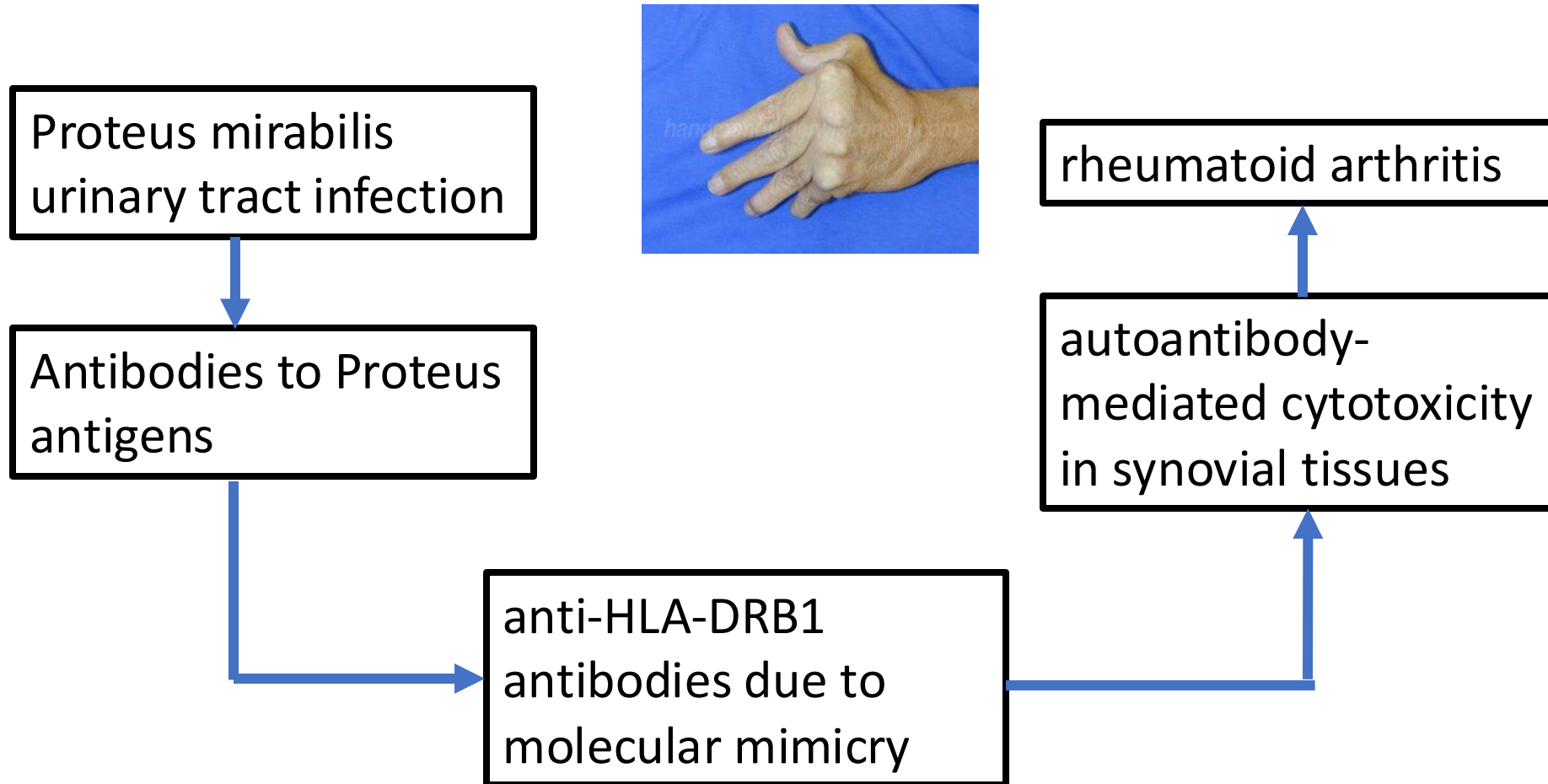
*S Seneff et al. Agricultural Sciences 2015; 6: 42-70.

Proteus mirabilis can fully metabolize glyphosate and use its phosphorus atom as a source of phosphorus*



*Z. Wybranych et al. Ecol Chem Eng A. 2015; 22(2): 185-193.

”Rheumatoid arthritis is an autoimmune disease triggered by Proteus urinary tract infection”*



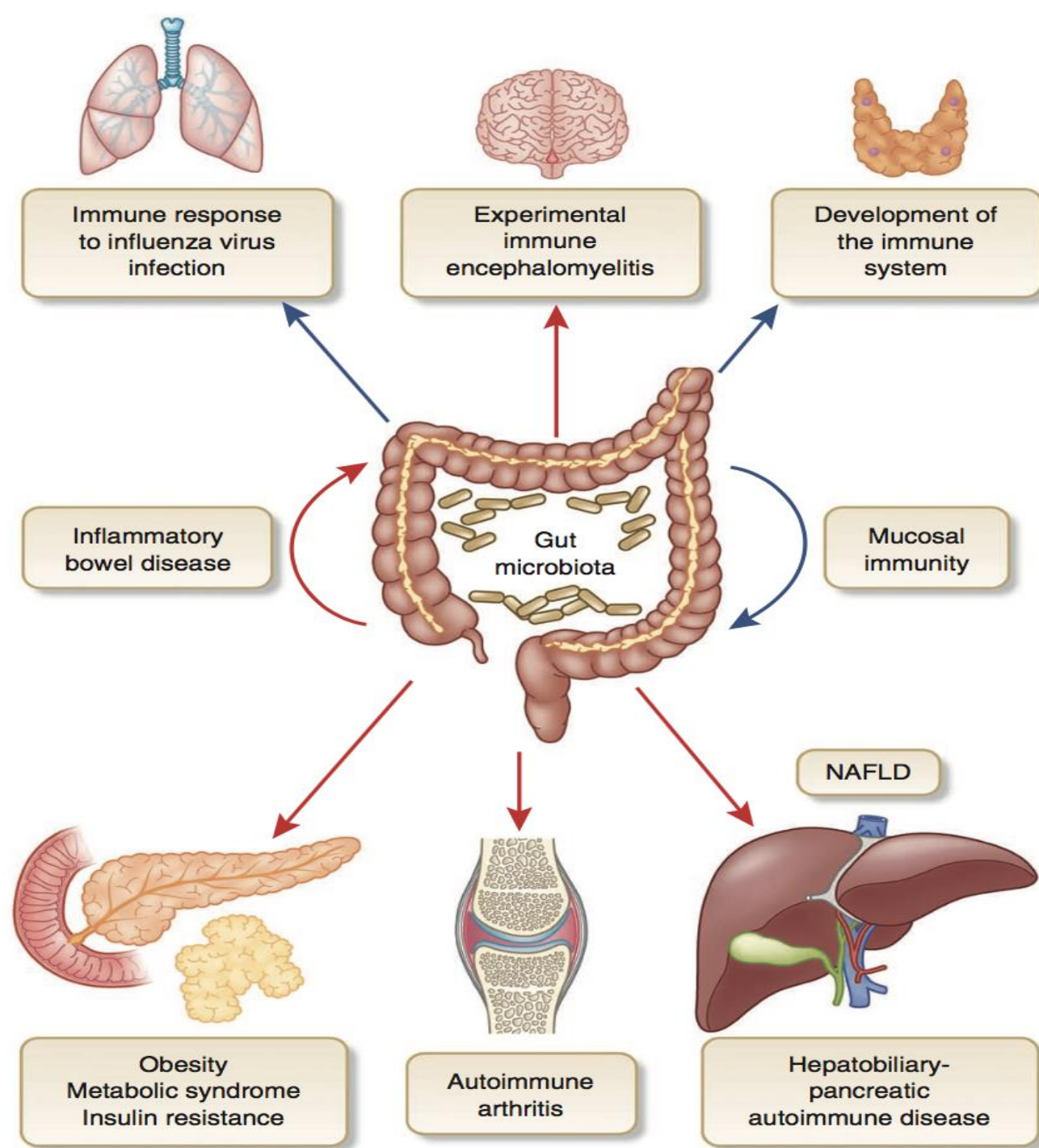
*A. Ebringer and T Rashid. Clinical & Developmental Immunology 2006; 13(1): 41-48.

Glyphosate and the Gut

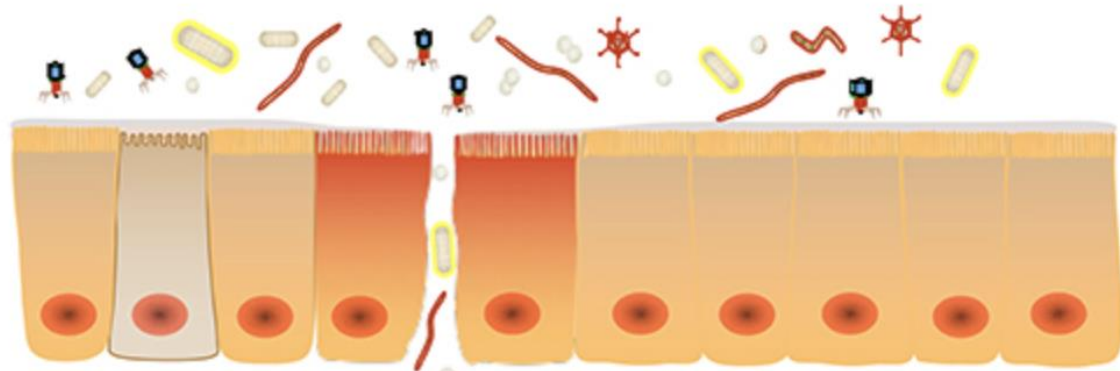
Imbalanced Gut Microbiome

Inflammatory bowel disease, autoimmune arthritis, obesity and metabolic syndrome, and nonalcoholic fatty liver disease can all be traced to imbalances in gut microbiome*

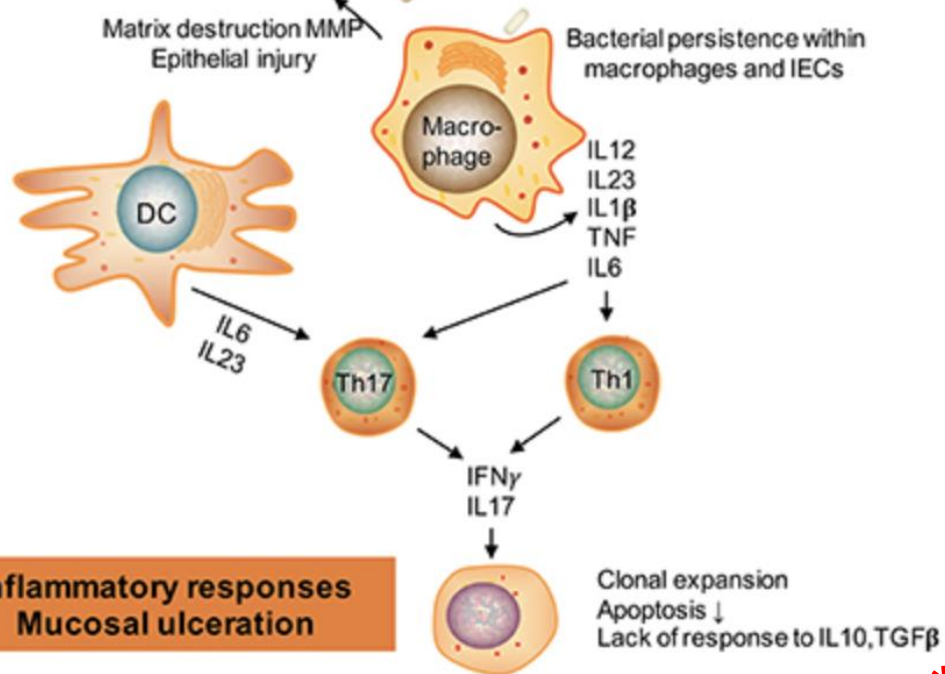
*Figure 1. RS Goldszmid and G Trinchieri. Nat Immunol 2012;13(10):932-8.



Glyphosate and the Gut: Pathogen Overgrowth*



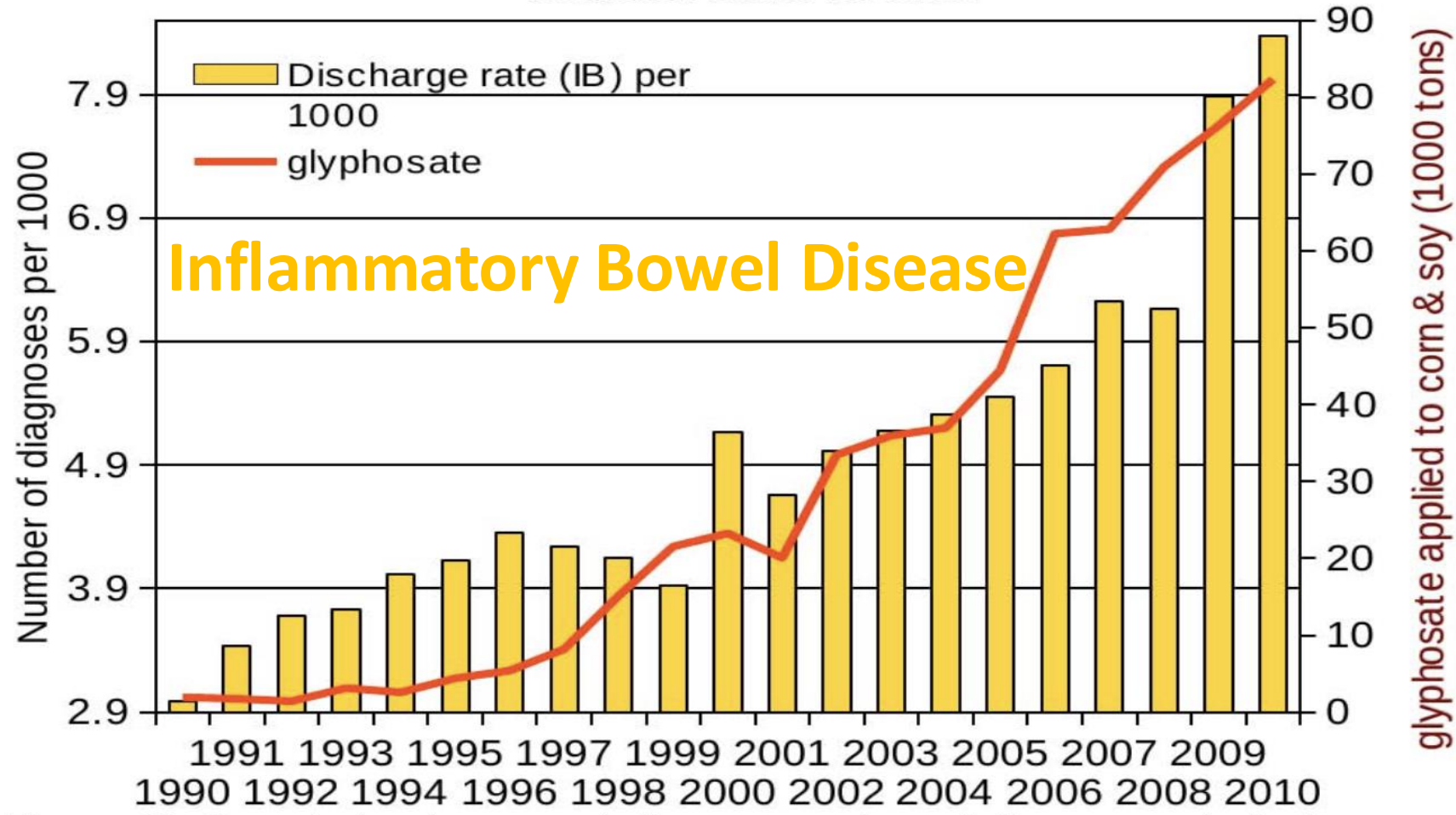
- Glyphosate is an antimicrobial agent that preferentially kills beneficial microbes, allowing pathogens to flourish in the gut
- Pathogens cross a leaky gut barrier
- Immune cells infiltrate the gut tissue and release inflammatory cytokines
 - This causes increased risk to inflammatory bowel diseases such as Crohn's, ulcerative colitis as well as Celiac disease (gluten intolerance)



* Samsel and Seneff. Entropy 2013; 15: 1416-1463.

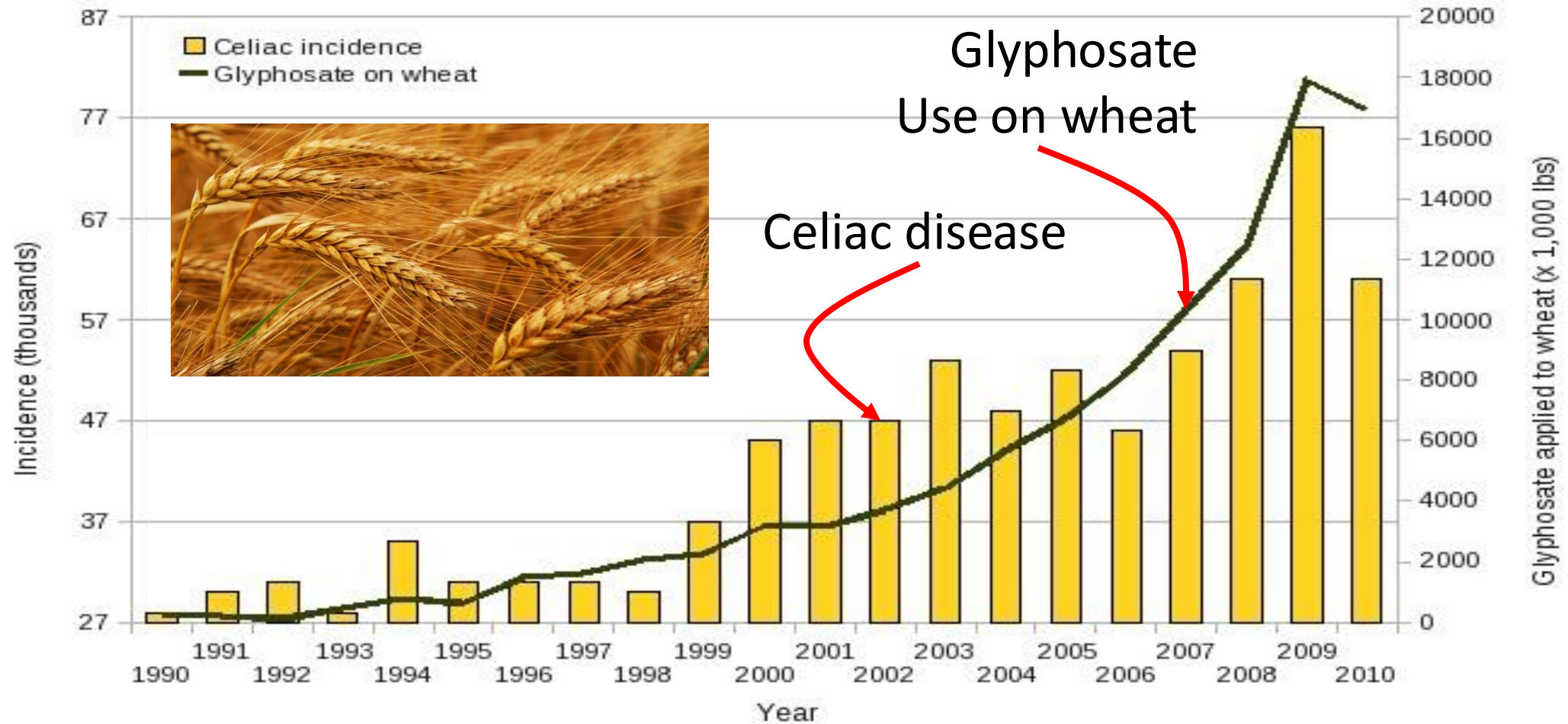
Hospital discharge diagnoses (any) of Inflammatory Bowel disease (Crohn's and Ulcerative Colitis ICD 555 & 556)

plotted against glyphosate applied to corn & soy ($R = 0.9378$, $p \leq 7.068e-08$)
Sources: USDA & CDC



*Figure 20, NL Swanson et al. Journal of Organic Systems 9(2), 2014, p. 25.

Glyphosate and Celiac Disease*



*Samsel and Seneff, *Interdisciplinary Toxicology* 2013;6(4): 159–184.

Impaired Digestive Enzymes

- Glyphosate has been found as a contaminant in digestive enzymes trypsin, pepsin and lipase*
- Trypsin impairment prevents proteins like gluten in wheat from being digested
- Undigested proteins induce release of zonulin which opens up gut barrier**
- Undigested proteins in the general circulation induce autoimmune disease



* A Samsel and S Seneff. J Biol Phys Chem 2017;17:8-32

** JJ Gildea et al. J Clin Nutr Diet. 2017, 3:1.

Celiac Disease, Glyphosate and Non-Hodgkin's Lymphoma

- Glyphosate preferentially kills *Bifidobacteria**
- *Bifidobacteria* are depleted in Celiac disease**
- Celiac disease is associated with increased risk to non-Hodgkin's lymphoma***
- Glyphosate itself is also linked directly to non- Hodgkin's lymphoma****

*A.A. Shehata et al., Curr Microbiol. 2013 Apr;66(4):350-8.

** M. Velasquez-Manoff, NY Times Sunday Review, Feb. 23, 2013.

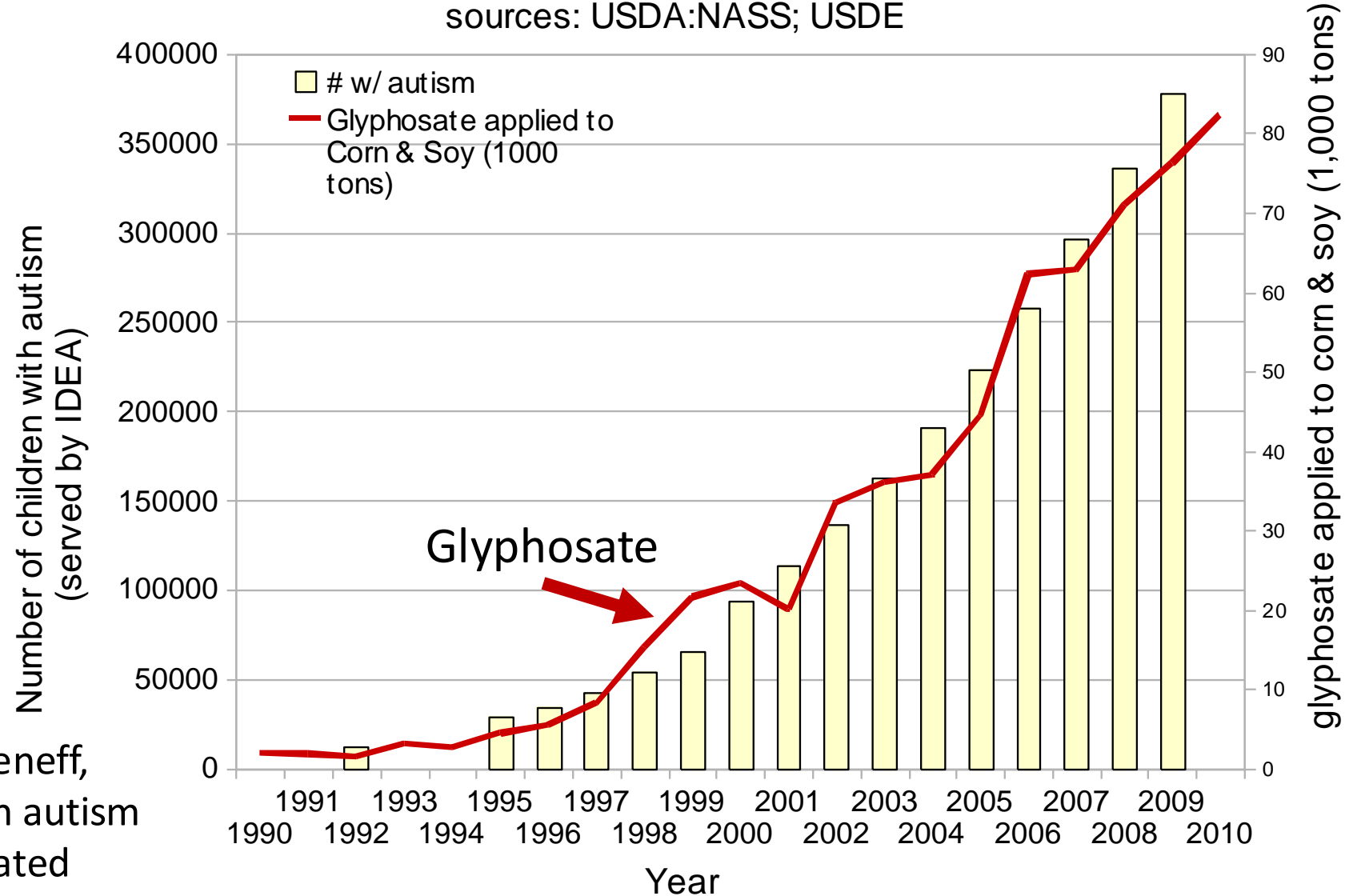
*** C. Catassi et al., JAMA. 2002 Mar 20;287(11):1413-9.

**** M. Eriksson et al., Int J Cancer. 2008 Oct 1;123(7):1657-63.

Glyphosate and Autism

Glyphosate and Autism*

Number of children (6-21yrs) with autism served by IDEA
plotted against glyphosate use on corn & soy ($R = 0.9869$, $p \leq 1.103e-06$)
sources: USDA:NASS; USDE



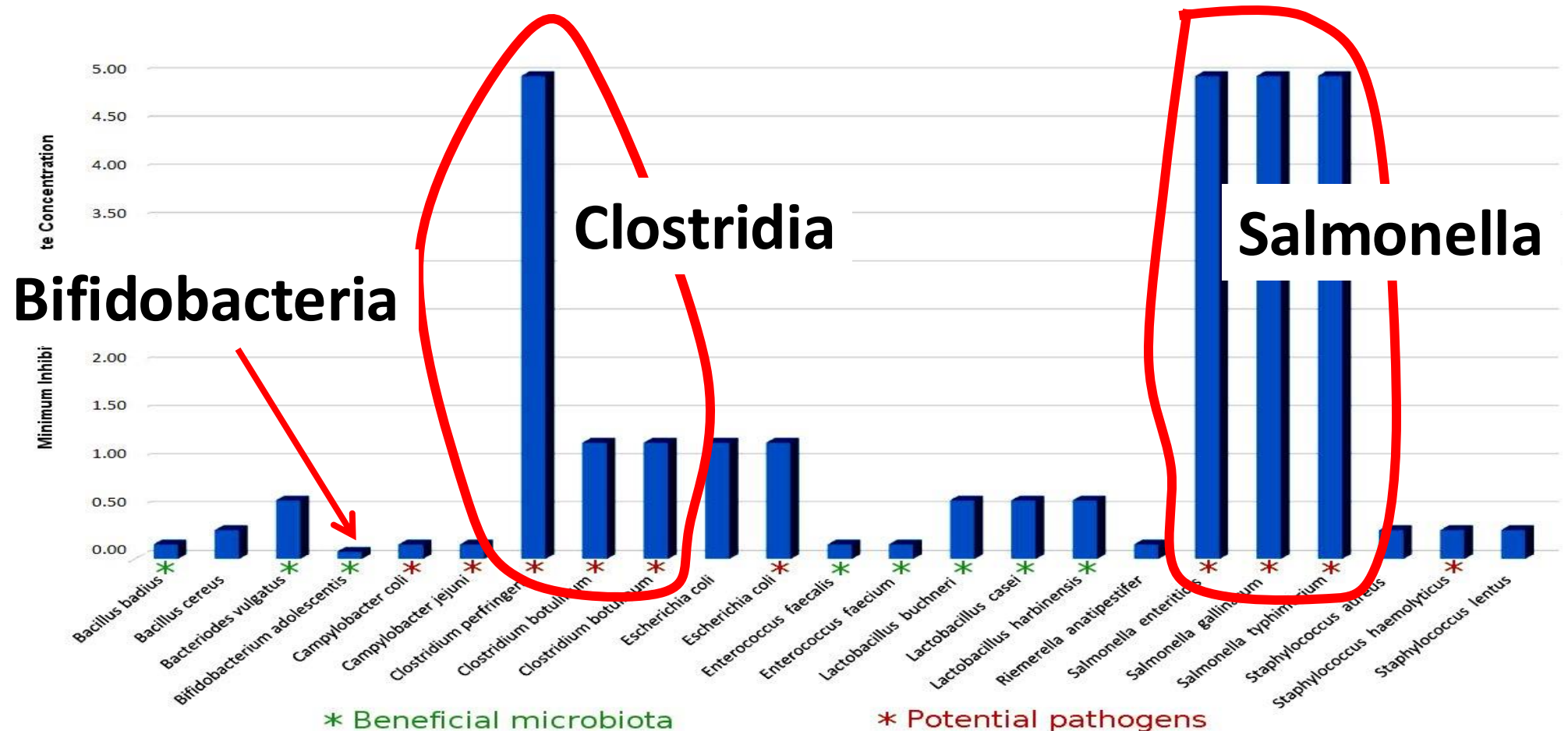
*J.E. Beecham and S. Seneff, "Is there a link between autism and glyphosate-formulated herbicides?" J Autism 2016; 3: 1.

Nancy Swanson, <http://www.examiner.com/article/>

data-show-correlations-between-increase-neurological-diseases-and-gmos

Pathogen Overgrowth in Poultry Microbes Exposed to Glyphosate*

Shehata AA, Schrödl W, Aldin AA, Hafez HM, Krüger M. The effect of glyphosate on potential pathogens and beneficial members of poultry microbiota in vitro. Curr Microbiol. 2013 Apr;66(4):350-8.



* Plot provided by Dr. Martin Michener

Evidence linking autism to Clostridia overgrowth*

- 14 autistic children with gut disorder compared to 21 controls
- Significant increase in *Clostridia* species in the gut in autistic children
- Associated with reduced tryptophan levels and increased expression of inflammatory markers
 - Tryptophan is a product of the shikimate pathway, which glyphosate blocks
 - Macrophages in inflamed tissue take up tryptophan, reducing bioavailability to the brain
- Proposed role for antibiotics
 - Glyphosate is a patented antimicrobial agent (2010)

*RA Luna et al., Cellular and Molecular Gastroenterology and Hepatology 2017;3(2): 218-230

Elevated Urinary Glyphosate and Clostridia Metabolites With Altered Dopamine Metabolism in Triplets With Autistic Spectrum Disorder or Suspected Seizure Disorder: A Case Study *

William Shaw, PhD

- Triplets: two boys, one girl. Both boys have autism and girl has seizure disorder
- Very high levels of glyphosate in urine in all three
- *Clostridia* overgrowth due to glyphosate disruption of gut microbes
 - Clostridia produce toxins which block the conversion of dopamine to norepinephrine.
 - Damage to neurons in the brain through oxidative stress

*W. Shaw. Integrative Medicine 2017;16(1);50-57.



Contents lists available at [ScienceDirect](#)

Neurotoxicology 2019; 75:1-8.

journal homepage: www.elsevier.com/locate/neuro

Full Length Article

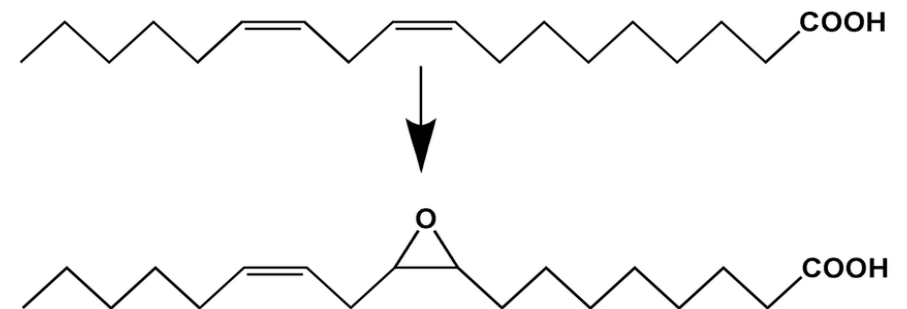
Gut microbiota and neurological effects of glyphosate

Lola Rueda-Ruzafa^a, Francisco Cruz^b, Pablo Roman^{c,d,e,*}, Diana Cardona^{c,e,f}

“In this work, we state a possible link between Gly[phosate]-induced dysbiosis and cognitive and motor aggravations in neurodegenerative and neurodevelopmental pathologies, such as autism spectrum disorder (ASD). Hence, we review the negative impact that Gly[phosate]-induced dysbiosis may have on depression/anxiety, autism, Alzheimer’s and Parkinson’s diseases.”

Autism-like Symptoms following Maternal Glyphosate Exposure*

- Exposure to herbicides during pregnancy might increase risk for autism in progeny
- Exposure of pregnant mice to high-dose glyphosate during pregnancy and lactation induced autism-like symptoms in juvenile offspring
 - Associated with gut microbiome imbalance and disrupted fatty acid metabolism
- Increased expression of **soluble epoxyhydrolase (sEH)** in prefrontal cortex of the brain
 - Produces pro-inflammatory fatty acid derivatives
- High sEH has been linked to depression, autism, schizophrenia and Parkinson's disease



*Yaoyu Pu et al. PNAS 2020; 117 (21): 11753-11759

How to explain this

- The story links together vitamin D, Cytochrome P450 (CYP) enzymes, aromatase, estrogen, testosterone and sEH
- Maternal vitamin D deficiency causes high testosterone in male offspring
- Aromatase deficiency causes low estrogen, high testosterone in the brain
- Estrogen suppresses synthesis of sEH [low estrogen = high sEH]
- Vitamin D activation depends on CYP enzymes
- Aromatase is a CYP enzyme
- Glyphosate suppresses CYP enzymes → low estrogen and low vitamin D

Glyphosate Suppresses Aromatase in the Placenta*

- Some agricultural workers using glyphosate have fertility problems
- Glyphosate is toxic to human placental JEG3 cells at concentrations lower than those found with agricultural use
- The additional ingredients in Roundup increase glyphosate toxicity
- Roundup disrupts aromatase activity

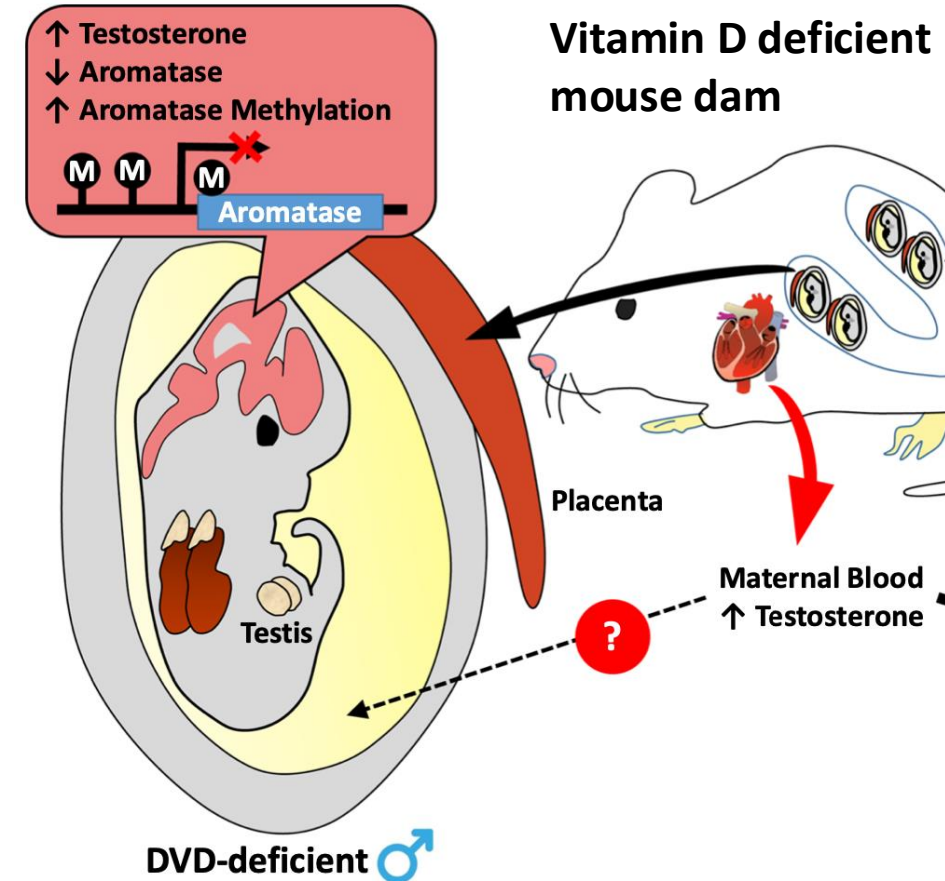
Aromatase is a cytochrome P450 (CYP) enzyme, and glyphosate has been shown to suppress CYP enzymes in the liver**

*Sophie Richard et al. Environmental Health Perspectives 2005; 113(6):716-720.

**Mohamed Ahmed Fathi et al. Environmental Science and Pollution Research 2020; 27(14): 16865-16875.

“Developmental vitamin D deficiency increases foetal exposure to testosterone”*

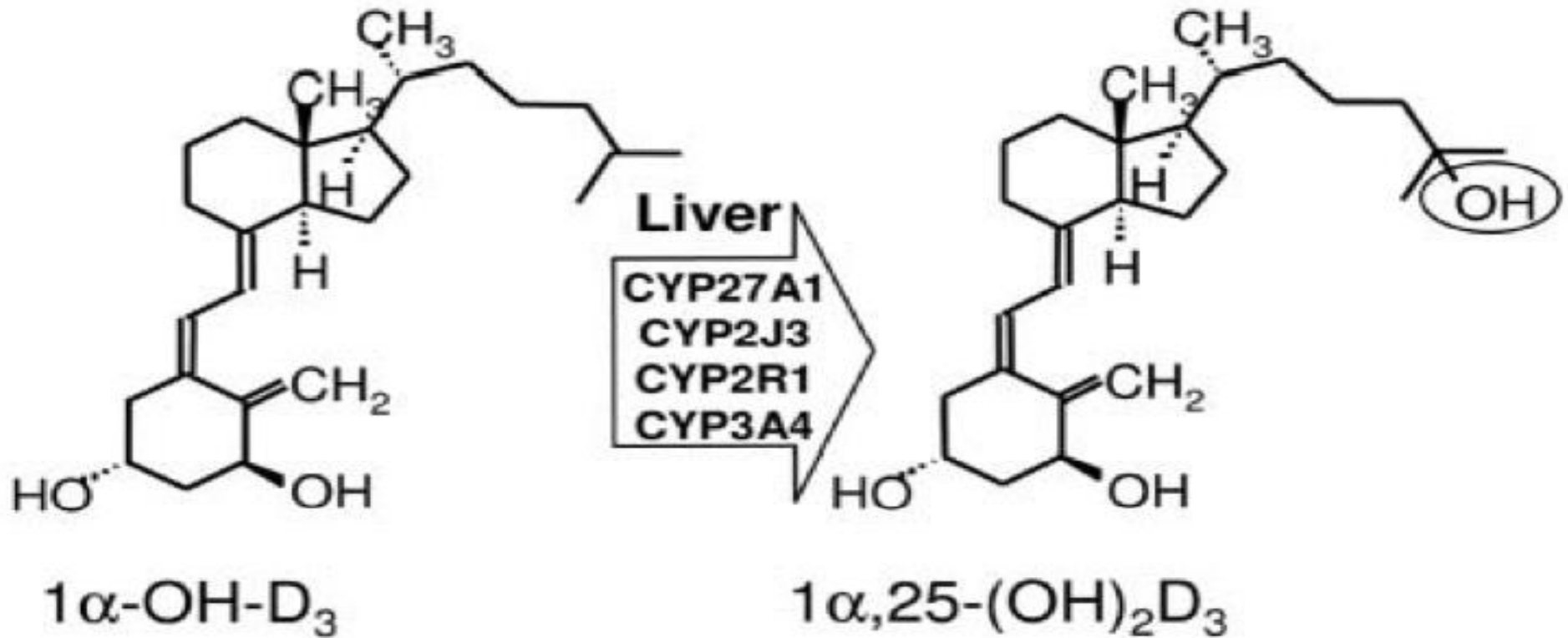
- Vitamin D regulates gene expression via methylation
- Vitamin D deficiency causes hypermethylation of the promoter for aromatase
 - This results in reduced aromatase expression in male brains
- Aromatase converts testosterone to estrogen
- Excess testosterone in male foetal brains.
→ autism



*Asad Amanat Ali et al. Molecular Autism (2020) 11:96.

CYP Enzymes Activate Vitamin D3*

This takes place in the liver, and the same enzymes detoxify a number of pharmaceutical drugs



* Figure 1 in Glenville Jones et al., Anticancer Research 26: 2589-2596 (2006)

“Glyphosate exposure induces synaptic impairment in hippocampal neurons and cognitive deficits in developing rats”*

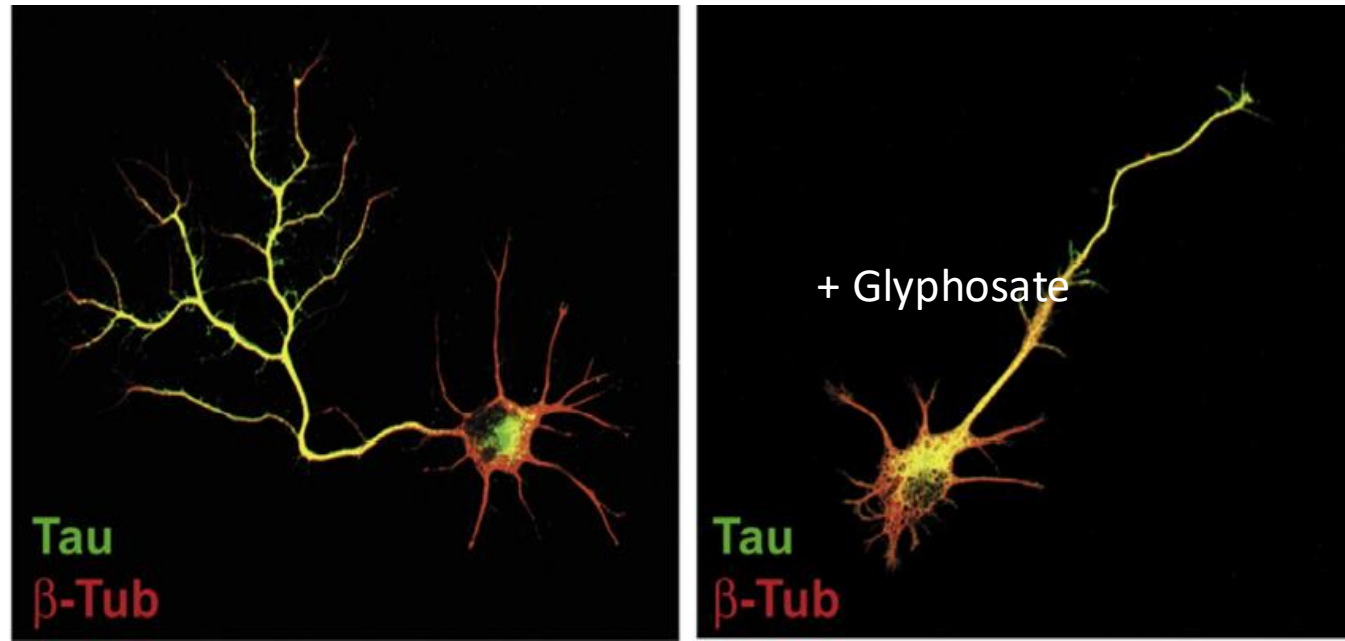
- Glyphosate-treated hippocampal neurons in culture showed a decrease in dendritic complexity and spine formation
- Rat pups were exposed to glyphosate (every two days from 7 days old to 27 days old)
 - Induced cognitive impairments
 - Reduced synaptic protein expression in hippocampus



*Sebastian Luna et al. Archives of Toxicology (2021) [Epub ahead of print]

“Neuronal development and axon growth are altered by glyphosate through a WNT non-canonical signaling pathway”*

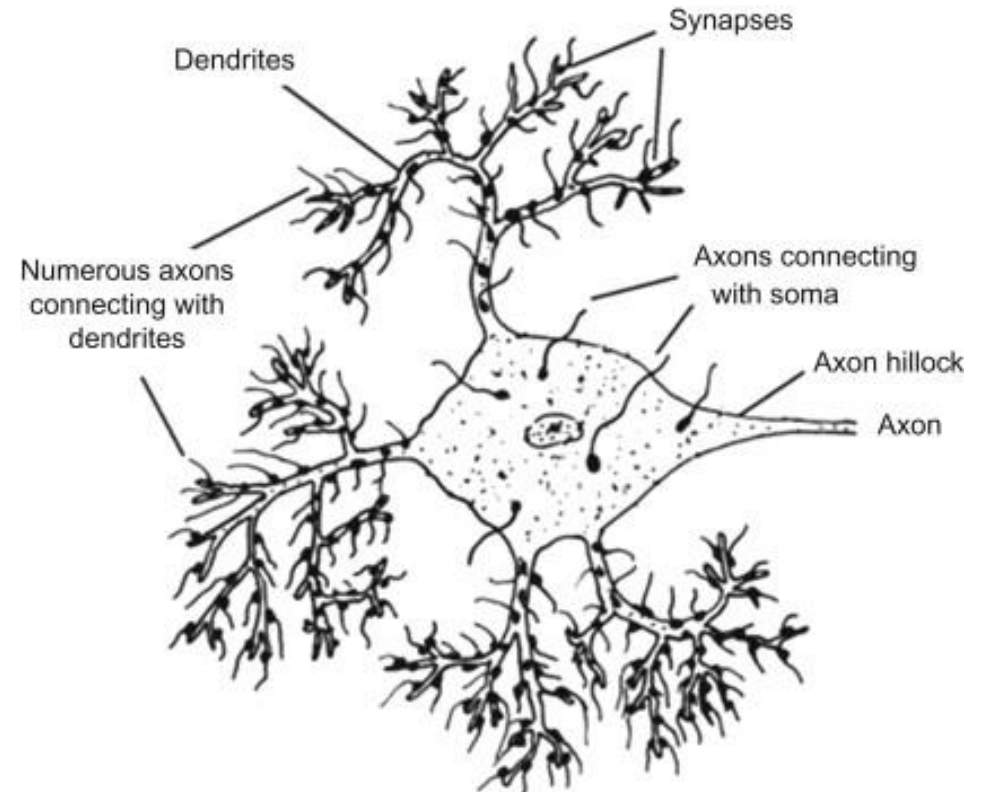
- Neurons grown in culture & exposed to glyphosate
- “They elicited shorter and unbranched axons and they also developed less complex dendritic arbors compared to controls”



*RP Coullery et al., NeuroToxicology 2016;52:150-161.

“Dendrite and spine modifications in autism and related neurodevelopmental disorders in patients and animal models” *

"Specifically, autism has been linked to a decrease in the density of spines with mature morphology, indicating a general spine immaturity state in autism."



*Verónica Martínez-Cerdeño, Dev Neurobiol 2017 Apr; 77(4): 393–404.

“Environment permissible concentrations of glyphosate in drinking water can influence the fate of neural stem cells from the subventricular zone of the postnatal mouse”*

"Our findings demonstrated that the permissible concentrations of glyphosate in drinking water recognized by environmental protection authorities are capable of inducing neurotoxicity in the developing nervous system."

"Our findings signify the need to review the safety standards established by environmental protection agencies concerning safe glyphosate concentrations in drinking water."

*Muhammad Irfan Masood et al., Environmental Pollution 270 (2021) 116179.

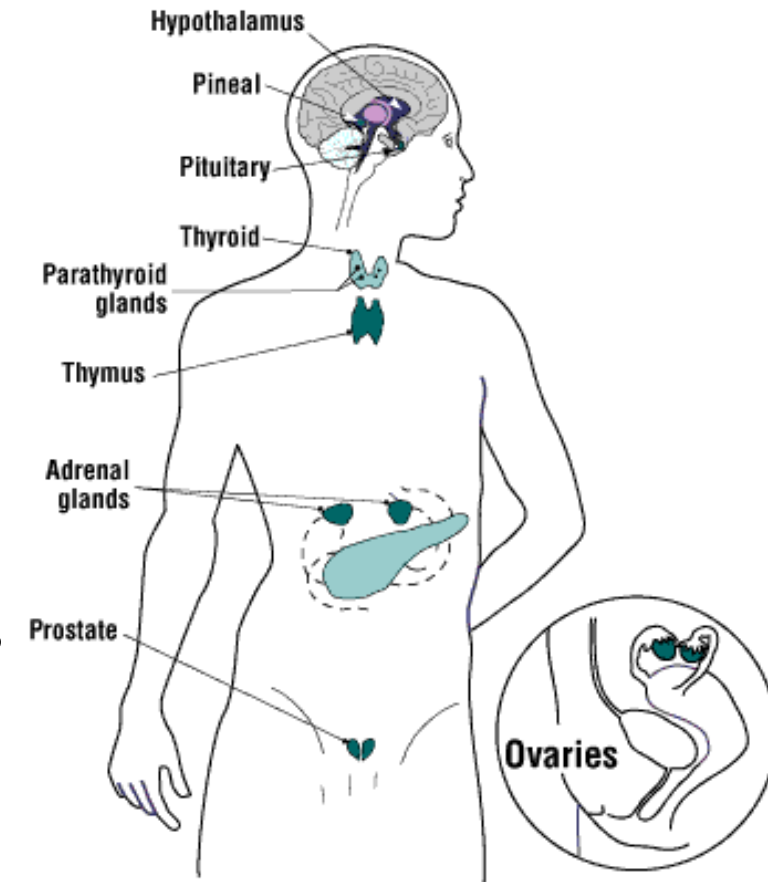
Recapitulation

- Glyphosate causes over-representation of Clostridia in the gut, depleting tryptophan → this maps to brain damage through inflammation
- Glyphosate causes autism-like symptoms in male mice linked to increased expression of soluble epoxyhydrolase (sEH)
 - Estrogen decreases expression of sEH
 - Aromatase converts testosterone to estrogen
- Aromatase expression in the placenta is suppressed by glyphosate
 - This explains glyphosate's effects and the link to autism
 - Low estrogen leads to high sEH
- Maternal vitamin D deficiency leads to excess testosterone in males
 - Vitamin D depends on liver CYP enzymes for activation, which glyphosate suppresses
- Aromatase is also a CYP enzyme and this explains how glyphosate suppresses it
- Glyphosate suppresses maturation of neuronal dendritic spines – a characteristic feature of autism

Glyphosate and Endocrine Disruption

Glyphosate is an Endocrine Disruptor*

- Glyphosate at parts per trillion triggers estrogen-sensitive breast cancer cells to proliferate
- Glyphosate increases expression levels of estrogen and progesterone receptors
- Glyphosate-based herbicides disrupt the hypothalamic-pituitary-thyroid (HPT) axis
- Glyphosate alters circulating levels of hormones
- Glyphosate induced hypothyroidism in female Wistar rats
- Glyphosate-based formulations altered reproductive developmental parameters in animal models
- Glyphosate induced malformation in zebrafish embryos



Zen Honeycutt on Glyphosate as an Endocrine Disruptor

- Zen Honeycutt is the Founder of the advocacy group Moms Across America
- On Dec. 10, 2020, a meeting of the Developmental and Reproductive Toxicant Identification Committee (DARTIC) was assembled to determine which chemicals might be endocrine disruptors
 - Under the California EPA's Office of Health Hazard Assessment (OEHHA)
- Zen presented slides showing compelling evidence that glyphosate is an endocrine disruptor
- The committee subsequently voted that glyphosate should be labelled as a HIGH probability endocrine disruptor on the Prop 65 list



[*https://www.momsacrossamerica.com/win_glyphosate_one](https://www.momsacrossamerica.com/win_glyphosate_one)

"Maternal urinary levels of glyphosate during pregnancy and anogenital distance in newborns in a US multicenter pregnancy cohort" *

- Glyphosate in urine measured mid-pregnancy
- Anogenital distance in girls was longer (more male typical) in association with higher urinary levels of glyphosate
- An earlier study on rats found a similar result **
- Glyphosate suppresses aromatase, which converts testosterone to estrogen
- Confirms that glyphosate is an endocrine disruptor in humans



* Corina Lesueur et al. Environmental Pollution 2021; 280: 117002.

** Manservisi et al. Environmental Health 2019; 18: 15.

Longer anogenital distance in females is linked to infertility

- Women in the highest tertile of anogenital distance had an 18-fold increased risk of having polycystic ovary syndrome (PCOS)*
 - Associated with irregular periods or no menstrual cycle, plus excess growth of hair
- PCOS is the most common cause of female infertility, affecting as much as 20% of the world's female population
- Women with PCOS have an increased risk of being diagnosed with autism and of having progeny with autism**

*Yingchen Wu et al. Human Reproduction 2017 Apr 1;32(4):937-943.

**Maria Katsigianni et al. Molecular Psychiatry 2019 Dec;24(12):1787-1797

Glyphosate and Premature Birth*

- Study based in Puerto Rico
- 53 cases (premature birth); 194 controls
- Models are adjusted for maternal age, education, pre-pregnancy BMI, and smoking
- Measured both glyphosate and AMPA
 - AMPA is a breakdown product of glyphosate
- Women who had high (> 0.65 micrograms/Liter) levels of AMPA in their urine at 26 weeks of gestation had a 4.5-fold increased risk of premature birth ($p < 0.006$). High urinary glyphosate was associated with a 3.77-fold increased risk.



*Monica K Silver et al. Environmental Health Perspectives 2021; 29(5): 057011.

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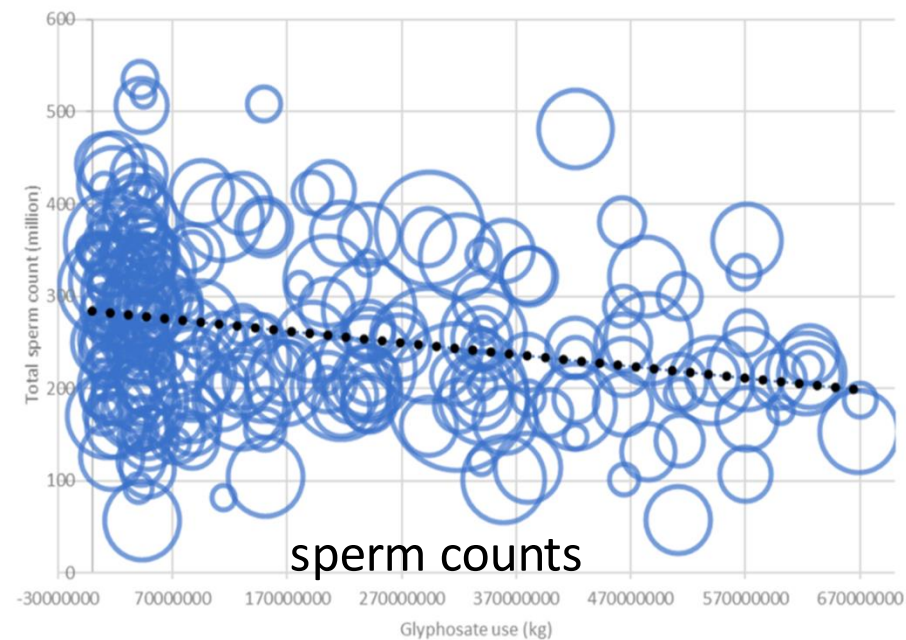
"Preterm birth is a national epidemic, costing the United States \$26.2 billion each year"

-- American Psychological Association

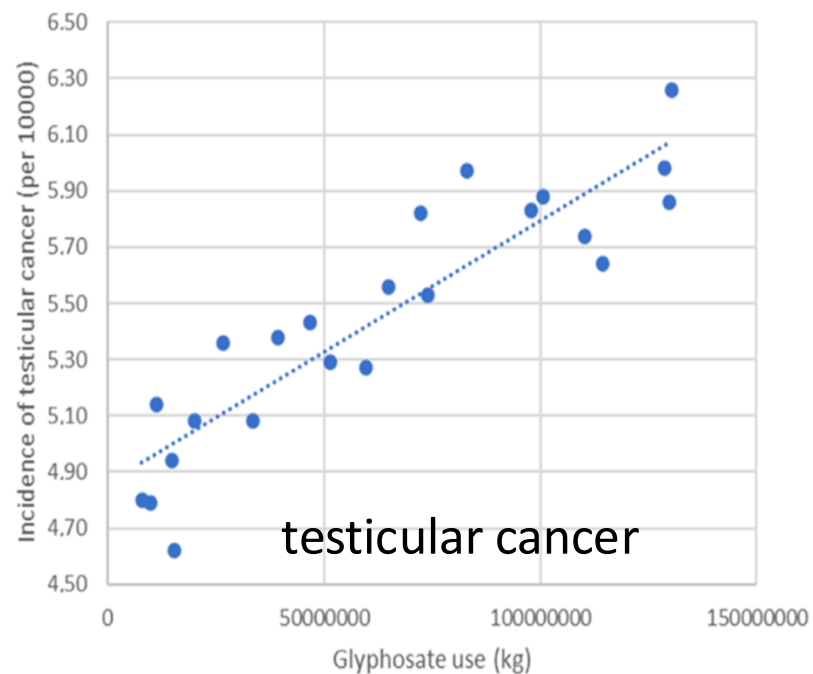


*Monica K Silver et al. Environmental Health Perspectives 2021; 29(5): 057011.

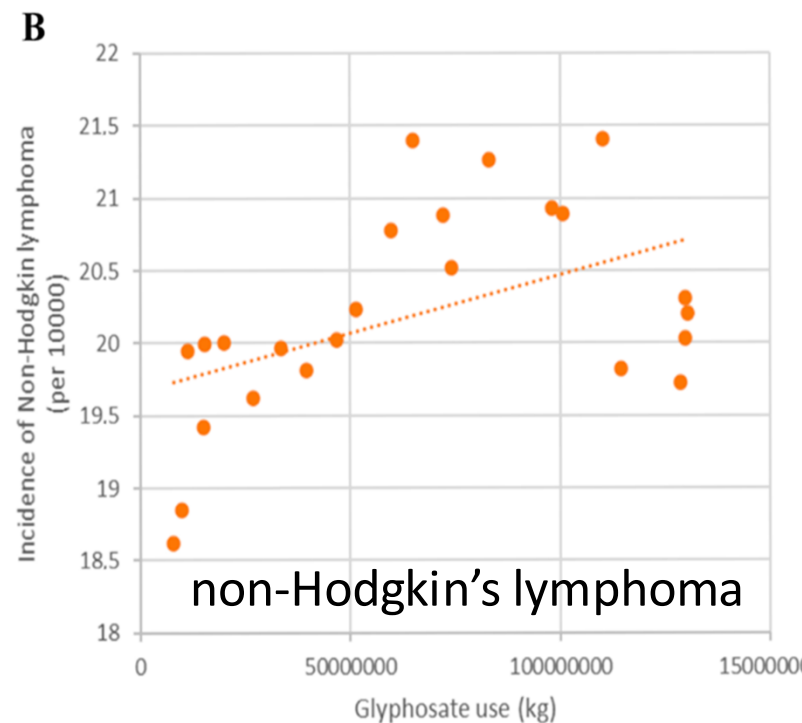
Glyphosate, Sperm Counts and Cancer*



$p < .000015$



$p < .000000000039$

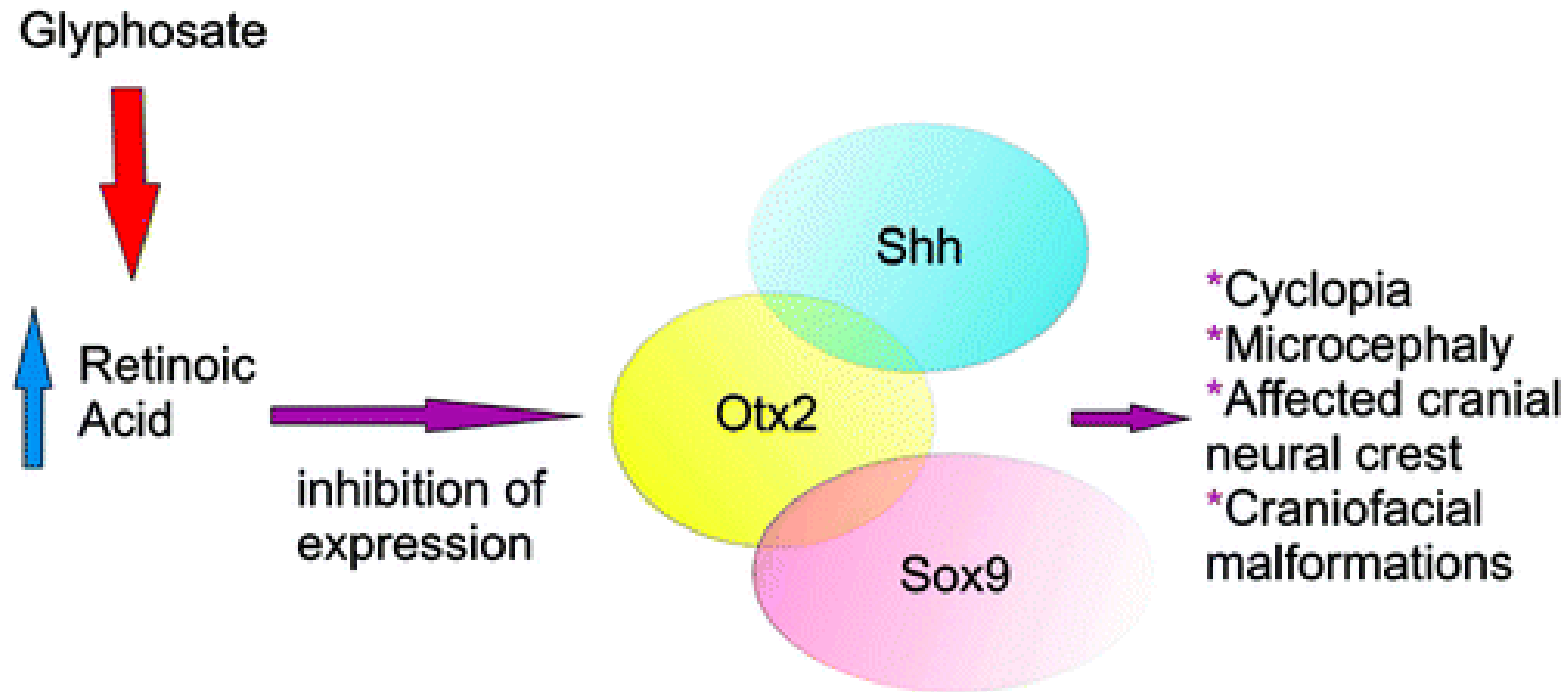


$p < 0.0053$

Data were obtained from publicly available databases maintained by the US government

*B. Sopko et al., ACS Omega 2021 June 2, 2021 [Epub ahead of print]

“Glyphosate-Based Herbicides Produce Teratogenic Effects on Vertebrates by Impairing Retinoic Acid Signaling”*

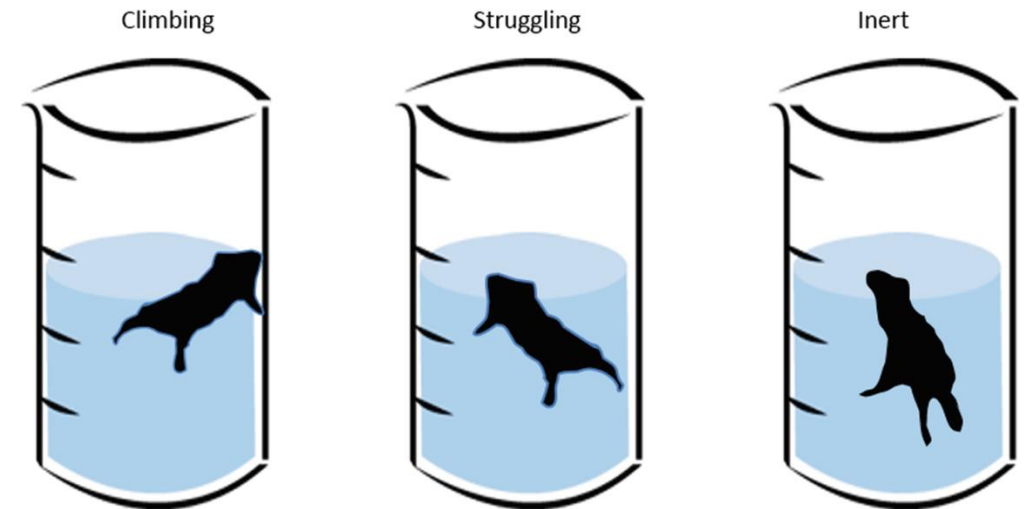


*A Paganelli et al., Chem Res Toxicol 2010; 23(10):1586-1595.

Transgenerational Effects

“Developmental exposure to glyphosate-based herbicide and depressive-like behavior in adult offspring: Implication of glutamate excitotoxicity and oxidative stress”*

- Mother rats were exposed to glyphosate while pregnant and for fifteen days following birth of the offspring.
- The offspring suffered from glutamate excitotoxicity in their brains persistently even after exposure was terminated.
- When the offspring were 60 days old, they showed signs of depression in a forced swimming test.



*Daiane Cattani et al., Toxicology 2017; 387: 67-80.

Epigenetic transgenerational toxicology through germline alterations by glyphosate^{*,**}

- Pregnant rats were exposed to glyphosate at half the No Observable Adverse Effect Level (NOAEL) from day 8 to day 14 of gestation (timed to match germ cell epigenetic programming)
- Offspring were bred to produce pups (F1), grandpups (F2) and great-grandpups (F3)
- Exposed rats showed no symptoms
- F1 generation were mostly fine
- F2 and especially F3 generations suffered from many diseases, including mammary tumors, delayed or early puberty, premature birth abnormalities, prostate disease, kidney disease, and obesity

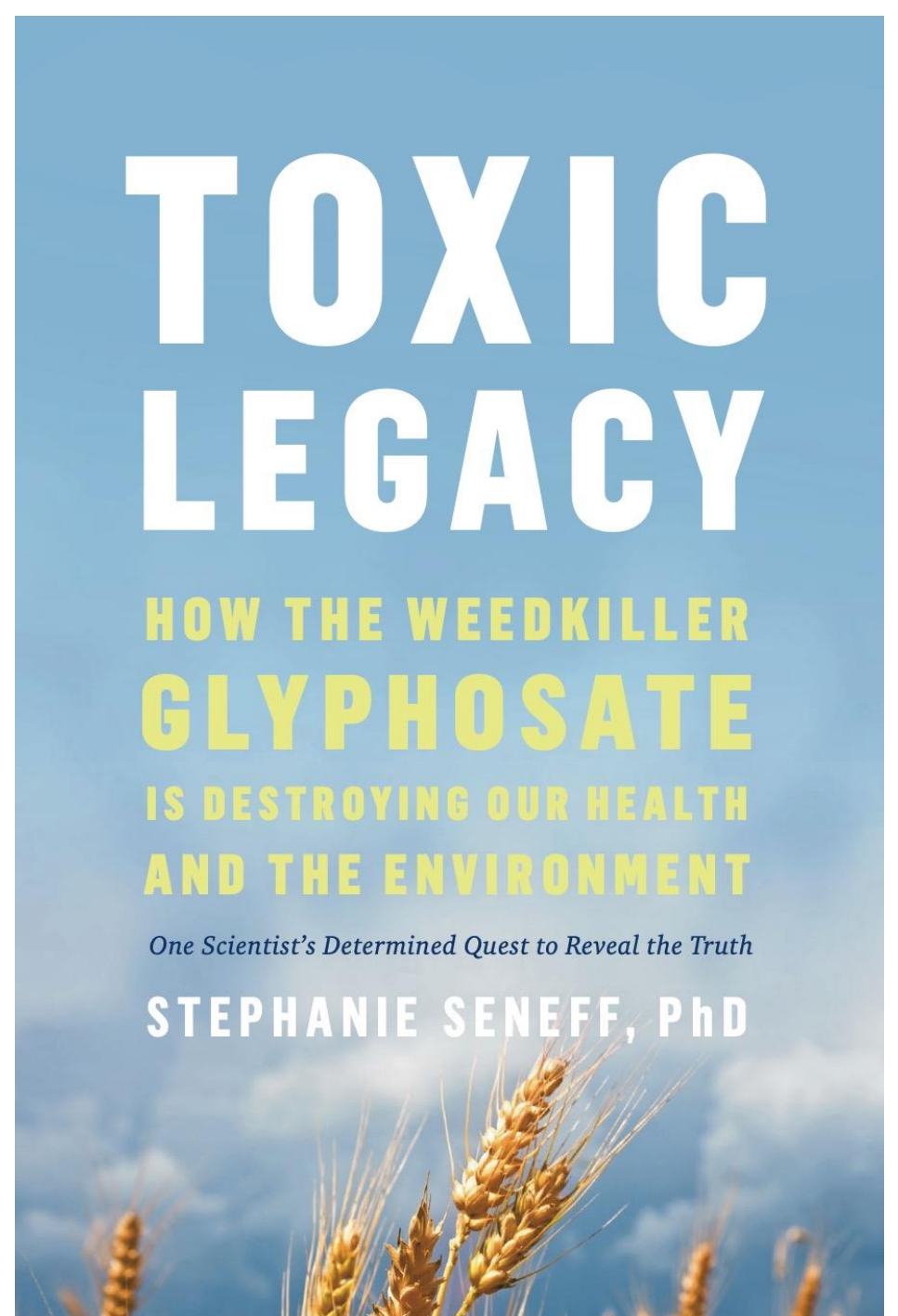


* Millissia Ben Maamar et al. Epigenetics 2020 Dec 9;1-18.

** Deepika Kubsad et al. Scientific Reports 2019; 9:6372.

My New Book!

- Expected to be released on July 1, 2021
- Presents extensive data on glyphosate toxicity to animals and humans
- Provides compelling arguments that glyphosate is insidiously, cumulatively toxic through its diabolical insertion into proteins by mistake in place of the coding amino acid glycine
- This unique feature explains why it is causal in so many diseases



How to Stay Healthy in a Toxic World

Go Organic!





Vs



No GMO's Allowed

Synthetic Pesticides Allowed

Roundup Herbicides Allowed

Hexane Allowed

Sewage Sludge Allowed

Antibiotics Allowed

Ractopamine Allowed

No GMO's Allowed

No Synthetic Pesticides Used

No Roundup Herbicides Used

No Hexane Used

No Sewage Sludge

No Antibiotics

No Ractopamine

Eat Natural Probiotic Foods

- Sauerkraut and apple cider vinegar contain Acetobacter, one of the very few classes of microbes that can metabolize glyphosate
- Kombucha and kimchi do too!



Some Important Nutrients

- Curcumin
- Garlic
- Vitamin C
- Methyl tetrahydrofolate
- Cobalamin (B12)
- N-acetyl cysteine
- Glutathione
- Taurine
- Epsom salt baths



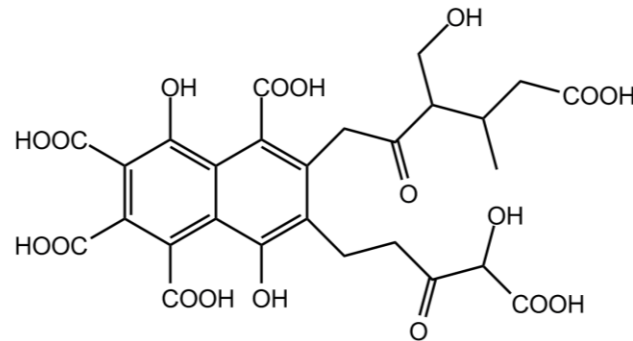
Treating Glyphosate Poisoning in Cows*



Activated charcoal, bentonite clay, humic and fulvic acids, and sauerkraut juice have been shown to be effective in reducing urinary levels of glyphosate and improving animal health



Bentonite Clay



Fulvic Acid



Activated Charcoal

*H Gerlach et al., J Environ Anal Toxicol 2014, 5:2

Biochar, Bentonite and Zeolite to maintain healthy microbial distribution in poultry*



*TP Prasai et al. PLoS ONE 2016; 11(4): e0154061.

Extracts from Common Plants Can Treat Glyphosate Poisoning*

- Roundup is toxic to hepatic and embryonic cells at doses far below those used in agriculture and at residue levels present in some GM food.
- Extracts from common plants such as dandelions, barberry, and burdock can protect from damage, especially if administered prior to exposure.



*C Gasnier et al. Journal of Occupational Medicine and Toxicology 2011, 6:3

Healthy Living is the Best Way to Protect Yourself from COVID-19

- Vitamin D deficiency is associated with 4-fold increased risk of dying from COVID-19
- Vitamin C and Vitamin K2 deficiency are also linked to poor outcomes
- Countries where fermented foods are a dietary staple have lower infection rates
- I believe the most important ways to protect yourself are to eat a **certified organic** whole-foods diet and to get out in the **sunlight** without sunscreen and without sunglasses



Conclusions

- Glyphosate is far more toxic to humans than we have been led to believe
- The rise in glyphosate usage on core crops in the United States correlates with the rise in prevalence of many diseases and conditions
- Glyphosate causes gut dysbiosis, which is increasingly recognized as a major driver behind multiple chronic diseases
- Glyphosate's disruption of gut microbes, CYP enzymes, and hormones can play a significant role in autism and other neurological diseases
- Glyphosate causes infertility in both males and females, as well as developmental disorders
- Many papers published in the last few years are revealing remarkably severe effects of low doses of glyphosate in animal studies, including transgenerational effects
- Glyphosate should be banned worldwide

“Future historians may well look back upon our time and write, not about how many pounds of pesticide we did or didn’t apply, but by how willing we are to sacrifice our children and future generations for this massive genetic engineering experiment that is based on flawed science and failed promises just to benefit the bottom line of a commercial enterprise.”

Prof. Don Huber

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Upcoming Webinars

Thursday, July 1 at 7:00 pm central

“Regenerating Human Health: Nourishing the Immune System” with Sara Keough

Our immune systems are greatly challenged in our modern world of toxic overload, chronic stress, nutritional deficiencies, inadequate sleep and a myriad of other lifestyle and environmental factors. In the next webinar in our series of 'Regenerating Human Health,' Sara Keough, MS, CNS, LDN will discuss healing foods and lifestyle changes that can deeply nourish and strengthen our immune systems from within.

Thursday, July 8 at 7:00 pm central

“Increasing Profitability in a Corn/Bean Rotation”

Understanding Ag panel webinar (with extended Q&A), Dan DeSutter, David Brandt and David Kleinschmidt will discuss how farmers can lower input costs while increasing farm profitability and resiliency. The secret to success is using soil-health improving regenerative ag principles and practices—and these preeminent experts will answer your questions regarding how you can do the same.