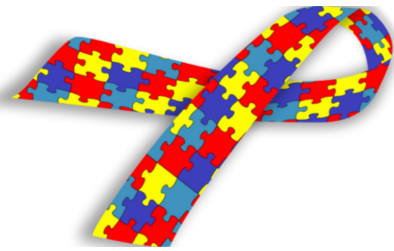
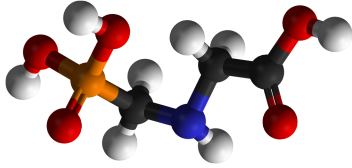
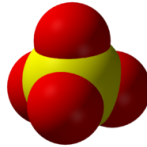


Glyphosate, Sulfate and Autism



Stephanie Seneff
MIT CSAIL
AutismOne
August 19, 2022



1

Download these slides!

<https://people.csail.mit.edu/seneff/2022/AutismOne2022.pptx>
Powerpoint slides

<https://people.csail.mit.edu/seneff/2022/AutismOne2022.pdf>
PDF file – two per page

2

Outline

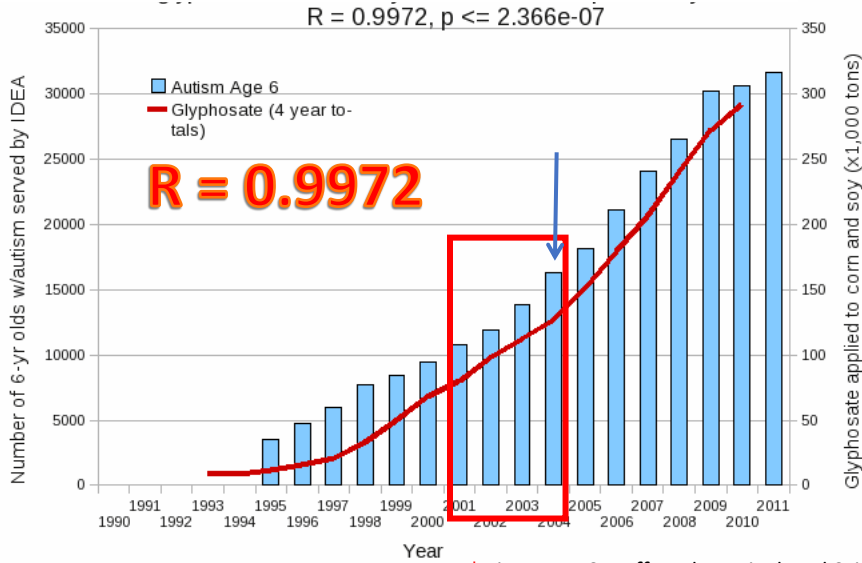
- Introduction
- Glyphosate Disrupts Sulfate Supply
- Autism and Sulfate
- Sulfate and the Brain
- Glyphosate, Autism and the Gut
- Glyphosate, Sulfate and Reproductive Issues
- How to Keep Your Family Healthy

3

Introduction

4

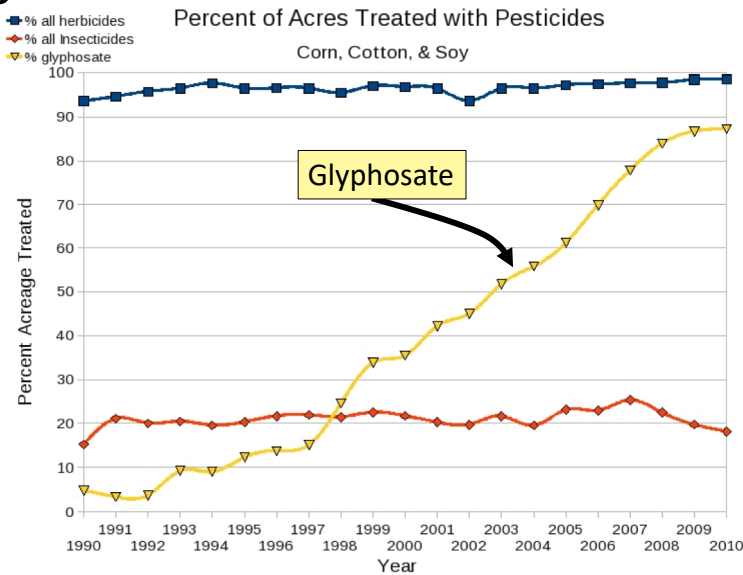
Autism Prevalence: 6-year-olds and Glyphosate Usage on Core Crops*



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

5

Glyphosate vs. Other Pesticides: Usage in the United States*



*<http://sustainablepulse.com/wp-content/uploads/GMO-health.pdf>

6

Glyphosate is Pervasive in Our Food Supply!

POISON FOODS
of
NORTH AMERICA

GLYPHOSATE IN FOODS FROM COUNTRIES WITH 10 OR MORE SAMPLES

ORIGIN	Yes	No	ASSESSMENT
CANADA	128	142	WORST
CHINA	145	152	WORST
UNITED STATES	142	82	WORST
TURKEY	32	122	BAD
TAIWAN	21	142	BAD
POLAND	18	142	BAD
SUBTOTAL	425	108	BAD
JAPAN	19	19	CAUTION
LEBANON	19	37	CAUTION
ITALY	36	18	CAUTION
INDIA	200	15	CAUTION
SUBTOTAL	302	17	CAUTION
KOREA	11	3	GOOD
BOLIVIA	24	4	GOOD
CHILE			GOOD
SPAIN			GOOD
EUROPE	12	3	GOOD
NETHERLANDS	12	3	GOOD
GUATEMALA	18	3	GOOD
INDONESIA	11	1	TEST
THAILAND	11	1	TEST
FRANCE	11	1	TEST
SOUTH AFRICA	11	1	TEST
MEXICO	18	2	EXCELLENT
CHINA	124	4	EXCELLENT

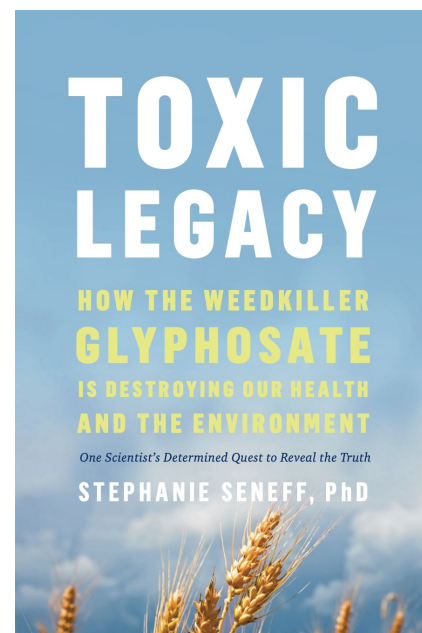
tony mitra



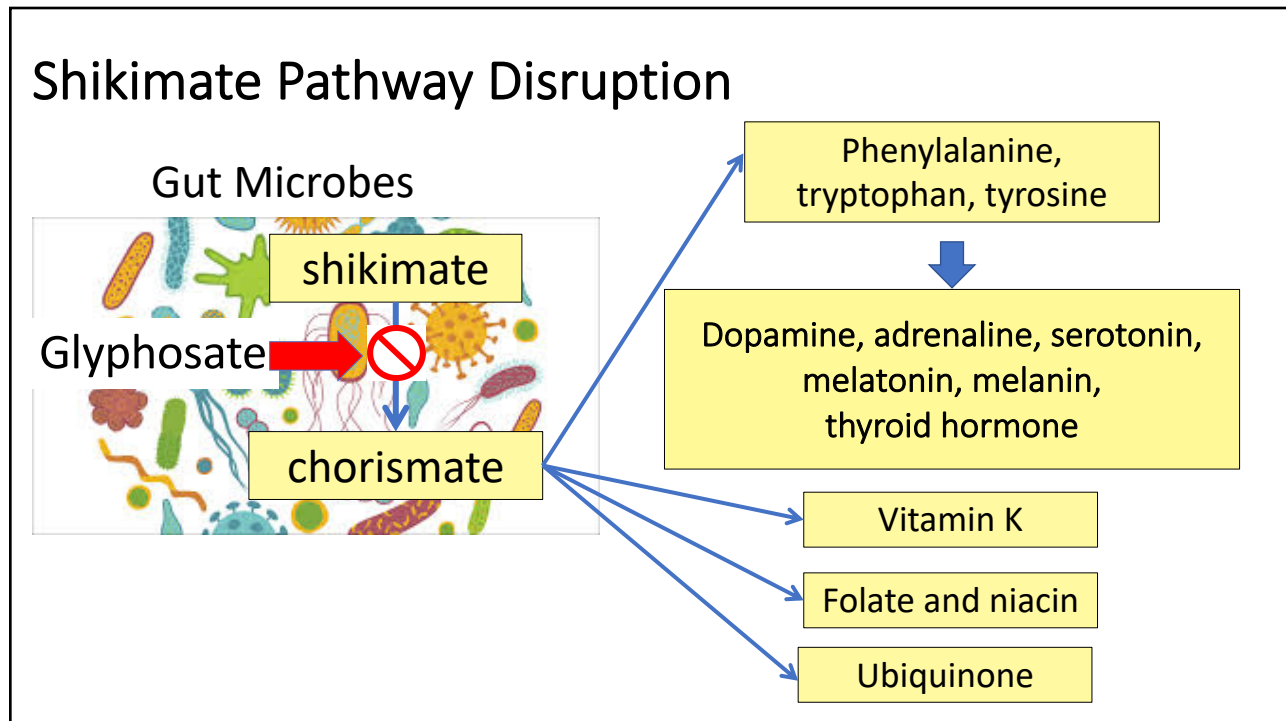
7

My New Book!

- Released by Chelsea Green in July 2021
- Presents extensive data on glyphosate toxicity to animals and humans
- *Shows how glyphosate interferes with sulfate homeostasis*
- Argues 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



8



9

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

10

Main Toxic Effects of Glyphosate*

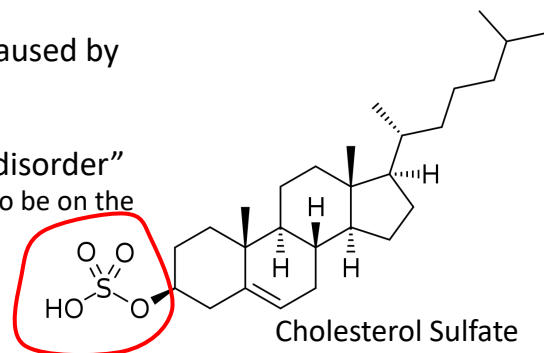
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*Samsel and Seneff, *Entropy* 2013, 15, 1416-1463

11

“The near universal presence of autism spectrum disorders in children with Smith-Lemli-Opitz syndrome”*

- “SLOS is an autosomal recessive condition caused by a defect in cholesterol synthesis”
- “SLOS appears to have the most consistent relationship with autism of any single gene disorder”
 - 75% of the children with SLOS were diagnosed to be on the autism spectrum
- “Therefore, a link between cholesterol metabolism and autism is suggested”



Hypothesis: Cholesterol sulfate synthesis in the skin is a major source of both cholesterol and sulfate to supply the brain

*Darryn M Sikora et al. *Am J Med Genet A* 2006; 140(14): 1511-8.

12

The Importance of Cholesterol Sulfate

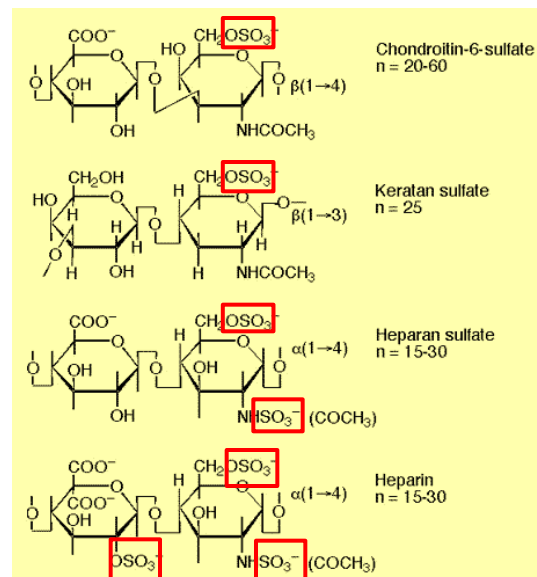
- *Cholesterol sulfate, produced in the skin*, supplies cholesterol, sulfate, and protons to all the tissues
- Sulfate is synthesized from sulfide in the skin and blood stream utilizing the energy in sunlight
- Cholesterol sulfate from the skin goes into the blood and enters the membranes of red blood cells, platelets and lipid particles
 - It protects them all from glycation and oxidative damage
- Sunscreen interferes with this process



13

Sulfated Glycosaminoglycans (GAGs)

- Prominent in extracellular matrix of all cells
- Controls uptake of nutrients and signaling molecules
- Amount of sulfate depends on availability
- Crucial for maintaining negative charge and gelled water



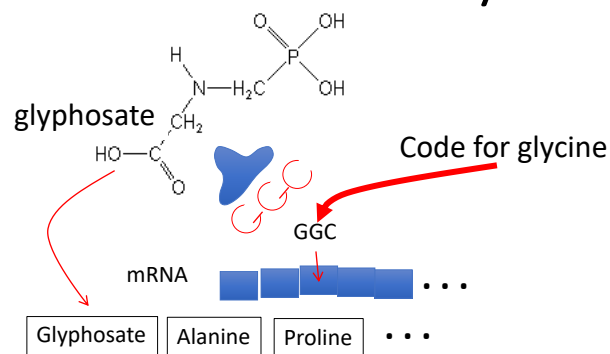
<http://www.science-autism.org/sulphate.htm>

14

Glyphosate Disrupts Sulfate Supply

15

What If Glyphosate can get Inserted into Proteins by Mistake in Place of Glycine???



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

16

Multiple species of bacteria
and multiple species of weeds
have developed resistance to glyphosate
by swapping out a crucial glycine residue in
the enzyme EPSP synthase in the shikimate
pathway, replacing it with alanine.*

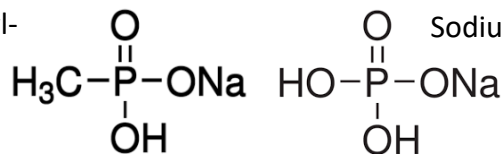
*S Seneff et al. J Bioinfo Proteomics Rev 2016; 2(3): 1-21.

17

Hypothesis: Glyphosate Disrupts Proteins that Bind Phosphate

- Glyphosate kills plants by suppressing EPSP synthase
- Glyphosate blocks EPSP synthase binding to the phosphate in PEP
- Glyphosate is a glycine molecule with a methylphosphonate unit attached to the nitrogen atom
- The binding site for PEP has a highly conserved glycine residue
 - If this glycine is swapped out for alanine, the enzyme becomes completely insensitive to glyphosate
 - This is the basis for many GMO glyphosate-resistant crops*

Sodium Methyl-
phosphonate



Sodium Phosphate

*T Funke et al. Proc Natl Acad Sci U
S A 2006; 103(35): 13010-13015

18

“Pathogenesis of COVID-19 described through the lens of an undersulfated and degraded epithelial and endothelial glycocalyx”*

"The undersulfated glycocalyx may not only increase susceptibility to SARS-CoV-2 infection, but would also result in a hyperinflammatory response, vascular permeability, and shedding of the glycocalyx components, giving rise to a procoagulant and antifibrinolytic state and eventual multiple organ failure."

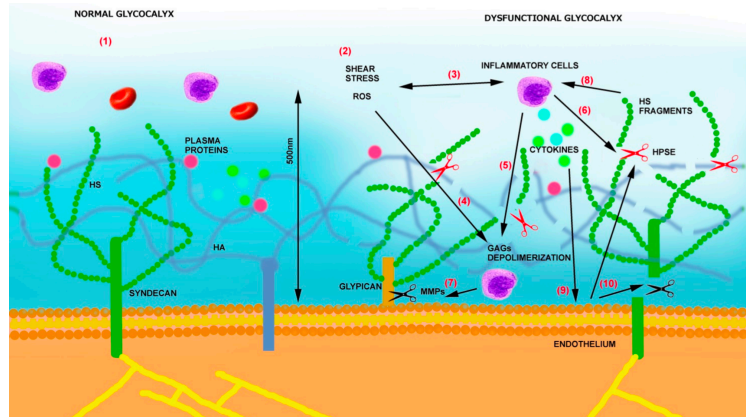


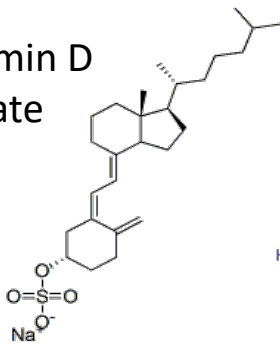
Figure from: V Masola et al. Int J Mol Sci 2021; 22: 2996.

*Heidi N. du Preez et al. FASEB J. 2022; 36: e22052z

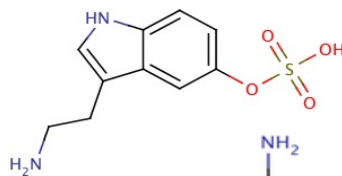
19

Safe Sulfate Transport: Carbon Rings

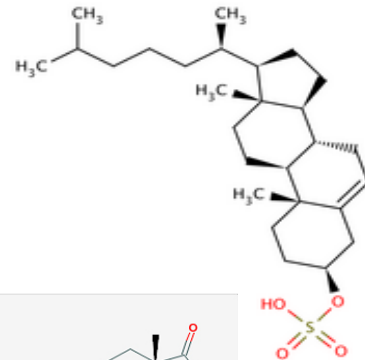
vitamin D sulfate



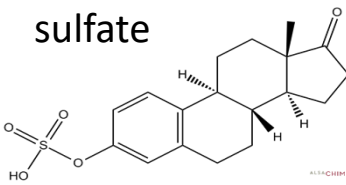
serotonin sulfate



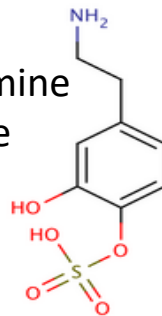
cholesterol sulfate



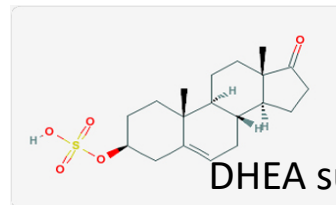
estrone sulfate



dopamine sulfate

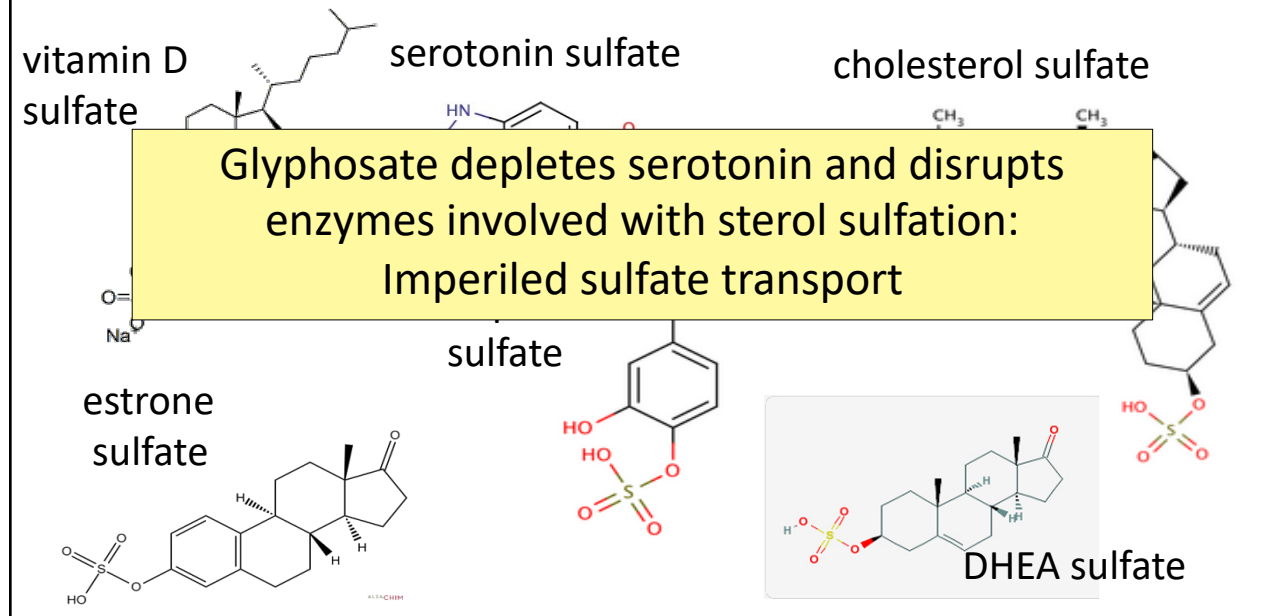


DHEA sulfate



20

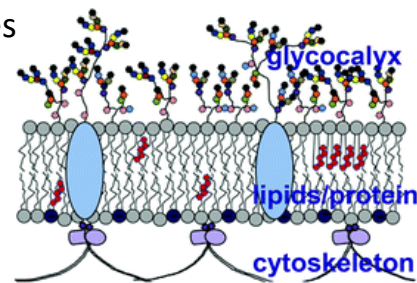
Safe Sulfate Transport: Carbon Rings



21

Sulfate's Critical Role for Maintaining Exclusion Zone Water*

- The glycocalyx which lines blood vessels generates electricity to supply the cells
- The glycocalyx extrudes protons
- Hypothesis:
 - Protons enter the cells along cytoskeletal "wires"
 - They fuel the mitochondrial intermembrane space
- Sulfate is crucial for maintaining gelled water in the glycocalyx
- *Sulfated glycosaminoglycans (GAGs) become depleted in sulfate with chronic exposure to glyphosate*



*S Seneff and G Nigh. Water 2019; 11: 22-42.

<https://waterjournal.org/current-volume/seneff-summary/>

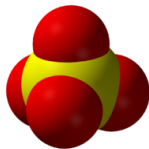
22

Autism and Sulfate

23

Sulfate in Fetal Development*

- Fetus depends on mother for sulfate supply
- Sulfate is essential for transporting sterols (like estrogen and DHEA) and supplying extracellular matrix proteins everywhere with sufficient negative charge
- Sulfate detoxifies xenobiotics like **acetaminophen (Tylenol)** and is essential for excreting toxins like **aluminum** and **mercury**
- Sulfate is severely deficient in autistic children (1/3 the normal level of free sulfate in blood stream)



*PA Dawson, "Sulfate in Fetal Development,"
Semin Cell Dev Biol 2011;22(6): 653-9.

24

Thyroid and Sulfate

- Autism is associated with disrupted sulfate management → systemic sulfate deficiency*
- Glyphosate suppresses pituitary release of thyroid stimulating hormone (TSH) → hypothyroidism**
- Hypothyroidism in mom is linked to autism in child***
- Hypothyroidism causes sulfate loss in urine****

*RH Waring and LV Klovrza. J Nutr & Environ Med 2000; 10: 25-32.

**JS de Souza et al. Toxicology. 2017 Feb 15;377:25-37.

***GC Román, Ann Neurol 2013;74(5):733-42.

****K Sagawa et al. Am J Physiol. 1999 Jan;276(1 Pt 2):F164-71.

25

Rosemary Waring on Autism (1990)*

“These results indicate that there may be a fault either in manufacture of sulphate or that sulphate is being used up dramatically on an unknown toxic substance these children may be producing.”

Waring deduced that there must be a severe defect in the enzymes that are involved in attaching sulfate to organic molecules

*p. 198, O'Reilly, B.A.; Waring, R.H. Enzyme and sulphur oxidation deficiencies in autistic children with known food/chemical intolerances. *Xenobiotica*. 1990, 20, 117–122.

26

Rosemary Waring Found Extremely Abnormal Urinary Sulfur Products in Autism*

TABLE 1. Excretion of urinary protein and anions in autism

	Autism (<i>n</i> = 232)	Controls (<i>n</i> = 68)
Age (years)	7.6 ± 2.4	8.5 ± 3.7
Protein $\mu\text{g ml}^{-1}$	103.2 ± 89.9*	64.5 ± 27.5
Sulphite	106.9 ± 162.9*	2.1 ± 6.3
Thiosulphate	130.8 ± 148.1*	18.6 ± 25.0
Thiocyanate	6.4 ± 16.9*	44.0 ± 101.0
Sulphate	6819.0 ± 6712.3*	3030.8 ± 1461.0

Anion excretion is given in nmol ml^{-1} , mean ± SD* $p < 0.001$ (Wilcoxon rank sum test).

*RH Waring and LV Klovrsza. Journal of Nutritional & Environmental Medicine 2000; 10: 25-32.

27

Rosemary Waring Found Extremely Abnormal Urinary Sulfur Products in Autism*

> 50-fold increase in urinary sulfite suggests a deficiency in sulfite oxidase

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*RH Waring and LV Klovrsza. Journal of Nutritional & Environmental Medicine 2000; 10: 25-32.

28

Glyphosate Plausibly Disrupts Sulfur Enzymes

Sulfite oxidase (SuOx)*

- Depends on molybdenum as catalyst (glyphosate chelation could make it unavailable)
- Changing glycine at residue 473 with aspartate destroys enzyme activity
 - Leads to severe impairment in ability to bind sulfite and 5-fold reduction in catalysis
 - Aspartate has similar properties as glyphosate, being bulky and negatively charged
- Defective SuOx leads to severe birth defects and neurological problems resulting in early death

The sulfotransferases**

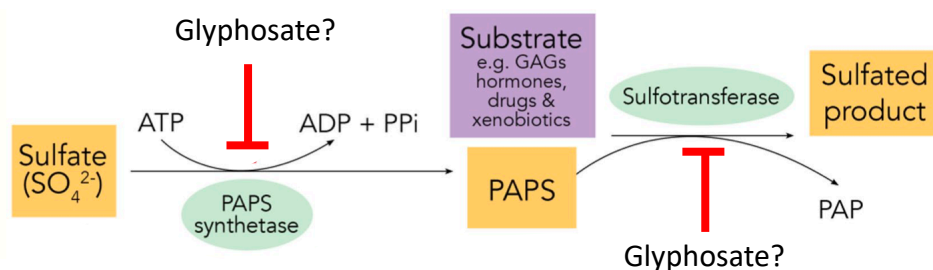
- GxxGxxK motif required for binding PAPS (activated sulfate)

*H.L. Wilson et al., Biochemistry 2006, 45, 2149-2160 2149.

**K. Komatsu et al., Biochem and Biophys Res Comm 1994;204(3): 1178-1185.

29

Major Enzymes disrupted in Sulfation Pathways by Glyphosate?



- Both PAPS synthetase and the class of sulfotransferases have highly conserved glycine residues at sites that bind phosphate

30

GxxGxxK Motif in Sulfotransferases*

- Sulfotransferases are crucial to attach sulfate ions to multiple bioactive molecules
- Steroids** (cholesterol, estrogen, testosterone, vitamin D, ...)
- Glycosaminoglycans** (chondroitin sulfate, heparan sulfate, ...)
- Polyphenols, aromatics** (curcumin, resveratrol, tryptophan, ...)
- Neurotransmitters** (dopamine, serotonin, melatonin, ...)

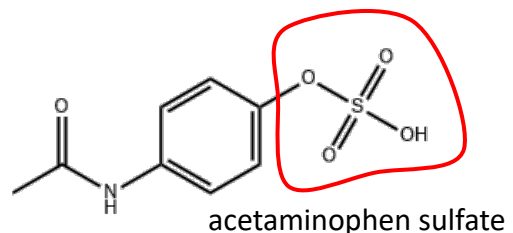
A	Human liver PST-M	GMA	G	DW	K	T	T	F	T	V	A	Q	N	I
	Human liver PST-P	GMA	G	DW	K	T	T	F	T	V	A	Q	N	I
	Human liver AST ₁	GMA	G	DW	K	T	T	F	T	V	A	Q	N	I
	Human brain AST ₂	GMA	G	DW	K	T	T	F	T	V	A	Q	N	I
	Human brain AST ₃	GMA	G	DW	K	T	T	F	T	V	A	Q	N	I
	Human placenta EST	GMA	G	DW	K	T	T	F	T	V	A	Q	N	I
B	Human liver EST	G	I	G	DW	K	N	H	F	T	V	A	L	N
	Guinea pig adrenal EST	G	I	S	G	DW	K	N	H	F	T	V	A	L
	Bovine placenta EST	G	D	V	G	DW	K	N	H	F	T	V	A	L
	Rat liver EST	G	I	V	G	DW	K	N	H	F	P	E	A	L
	Rat liver PST	G	T	T	G	DW	K	N	T	F	T	V	A	Q
	Mouse liver PST	G	T	I	G	DW	K	N	T	F	T	V	A	Q
C	Human liver HST	G	V	S	G	DW	K	N	H	F	T	V	A	Q
	Human liver HST	G	V	S	G	DW	K	N	H	F	T	V	A	Q
	Human liver HST	G	V	S	G	DW	K	N	H	F	T	V	A	Q
	Mouse liver HST	G	T	I	G	DW	K	N	H	F	T	V	A	Q
	Rat liver HST	G	T	V	G	DW	K	N	H	F	T	V	S	Q
	Rat liver HST	G	T	T	G	DW	K	N	H	F	T	V	A	Q
	Guinea pig adrenal HST	G	T	V	G	DW	K	N	H	F	T	V	A	Q

*H Chiba et al. Proc. Natl. Acad. Sci. USA 1995; 92:8176-8179.

31

“Sulfation deficit in ‘low-functioning’ autistic children: a pilot study”*

- Specifically looked at ability to metabolize acetaminophen
- Found highly statistically significant result:
 - Autistic kids were unable to conjugate acetaminophen with **sulfate!** ($p < .00002$)
- Glyphosate disrupts multiple enzymes involved in sulfation pathway in E coli**



*AA Pirrone et al., Biol Psychiatry. 1999 Aug 1;46(3):420-4.

**W. Lu et al., Mol. BioSyst., 2013, 9, 522-530.

32

“Thimerosal Exposure and the Role of Sulfation Chemistry and Thiol Availability in Autism”*

"The purpose of the present critical review is to provide mechanistic insight regarding how limited thiol [*organosulfur compound*] availability, *abnormal sulfation chemistry*, and decreased GSH [*glutathione*] reserve capacity in children with an ASD could make them more susceptible to the toxic effects of TM [*Thimerosal*] routinely administered as part of mandated childhood immunization schedules."



*JK Kern et al. Int. J. Environ. Res. Public Health 2013, 10, 3771-3800.

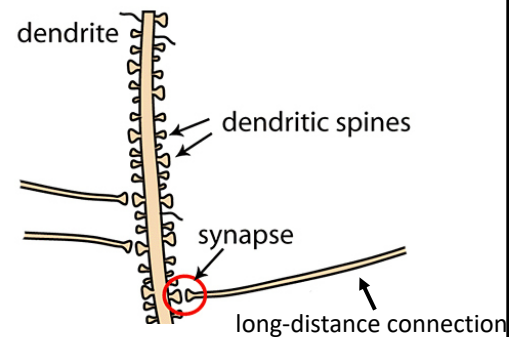
33

Sulfate and the Brain

34

"The role of heparan sulfate deficiency in autistic phenotype"*

- Autistic brains are structurally abnormal: too many dendritic spines and too few long-distance connections
- Heparan sulfate plays a crucial role in neurodevelopment, regulating axonal guidance and dendritic spine formation
- Heparan sulfate deficiency results in excess spine formation



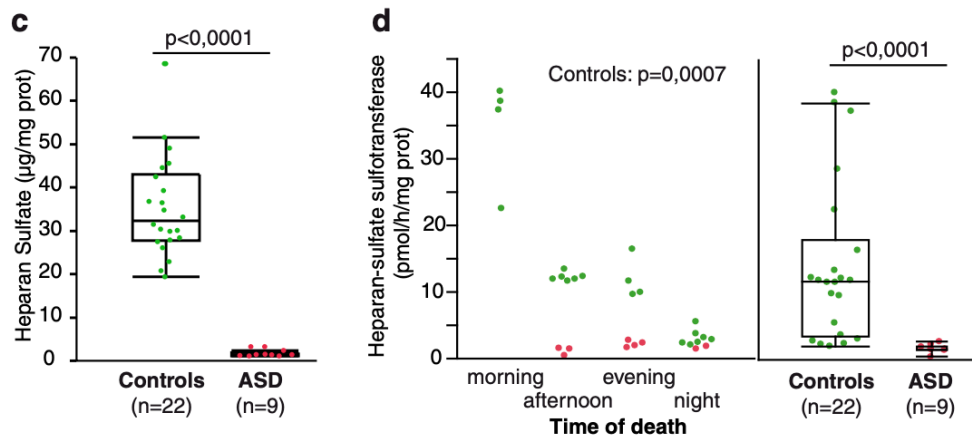
*Christine Pérez et al., *Neural Development* 2016; 11: 11.

35

"Decreased phenol sulfotransferase activities associated with hyperserotonemia in autism spectrum disorders"*

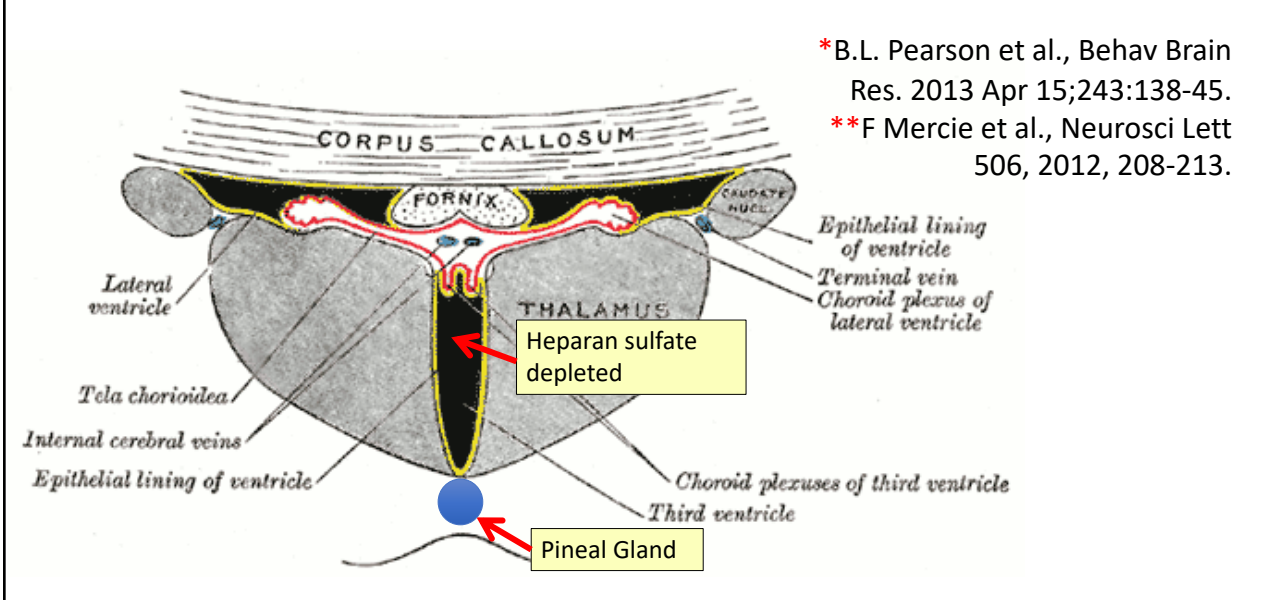
*Pagan et al. *Translational Psychiatry* 2021; 11:23.

Pineal glands



36

The third ventricle is depleted in heparan sulfate in association with autism in both humans and mice^{*,**}



37

“Heparan sulfate deficiency in autistic postmortem brain tissue from the subventricular zone of the lateral ventricles”^{*}

“Aberrant extracellular matrix glycosaminoglycan function localized to the subventricular zone of the *lateral ventricles* may be a biomarker for autism, and potentially involved in the etiology of the disorder.”

New neurons develop from stem cells in this zone through the action of “fractones” composed of heparan sulfate proteoglycans^{**}

*BL Pearson et al., Behav Brain Res. 2013;243:138-45
 **F. Mercier et al., Neuroscience Letters 506 (2012) 208–213

38

Autism-like socio-communicative deficits and stereotypies in mice lacking heparan sulfate*

- Experiment with “designer” mice: blocked heparan sulfate synthesis in brain ventricles
 - Mice exhibited all the classic features of autism – both cognitive and social



"Fractone-associated N-sulfated heparan sulfate shows reduced quantity in BTBR T+tf/J mice: a strong model of autism."**

* F. Irie et al., PNAS Mar. 27, 2012, 109(13), 5052-5056.

**KZ Meyza et al., Behav Brain Res 2012;228:247–53.

39

“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 (fewer synaptic connections)
- 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
 - Too few long-distance connections just as observed in autism in humans



*Sebastian Luna et al. Arch Toxicol 2021; 95(6): 2137-2150.

40

"Anxiety and Gene Expression Enhancement in Mice Exposed to Glyphosate-Based Herbicide"*

- Mice exposed to low-dose glyphosate-based herbicide for six weeks exhibited increased anxiety-like behavior
- Decreased serotonin expression in the amygdala. (the brain center for emotion)
- Neuronal hyperactivity observed in the amygdala
 - Linked to anxiety behaviors
- Serotonin inhibits glutamate release
- Glutamate activates receptors that induce excessive excitation of neurons and can lead to neurotoxicity



*Yassine Ait bali et al. Toxics 2022; 10: 226.

41

Glyphosate, Autism and the Gut

42



Article

Lifelong Exposure to a Low-Dose of the Glyphosate-Based Herbicide RoundUp® Causes Intestinal Damage, Gut Dysbiosis, and Behavioral Changes in Mice*

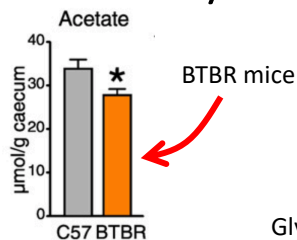
Ingrid Del Castillo ^{1,†}, Arthur S. Neumann ^{2,†}, Felipe S. Lemos ², Marco A. De Bastiani ³, Felipe L. Oliveira ², Eduardo R. Zimmer ³, Amanda M. Rêgo ⁴, Cristiane C. P. Haroim ⁵, Luis Caetano M. Antunes ^{4,6}, Flávio A. Lara ⁴, Claudia P. Figueiredo ^{1,2} and Julia R. Clarke ^{1,2,*}

- Lifelong exposure of mice to low doses of Roundup via drinking water
- Increased repetitive behavior and impaired social interest
- Evidence of increased gut permeability
- Altered gut microbiome

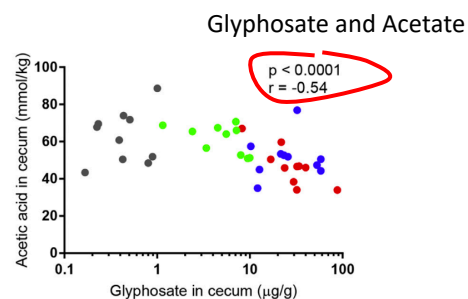
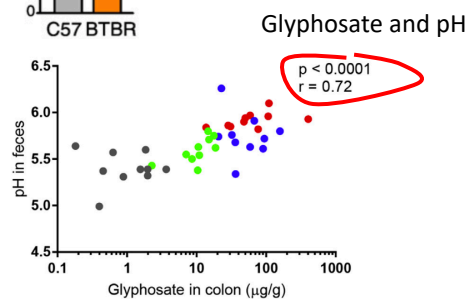
*Ingrid Del Castillo et al. *Int. J. Mol. Sci.* **2022**, *23*, 5583

43

BTBR mice have low acetate, and glyphosate disrupts acetate synthesis in gut*



Children with autism had only 3.5 mg/ml acetate in stool samples compared to 5.1 in controls.**

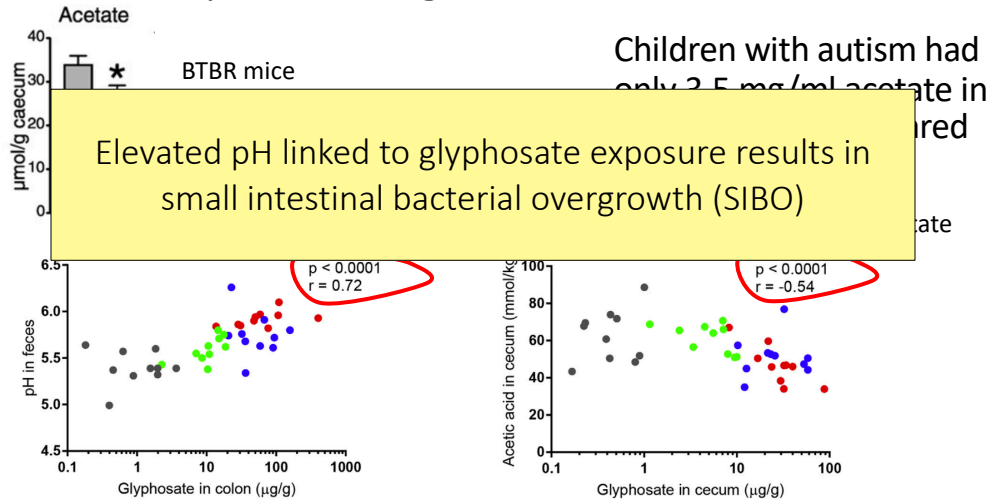


*LN Nielsen et al. *Environmental Pollution* 2018;233:364e376.

**JB Adams et al. *BMC Gastroenterology* 2011; 11:22.

44

BTBR mice have low acetate, and glyphosate disrupts acetate synthesis in gut*



*LN Nielsen et al. Environmental Pollution 2018;233:364e376.

**Adams et al. BMC Gastroenterology 2011; 11:22.

45

Sulfur Reducing Bacterial Overgrowth with Diet High in Simple Sugars and Fat*

- Mouse study, two diets
 1. High fat, high simple sugars
 2. Low fat, high complex carbohydrates
- Mice fed diet (1) had overgrowth of *Desulfovibrio* due to extraction of sulfate from host mucins
 - Associated with low levels of short chain fatty acids, acetate, and propionate
- High levels of hydrogen sulfide (H_2S) led to suppression of cytochrome C oxidase in the mitochondria of host colonic cells
 - Lower metabolic activity; Reduced uptake of nutrients.
- These results are consistent with observations of *Desulfovibrio* overgrowth, low acetate and propionate, and reduced nutrient uptake linked to autism



*FE Rey et al. Proc Natl Acad Sci U S A. 2013 Aug 13; 110(33): 13582-13587.

46

Sulfur Reducing Bacterial Overgrowth with Diet High in Simple Sugars and Fat*

- Mouse study, two diets
 1. High fat, high simple sugars
 2. Low fat, high complex carbohydrates
- Mice fed Desulfovibrio
 - Assoc and p Cheap vegetable-based fats (corn oil, soybean oil, cottonseed oil, canola oil) and simple sugars (cane sugar, beet sugar, high fructose corn syrup) can all be expected to be contaminated with glyphosate
- High level C oxidase
 - Lower metabolic activity; Reduced uptake of nutrients.
- These results are consistent with observations of Desulfovibrio overgrowth, low acetate and propionate, and reduced nutrient uptake linked to autism



*FE Rey et al. Proc Natl Acad Sci U S A. 2013 Aug 13; 110(33): 13582-13587.

47

Dissimilatory sulfate reduction induced by glyphosate

- Multiple enzymes involved in *assimilatory* sulfate reduction in E coli are disrupted by glyphosate (PAPS reductase, APS kinase, sulfite reductase)*
 - Causes deficiency in sulfur-containing amino acids
 - Leads to increase in Desulfovibrio and Bilophila wadsworthia species
 - *Dissimilatory* sulfate reduction → excessive hydrogen sulfide gas → brain fog
- Disrupted sulfur assimilation leads to impaired iron absorption**
 - Iron deficiency anemia is an epidemic worldwide

*W Lu et al. Mol Biosyst. 2013 Mar;9(3):522-30.

**BH Hudson et al. PNAS 2018 ePub ahead of print.

48

Is Encephalopathy a Mechanism to Renew Sulfate in Autism?*

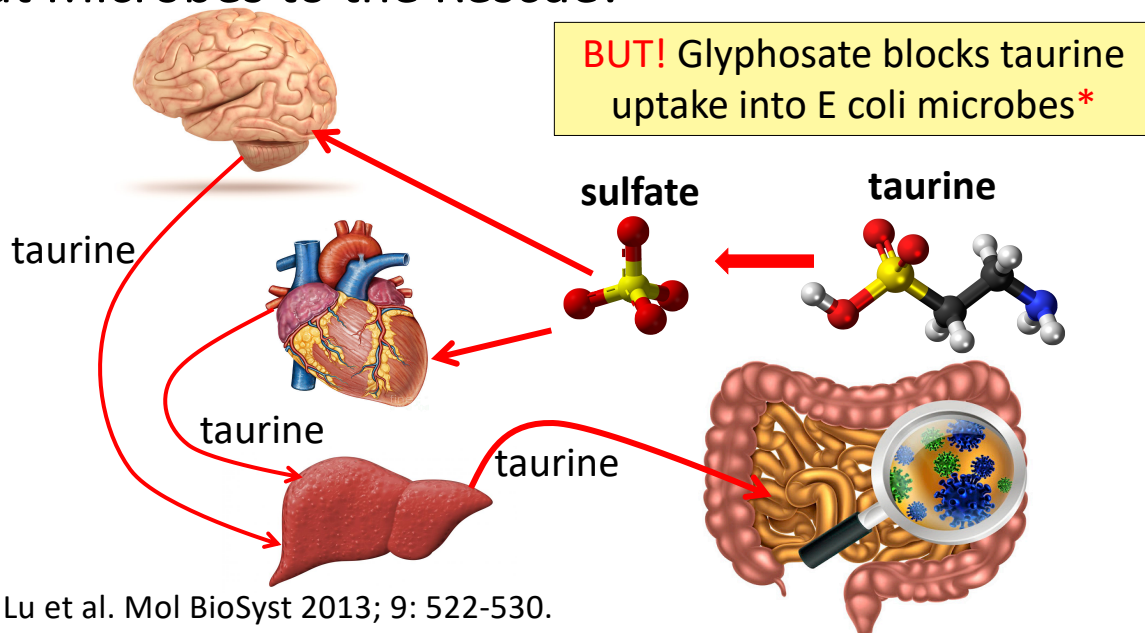
Abstract: “This paper makes two claims:

- (1) Autism can be characterized as a chronic low-grade encephalopathy, associated with excess exposure to nitric oxide, ammonia and glutamate in the central nervous system, which leads to hippocampal pathologies and resulting cognitive impairment, and
- (2) Encephalitis is provoked by a systemic deficiency in sulfate, but associated seizures and fever support sulfate restoration. ...”

*S Seneff et al., Entropy 2013; 15: 372-406.

49

Gut Microbes to the Rescue!



*W Lu et al. Mol BioSyst 2013; 9: 522-530.

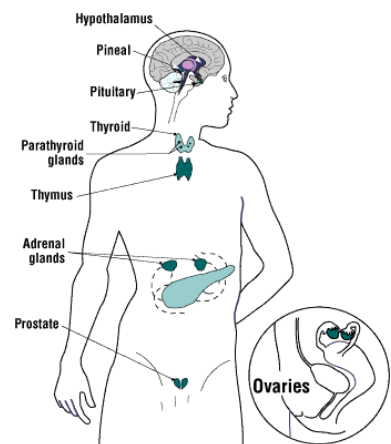
50

Glyphosate, Sulfate and Reproductive Issues

51

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



*Juan P. Muñoz et al. Chemosphere October 19, 2020 [Epub ahead of print]

52

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.

53

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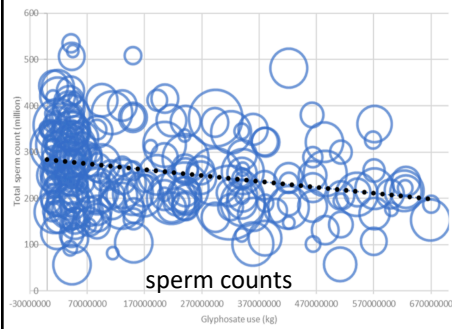
"Preterm birth is a national epidemic, costing the United States \$26.2 billion each year"
-- American Psychological Association



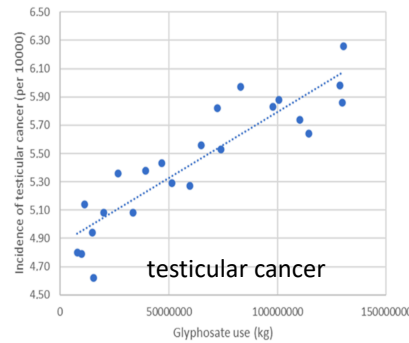
*Monica K Silver et al. Environmental Health Perspectives 2021; 29(5): 057011.

54

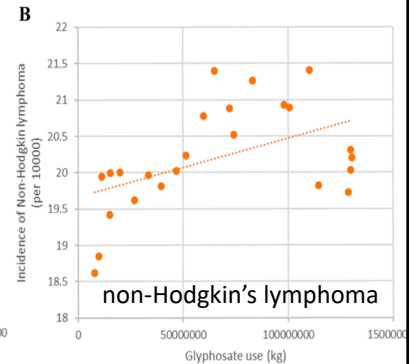
Glyphosate, Sperm Counts and Cancer*



$p < .000015$



$p < .0.00000000039$



$p < 0.0053$

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

*B. Sopko et al., ACS Omega 2021; 6(23):14848–14857.

55

"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 Lesseur et al. Environmental Pollution 2021; 280: 117002.

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

56

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.

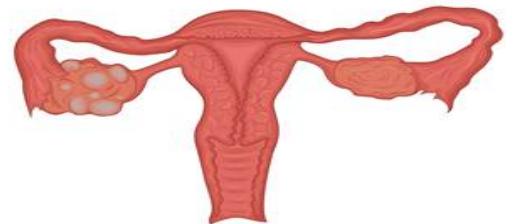
Maria Katsigianni et al. Molecular Psychiatry 2019 Dec;24(12):1787-1797

***W Oostdijk et al. J Clin Endocrinol Metab 2015;100(4):E672-80.

57

Polycystic Ovarian Syndrome (PCOS)*

- PCOS is the most common reproductive disorder in the world
 - It affects 8-20% of women of reproductive age
- 40% of women with PCOS develop infertility
- 90-95% of women being treated in infertility clinics who have impaired ovulation suffer from PCOS



*medium.com/@drjasonfung/the-faces-of-polycystic-ovary-syndrome-pcos-4491740c69ae

58

PCOS, Autism, PAPS Synthase and Sulfotransferase

- PAPS synthase converts sulfate to the activated form of sulfate
 - It is essential for DHEA sulfate synthesis
- Defective PAPS synthase → polycystic ovary syndrome (PCOS) in women, high androgen*
 - Glycine 270 → aspartate mutation
 - Aspartate, like glyphosate, is bulky and negatively charged
- Glyphosate's disruption of sulfotransferases also interferes with the synthesis of DHEA sulfate



*Cherskov et al. Translational Psychiatry 2018; 8:136.

59

How to Keep Your Family Healthy

60



61



62



63

Supplemental Sources of Sulfur*

- glucosamine sulfate
- chondroitin sulfate
- glutathione
- N-acetylcysteine
- alpha lipoic acid
- taurine
- DMSO, MSM
- S-adenosylmethionine (SAME)
- Epsom salts (Mg-sulfate)

These can have many beneficial effects and are nearly nontoxic

My personal favorite is Epsom salt baths:
Magnesium sulfate uptake through the skin

*S Parcell, Alternative Medicine Review 7(1), 2002, 22-44

64

Let the Sun Shine In!



65

Summary

- Sulfate plays many essential roles in the body
 - Sulfate dysbiosis is a core feature of autism
- Heparan sulfate deficiency in the brain is associated with autism in both humans and mouse models
- Sulfate synthesis and transfer depend critically on specific glycine residues in the enzymes that do this work
 - Glyphosate substitution for glycine would disrupt these enzymes
- A low-grade encephalopathy characterizes autism, and it can induce a resupply of sulfate mediated by the amino acid taurine and the gut microbes
- Glyphosate disrupts development in girls with a link to PCOS
 - PCOS is a major risk factor for female infertility and for autism
- A high-sulfur certified organic diet and abundant sun exposure are keys to good health and longevity

66