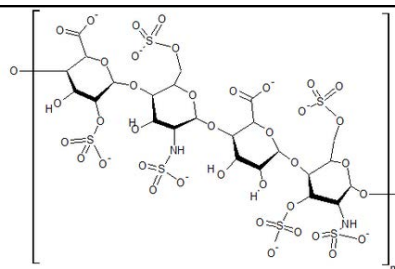
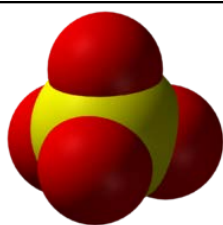


## Download These Slides

<http://people.csail.mit.edu/seneff/2018/Toronto.pptx>



**Sulfate is the most common nutritional deficiency that you never heard of**

Stephanie Seneff  
MIT CSAIL  
March 27, 2018

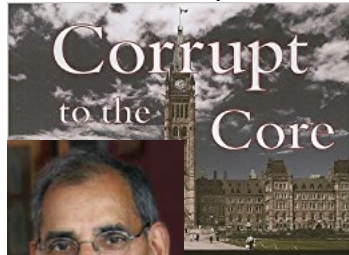


## In Memory Of John Balatinecz



January 19, 1937 – August 6, 2017

Shiv Chopra



Tony Mitra



Zen Honeycutt

Some John Balatinecz "Groupies"



Rachel Parent



Jack Wilson

## John Balatinecz Email message to Jack Wilson:

“Since you are a super **Praise** person, and are even e... it now)  
time, why do... Doctors one at a  
attorney in Te **Guidance** David Mathews, the  
Monsanto (dmlawfirm.com). He might even post  
your latest pamphlet in his website ... Your info  
might ev **Optimism** decision to start the  
lawsuit of the century.

## Outline

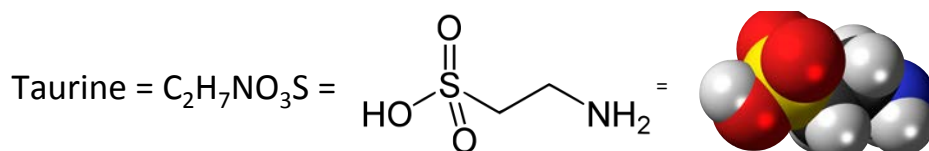
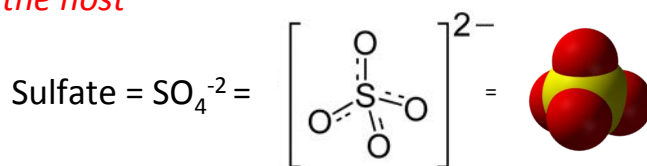
- Introduction
- Cholesterol Sulfate
- Glycocalyx & Heparan Sulfate
- Bile Acids
- Glyphosate
- Diseases Linked to Sulfate Deficiency
- Curcumin and Other Flavonoids
- Prevention of Disease through Diet and Lifestyle

## The Big Ideas

- Cardiovascular disease is a *cholesterol sulfate* deficiency problem
- *Heparan sulfate* deficiency is a key factor in autism
- Most modern diseases that are on the rise are mechanisms to renew sulfate supply to the blood
- Glyphosate (the active ingredient in the pervasive herbicide Roundup) disrupts the body's ability to properly synthesize and utilize sulfate
- *Taurine* is a storage form of sulfate

## Taurine: Brief Chemistry Refresher Course

- Taurine is the only sulfonated amino acid
  - It does not incorporate into proteins
  - It is the most common free amino acid in the body
  - It is stored in large quantities in the heart, brain and liver
- Human cells can not metabolize taurine, but *microbes* can extract its sulfur atom to synthesize sulfate or methionine *for the host*



## Perinatal Taurine is Essential\*

- Taurine accumulates in maternal tissues during pregnancy, and is released to the fetus during the perinatal period
- Mother's milk is rich in taurine, and it accumulates in the neonatal brain
- Taurine deficiency in the mom leads to:
  - Growth retardation in the offspring (insufficient methionine?)
  - Impaired development of central nervous system and pancreas
  - Impaired glucose tolerance and vascular dysfunction
- Gestational diabetes in offspring transmits the effects to the next generation

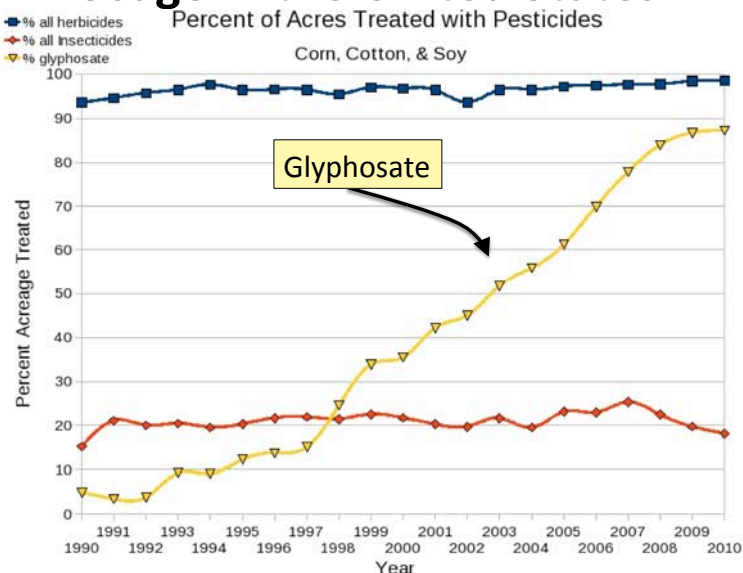
\*L Aerts and FA Van Assche. J Perinat Med. 2002;30(4):281-6.

## Roundup and GMO Crops

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

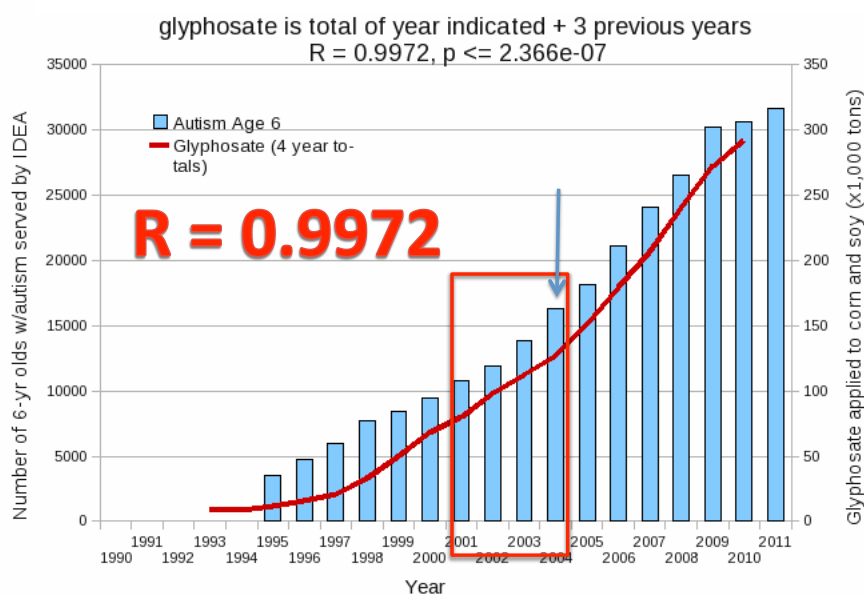


## Glyphosate vs. Other Pesticides: Usage in the United States\*



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

## Autism Prevalence: 6 year olds\*



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

## Cholesterol Sulfate

### They Knew a Long Time Ago\*

- Article published in 1960
- Fed cholesterol to monkeys
  - induced atherosclerosis
- If sulfur-containing nutrients are added, atherosclerosis is prevented
- These nutrients provide source of sulfate to enable cholesterol transport



\* G.V. Mann et al., Am. J. Clin. Nutr. 8, 491-497, 1960.

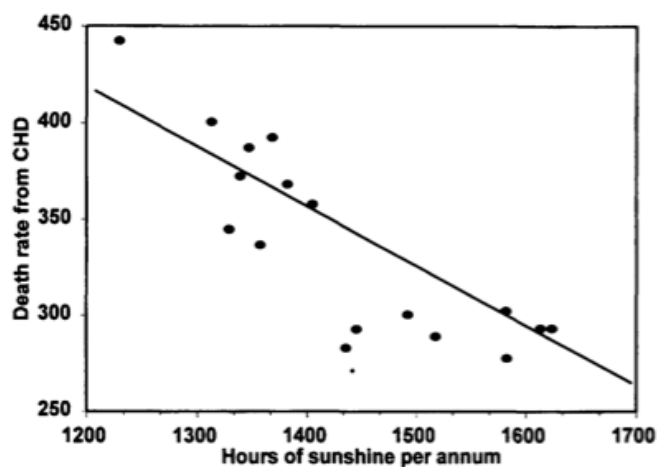
## They Knew a Long Time Ago\*

- "A form of vascular disease resembling
- human atherosclerosis has been produced in the New World primate *Cebus fatuella*. ... In
- order to produce these phenomena, the diets had to be rich in cholesterol, choline and neutral fat but relatively *low in organic sulfur compounds*. Without this deprivation of organic sulfur the response of the serum lipids to cholesterol feeding was small."



\* G.V. Mann et al., Am. J. Clin. Nutr. 8, 491-497, 1960.

## Heart Disease Mortality and Sunlight\*

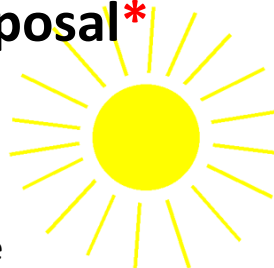


\*Grimes et al., Q. J. Med. 1996; 89:579-589

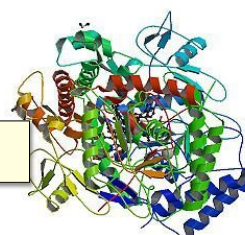


## A Provocative Proposal\*

- Cholesterol sulfate supplies sulfur, cholesterol, energy and negative charge to all the tissues
  - Also protects skin from UV damage and keeps microbes out



- Sulfate is synthesized from sulfide in the skin and blood stream utilizing energy in sunlight
- Endothelial Nitric Oxide Synthase (eNOS) performs the magic

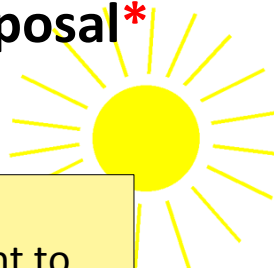


The skin is a solar powered battery!

\*S Seneff et al., Entropy 2012, 14, 2492-2530.

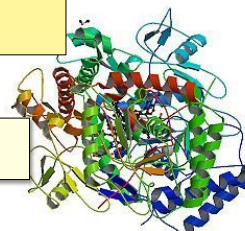
## A Provocative Proposal\*

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- Sulfate is synthesized from sulfide in the skin and blood stream utilizing energy in sunlight
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Melanin converts UV light to visible light, and the flavins in eNOS respond to blue light by emitting electrons



The skin is a solar powered battery!

\*S Seneff et al., Entropy 2012, 14, 2492-2530.

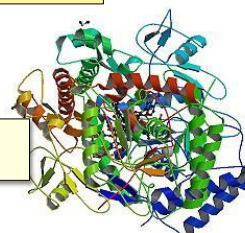
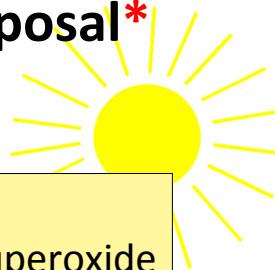
## A Provocative Proposal\*

- Cholesterol sulfate supplies sulfur, cholesterol, energy and negative charge to all the

These electrons produce superoxide from oxygen that combines with sulfur to form sulfate

- Sulfur in blood
- Endothelial Nitric Oxide Synthase (eNOS) performs the magic

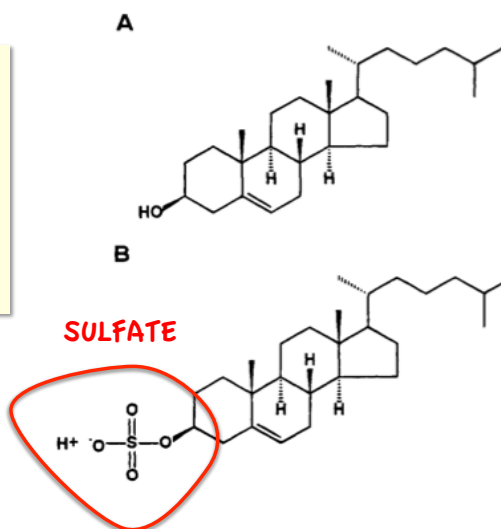
The skin is a solar powered battery!



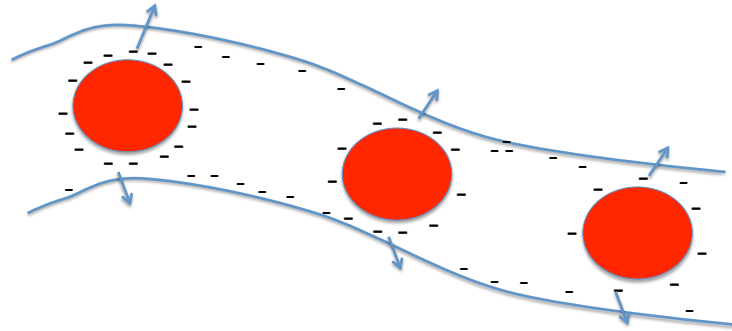
\*S Seneff et al., Entropy 2012, 14, 2492-2530.

## Cholesterol and Cholesterol Sulfate

Sulfation makes cholesterol water-soluble and therefore much easier to transport



## Cholesterol sulfate provides negative charge\*



Red blood cells export cholesterol sulfate to the capillary wall, supplying it with cholesterol, sulfate, and negative charge

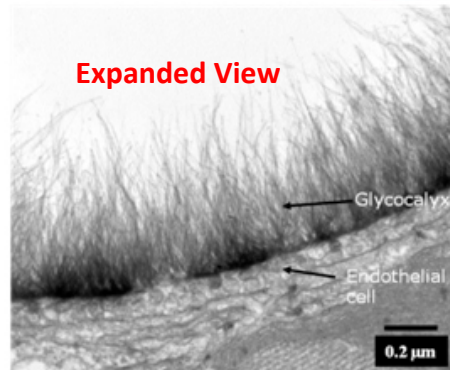
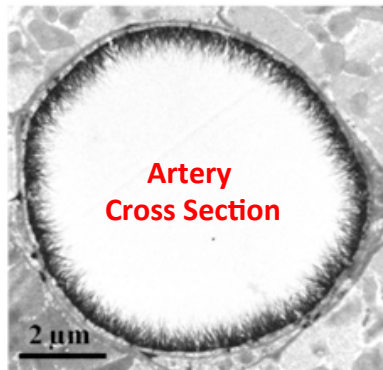
\* Davidson and Seneff, Entropy 14, 1399-1442, 2012.

## Rouleaux – Insufficient Negative Charge\*

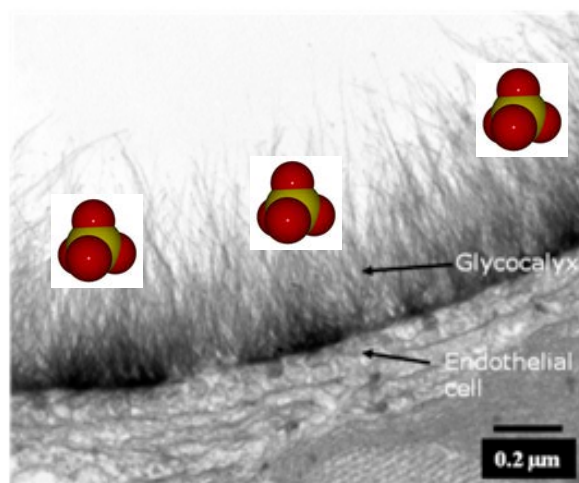


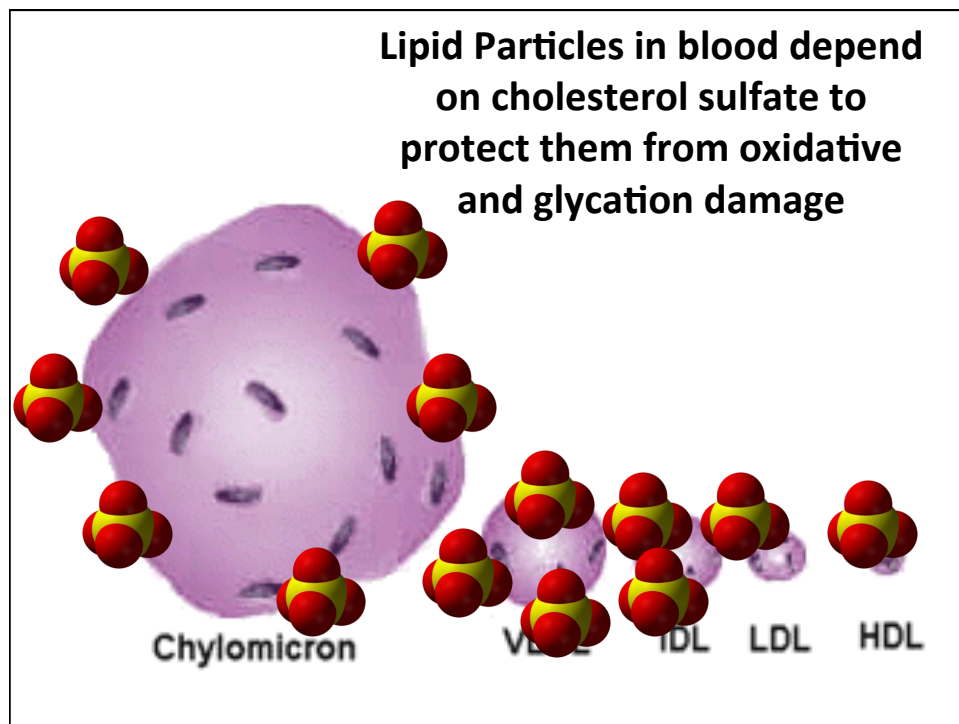
\*Dr. Marcial Vega; <https://www.youtube.com/watch?v=9vhHe55s9rg>

## Sulfate and the Glycocalyx



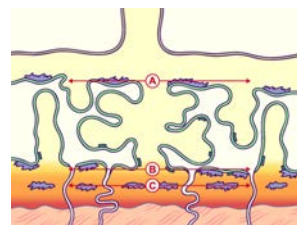
## Sulfate is Crucial to Maintain Structured Water in the Glycocalyx





### Cholesterol Sulfate in Placental Villi\*

- Placental villi are highly enriched in cholesterol sulfate, especially in third trimester of pregnancy
- Mother's serum cholesterol sulfate steadily rises through pregnancy
- In third trimester, villi contain **24** picomol/mg of cholesterol sulfate, compared to only **1.5** in blood serum of a non-pregnant woman



\* Lin et al., Journal of Chromatography B, 704 (1997) 99–104

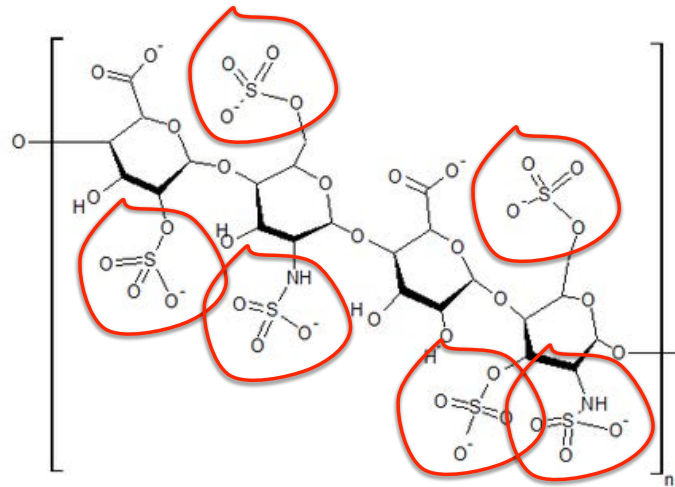
## Sulfate in Fetal Development\*

- 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)

\* Dawson, "Sulfate in Fetal Development," Semin Cell Dev Biol 2011

## Glycocalyx & Heparan Sulfate

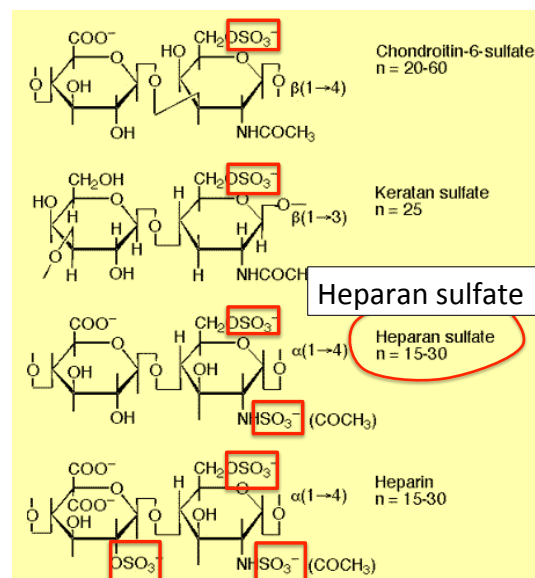
## Heparan Sulfate: Wonder Worker



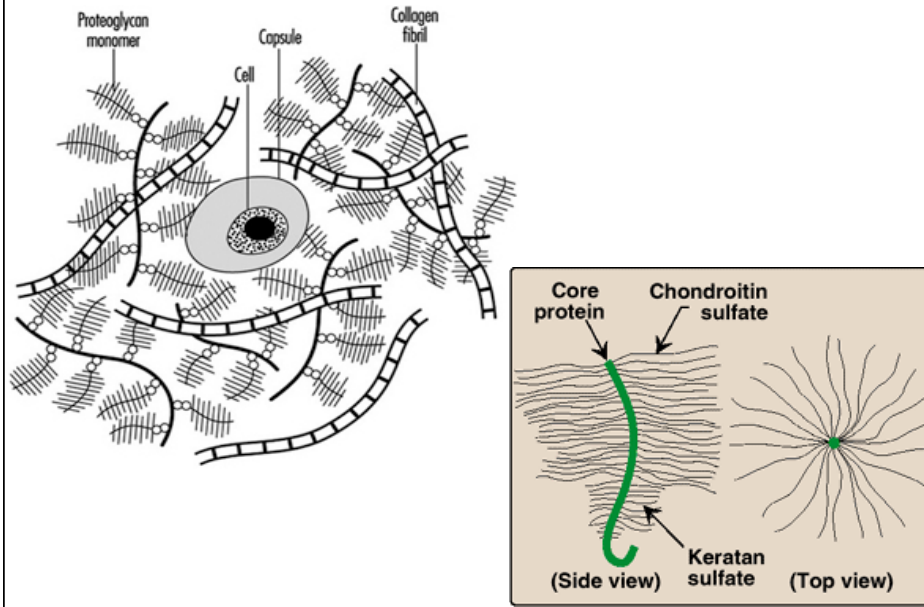
Polymers of sugars with attached nitrogen and sulfates: safe glucose storage

## Sulfated Glycosaminoglycans (GAGs)

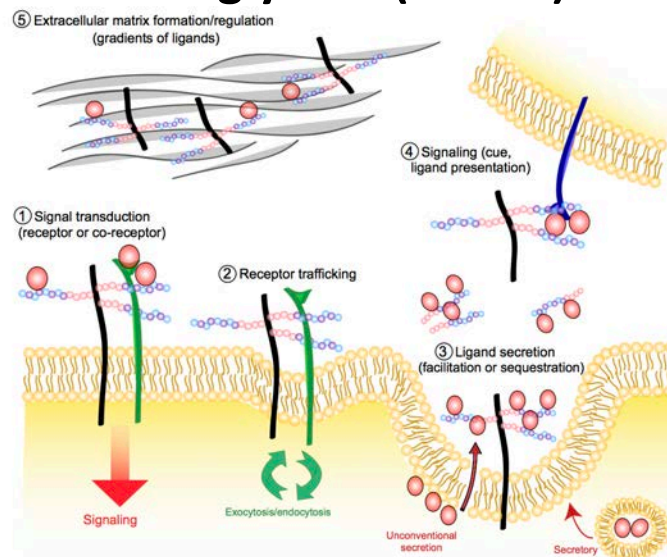
- Prominent in glycocalyx: extracellular matrix of cells
- Amount of sulfate depends on availability
- Regulate signaling and nutrient uptake



**'Bottle brush' molecule structures - protein centered, carbohydrate bristles terminating with sulfate/water 'activity areas'**



## Multiple Roles of Heparan Sulfate Proteoglycans (HSPGs)\*

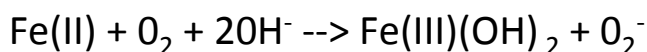


\*Figure 3. FE Poulain and HJ Yost. Development 2015; 142: 3456-3467.



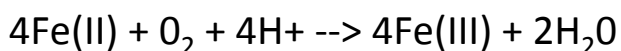
## Heparin Protects from ROS due to Iron\*

Free radical production (*Fenton* reaction):

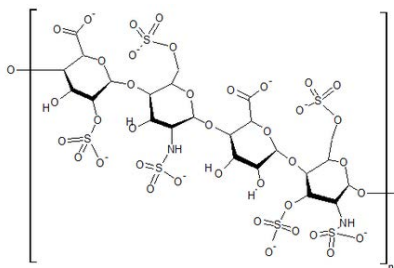


superoxide

But, in the acid environment of heparin:



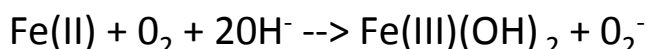
water



\*M.A. Ross et al., Biochem. J. 1992, 286: 717-720.

## Heparin Protects from ROS due to Iron\*

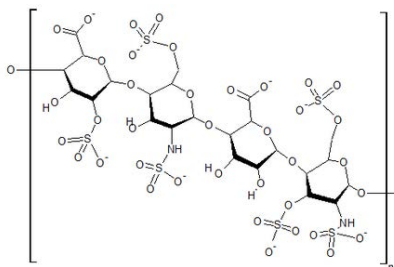
Free radical production (*Fenton* reaction):



superoxide

But, Iron's reaction with oxygen is a major contributor to the artery damage caused by inflammation

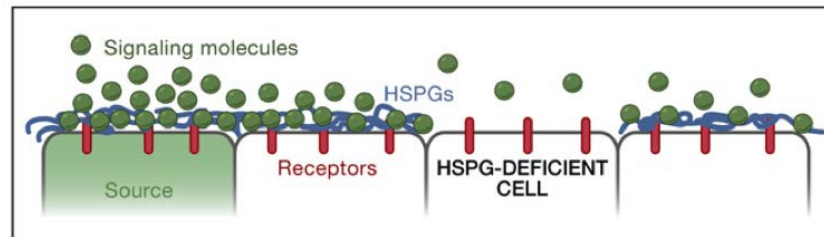
er



\*M.A. Ross et al., Biochem. J. 1992, 286: 717-720.

## Disrupted Signaling when HSPGs are Depleted\*

HSPGs = Heparan Sulfate Proteoglycans



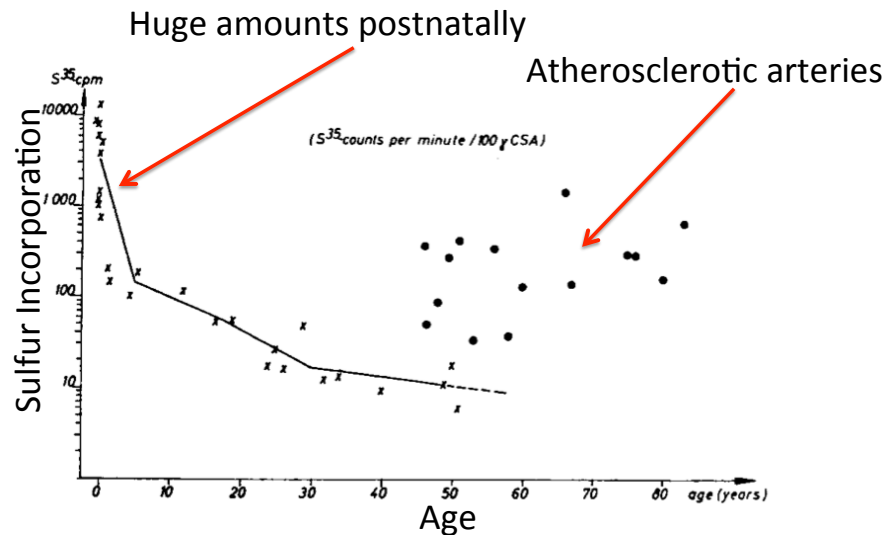
\*Figure 5 in P Muller and AF Schier, Developmental Cell 21, July 19, 2011, 145-158.

## “The universal non-specific mesenchymal reaction”\*

- Studied incorporation of sulfur into GAGs in connective tissue surrounding artery walls, in humans and in rats
- Showed that *aging* leads to a reduction in uptake of sulfur AND slower recycling of GAGs
- Showed also that *atherosclerosis* is a special condition where *much more* sulfur is taken up specifically at the regions where cholesterol and fat have accumulated

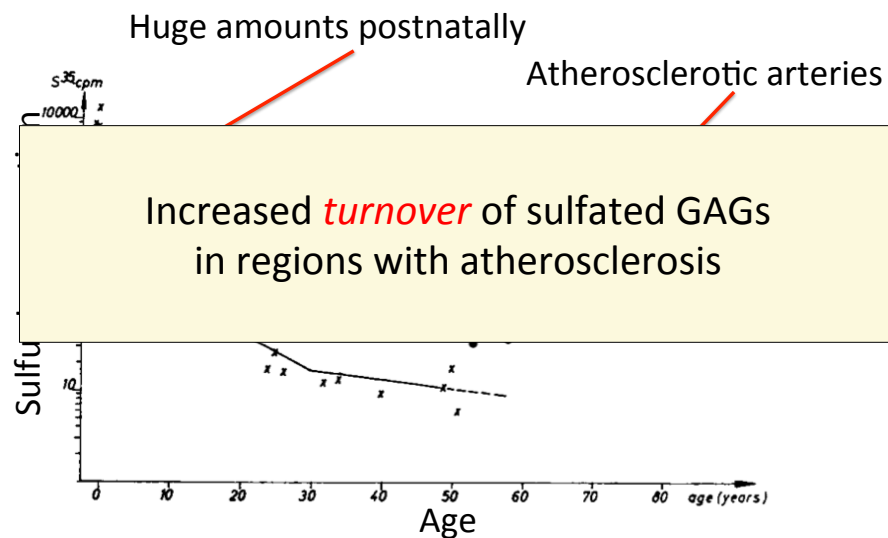
\*WH Hauss et al., Annals NY Acad Sci 156, 207-218, 1969.

## Incorporation of sulfur into GAGs in artery wall\*



\*Figure 6, WH Hauss et al., Annals NY Acad Sci 156, 207-218, 1969.

## Incorporation of sulfur into GAGs in artery wall\*



\*Figure 6, WH Hauss et al., Annals NY Acad Sci 156, 207-218, 1969.

## Heparan Sulfate Deficiency and Autism\*

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



\* F. Irie et al., Autism-like socio-communicative deficits and stereotypies in mice lacking heparan sulfate. PNAS Mar. 27, 2012, 109(13), 5052-5056.

## Recapitulation

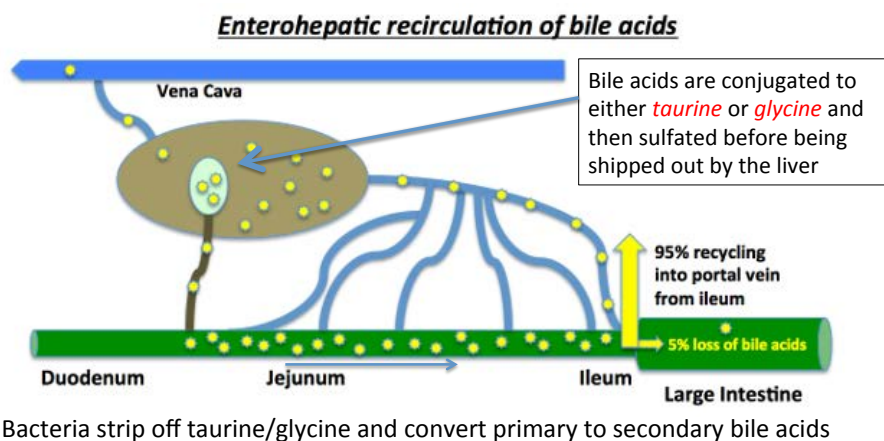
- Cholesterol sulfate is supplied to the vasculature by red blood cells and endothelial cells in response to sunlight – eNOS performs the magic
- Sulfate plays an important role in the vasculature to induce flow and protect from damage due to iron
- The glycocalyx is a complex structure containing abundant heparan sulfate, which regulates cellular signaling and protects the cell membrane from damage
- Heparan sulfate is taken up by cells along with nutrients and it supports acidification of the lysosome to digest nutrients and clear cellular debris
- Heparan sulfate deficiency is associated with autism in a mouse model

# Bile Acids

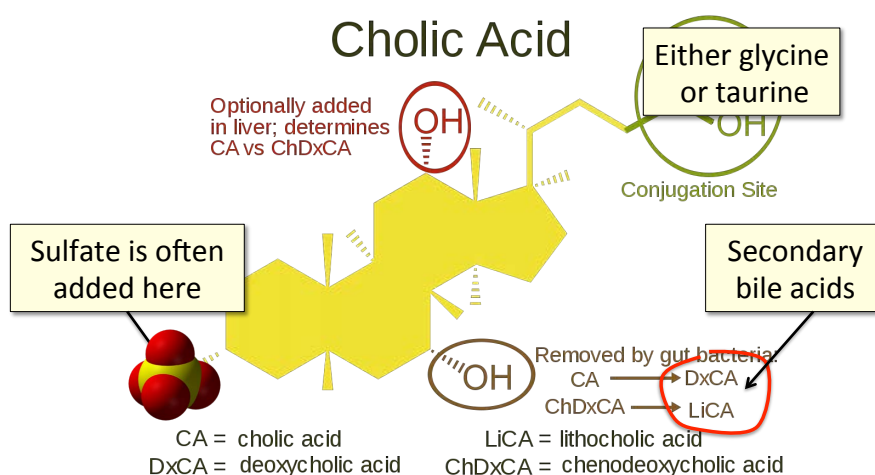
## Bile Acids: A Brief Tutorial

- Bile acids are synthesized in the liver from cholesterol, and circulate between the liver and the digestive tract, with about 5% being lost to the feces with each cycle
  - Bile acid synthesis depends on *cytochrome P450 enzymes*
- Bile acids are conjugated with either taurine or glycine and often sulfated before being secreted
- Conjugated bile salts sit at the lipid/water interface and, at the right concentration, form micelles and solubilize lipids
- Bile acid-containing micelles aid lipases to digest lipids and bring them near the intestinal brush border membrane, promoting fat absorption.

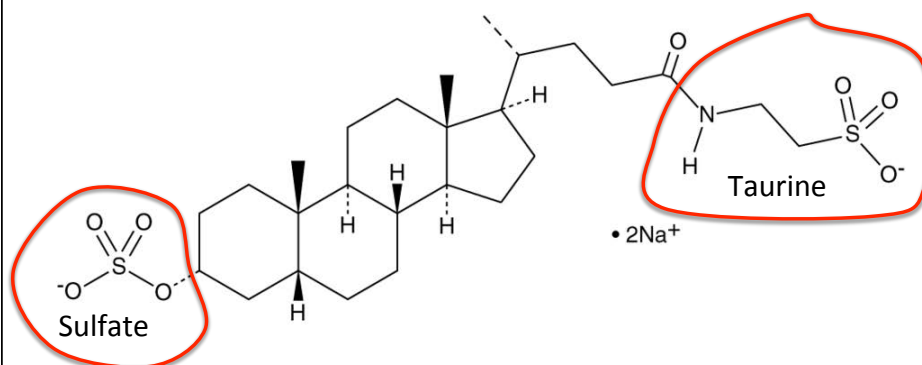
## A cartoon depiction of bile circulation



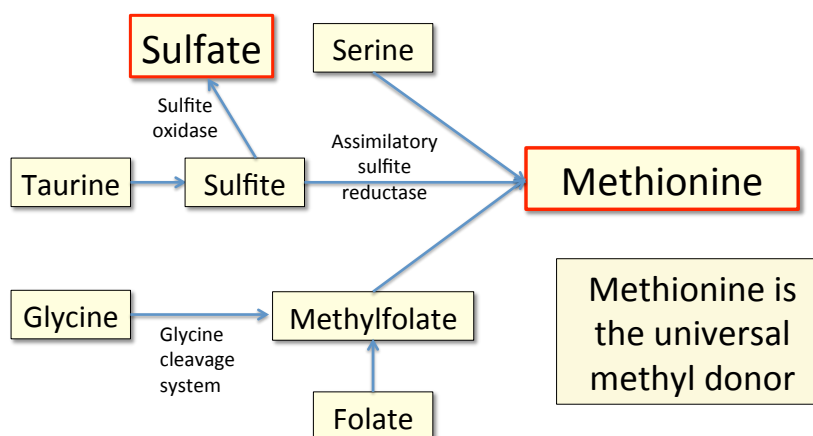
## Modifications of Bile Acids



## Taurolithocholic acid 3-sulfate



## A Hypothesis: Liver delivers taurine and glycine to bacteria to synthesize methionine and sulfate for the host



## **Bifidobacteria modify bile acids to increase gelling potential\***

- *Bifidobacteria* are the most significant microbes in the gut for deconjugating taurine and glycine from bile acids
- Release of deconjugated bile acids by Bifidobacteria causes the aqueous medium to gel

“If such a phenomenon occurs in physiological conditions of human gut, it may improve bacterial ability to colonize the gastrointestinal tract and their survival in this specific ecological niche.”

\*P Jarocki et al. PLOS ONE December 3, 2014; 9(12): e114379.

# **Glyphosate**



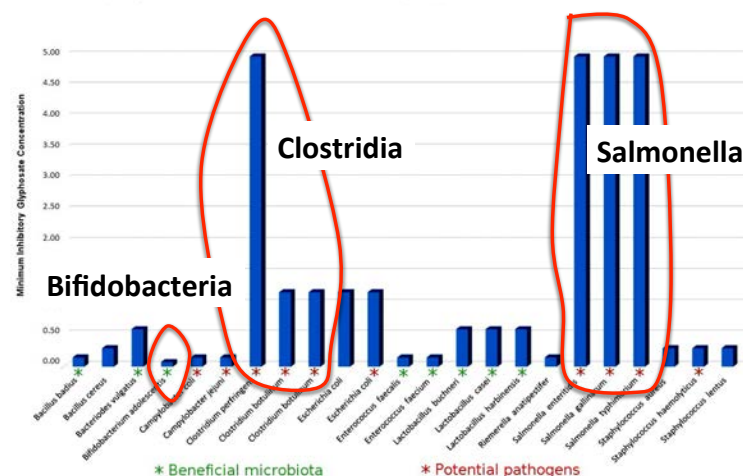
## Main Toxic Effects of Glyphosate\*

- Kills beneficial gut bacteria and allows pathogens to overgrow
  - Bifidobacteria are especially susceptible
- Interferes with function of cytochrome P450 (CYP) enzymes
- Chelates important minerals (iron, cobalt, zinc, manganese, etc.)
- Interferes with synthesis of aromatic amino acids and methionine
  - Leads to shortages in critical neurotransmitters and folate
- Disrupts sulfate synthesis and sulfate transport

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

# 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

## Glyphosate contamination in bile acids\*

- Monsanto's own early studies found glyphosate contamination in bile acids
- Likely mechanism is its role as a glycine analogue:
  - Glyphosate conjugates to the bile acids in place of glycine
- This would be especially damaging to Bifidobacteria, because they deconjugate the bile acids, thus importing and freeing glyphosate

\*Anthony Samsel, personal communication

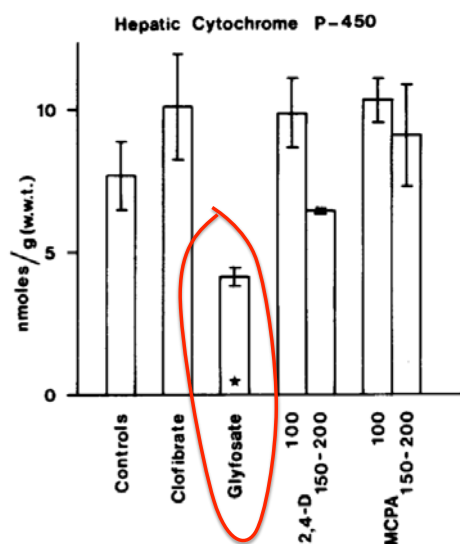
## Glyphosate impairs taurine metabolism by E coli\*

Gene name	Description	Fold reduced
ompF	taurine ATP-binding component of a transport system	-11.07
opmT	taurine transport system periplasmic protein	-2.57
panC	taurine transport system permease protein	-2.07
tauA	taurine transporter subunit tauA	-5.59
tauB	taurine transporter subunit tauB	-6.09
tauC	taurine transporter subunit tauC	-4.62
potF	sulfite reductase (NADPH), flavoprotein beta subunit	-4.55
pntA	sulfite reductase, alpha subunit	-3.23

- ompF, involved in taurine transport, was the most reduced enzyme in the entire table
- Enzymes involved in both taurine transport/ metabolism and assimilatory sulfite incorporation into methionine were suppressed

\*Appendix in W Lu et al. Mol BioSyst 2013 9: 522-530.

## Inhibition of Cytochrome P450 Enzymes (CYPs) by Various Pesticides\*



Study in rats on  
2,4-D, clofibrate,  
MCPA, and  
glyphosate

\* E Hetanen et al., Acta Pharmacol.  
Et Toxicol. 1983, 53, 103-112.

## Bifidobacteria, acetate, NaCl and $\text{SO}_4^{-2}$ in autism

- Autistic children have low Bifidobacteria ( $p = 0.002$ )\*
- Autistic children are hyponatremic (low sodium)\*\*
  - Recurring diarrhea (glyphosate induces leaky gut)\*\*\*
  - Depletion of taurine (taurine-conjugated bile acids lost to feces)
- Autistic children have low gut acetate ( $p = 0.00002$ )\*
  - Loss of acetate-producing microbes that feed on bile acids
- Autistic children have sulfate deficiency\*\*\*\*

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

\*\* P Good. Medical Hypotheses 2011;77:1015-1021.

\*\*\* JJ Gildea et al. Journal of Clinical Nutrition & Dietetics 2017;3:1.1).

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

## A BTBR Mouse Model of Autism\*

These mice had all the mouse features of autism

They were fed “standard rodent chow” – glyphosate contaminated?

Some features in the gut:

- Reduced levels of bile acids (due to impaired CYP7A1 activity in the liver)
- Further reduced levels of secondary bile acids (impaired metabolism by gut microbes)
- Reduced levels of Lactobacillus and Bifidobacteria
  - These microbes are preferentially killed by glyphosate
- Serotonin deficiency
  - Serotonin is derived from tryptophan, a product of the shikimate pathway which glyphosate disrupts

\*AV Glubeva et al. EBioMedicine. 2017 Oct;24:166-178.

## A BTBR Mouse Model of Autism\*

These mice had all the mouse features of autism

They were fed “standard rodent chow” – glyphosate contaminated?

S

- These BTBR mice also had heparan sulfate deficiency in the brain ventricles and a missing corpus callosum
- 
- Reduced levels of Lactobacillus and Bifidobacteria
  - These microbes are preferentially killed by glyphosate
- Serotonin deficiency
  - Serotonin is derived from tryptophan, a product of the shikimate pathway which glyphosate disrupts

\*AV Glubeva et al. EBioMedicine. 2017 Oct;24:166-178.

## Hormones Enhance Sulfate Levels\*

- Sulfate is the fourth most common anion in the body
- Serum sulfate is elevated in infants, young children and pregnant women.
- Estrogen, progesterone, growth hormone and insulin-like growth factor all enhance the expression of the sodium-sulfate cotransporter, increasing serum sulfate levels.

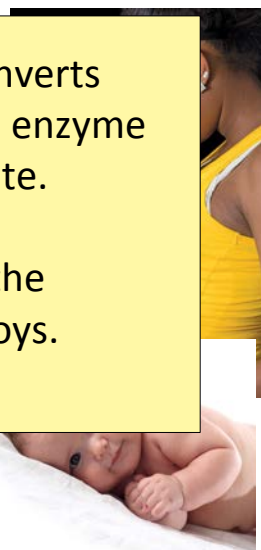


\*HJ Lee et al. Proc Soc Exp Biol Med. 2000;225(1):49-57.

## Hormones Enhance Sulfate Levels\*

- Aromatase, an enzyme that converts testosterone to estrogen, is a CYP enzyme that is inhibited by glyphosate.
- This could partially explain the increased risk to autism in boys.

increasing serum sulfate levels.



\*HJ Lee et al. Proc Soc Exp Biol Med. 2000;225(1):49-57.

## Sulfate Deficient Mice\*

Mice missing the sodium sulfate cotransporter gene (NaSi<sup>-/-</sup> mice) survived in utero but exhibited several metabolic problems:

- Severely reduced serum sulfate levels (75% reduction)
- Significantly reduced litter size and miscarriages
- A seizure disorder
- Stunted growth
- Increased liver size
- 1.5 to 2-fold increased phenol sulfotransferase activity

\*PA Dawson et al. PNAS 2003; 100(23): 13704-13709.

## Sulfate Deficient Mice\*

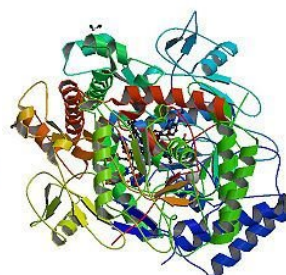
Mice missing the sodium sulfate cotransporter gene (NaSi<sup>-/-</sup> mice) survived in utero but exhibited several

**Toxic phenol-sulfate metabolites  
are implicated in autism\*\***

- A seizure disorder
- Stunted growth
- Increased liver size
- 1.5 to 2-fold increased phenol sulfotransferase activity

\*PA Dawson et al. PNAS 2003; 100(23): 13704-13709.

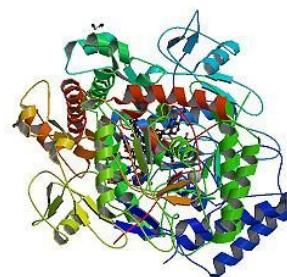
## eNOS is Very Vulnerable\*



\*S. Seneff et al., Entropy 2012, 14, 2492-2530

## eNOS is Very Vulnerable\*

- eNOS depends on:
  - Cobalamin (vitamin B12, cobalt)
  - Heme iron, sulfur, zinc, oxygen
  - Glutathione
  - Sunlight/melanin
  - Tryptophan: source of NAD
- eNOS is a cytochrome P450 enzyme:
  - Highly vulnerable to various environmental toxicants like mercury, aluminum, *glyphosate*, etc.



\*S. Seneff et al., Entropy 2012, 14, 2492-2530.

## eNOS is Very Vulnerable\*

- eNOS depends on:

Glyphosate disrupts eNOS function in multiple ways

- Tryptophan: source of NAD
- eNOS is a cytochrome P450 enzyme:
  - Highly vulnerable to various environmental toxicants like mercury, aluminum, *glyphosate*, etc.

\*S. Seneff et al., Entropy 2012, 14, 2492-2530.

## Glyphosate disrupts eNOS!

- Glyphosate chelates cobalt, zinc and iron, making them unavailable
- Glyphosate interferes with the synthesis of pyrrole, the precursor to heme (in eNOS)
- Glyphosate depletes glutathione by interfering with methionine synthesis by gut microbes
- Glyphosate depletes melanin in the skin (product of shikimate pathway)
  - Impaired conversion of UV light to visible light
- Glyphosate disrupts tryptophan synthesis, depleting NAD
- eNOS has two highly conserved glycine residues
  - Essential for attaching to the membrane and forming a dimer

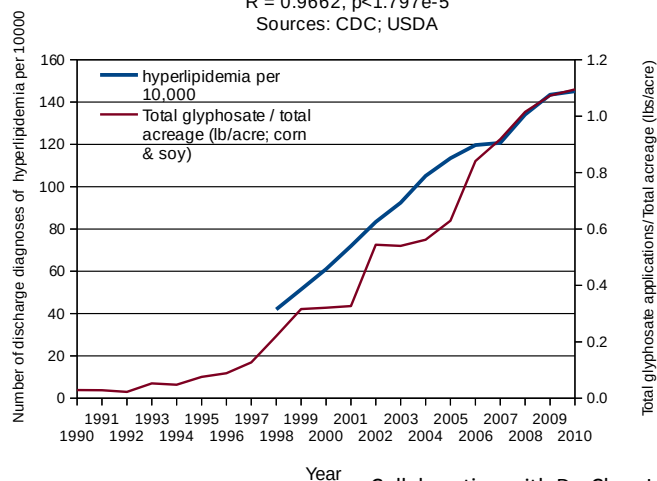


## High Serum Lipids is Correlated with Glyphosate Usage on Corn and Soy Crops

Hospital Discharge Diagnoses of Hyperlipidemia (ICD 272.0-4)  
& Glyphosate applied to corn & soy crops

$R = 0.9662$ ,  $p < 1.797 \times 10^{-5}$

Sources: CDC; USDA



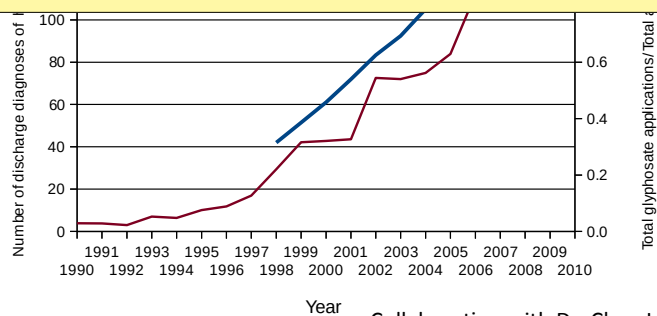
Collaboration with Dr. Chen Li and Dr. Nancy Swanson

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Glyphosate disrupts bile acid synthesis and forces liver to distribute cholesterol as LDL particles instead

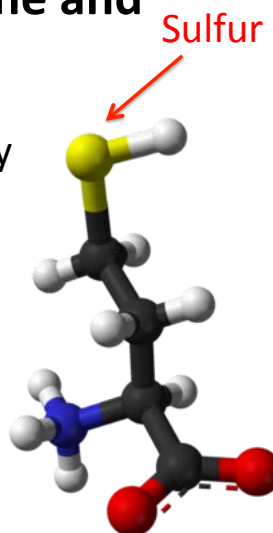


Collaboration with Dr. Chen Li and Dr. Nancy Swanson

## Diseases Linked to Sulfate Deficiency

### Elevated Homocysteine and Heart Disease\*

- 587 patients with coronary artery disease followed over median period of 4.6 years
- Homocysteine > 15  $\mu\text{mol/Liter}$   
→ *6.5-fold increase*  
in death rate compared to  
homocysteine < 10  $\mu\text{mol/Liter}$

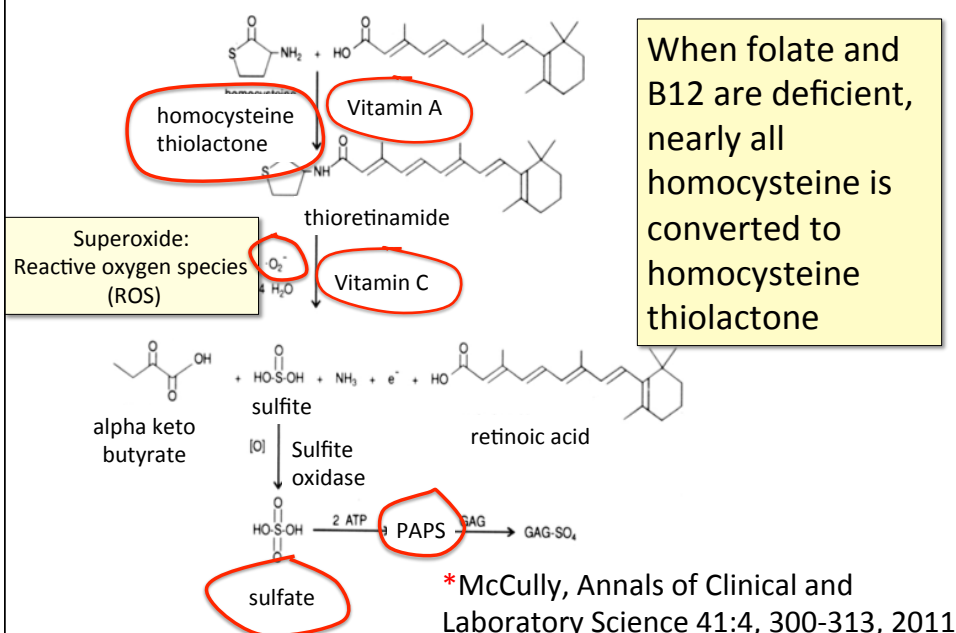


\*P.O. Lim et al., Journal of Human Hypertension (2002) 16, 411–415.

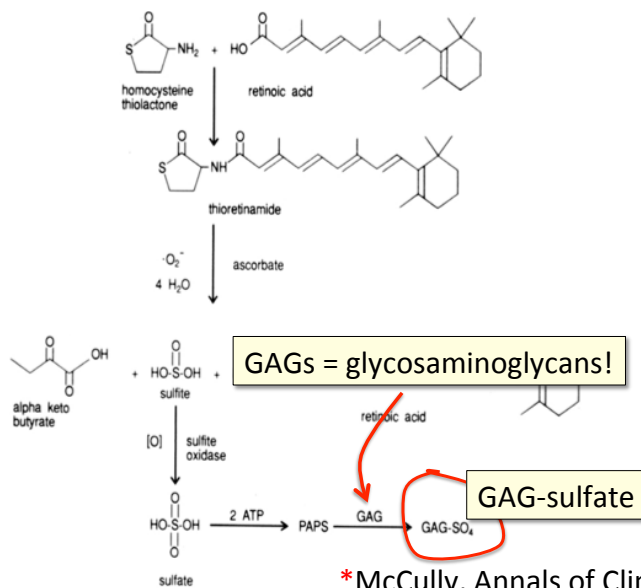
## Hypothesis:

Homocysteine becomes elevated when sulfate supplies are depleted because it can be a source of new sulfate

## Pathway from Homocysteine to Sulfate\*



## Pathway from Homocysteine to Sulfate\*



\*McCully, Annals of Clinical and Laboratory Science 41:4, 300-313, 2011

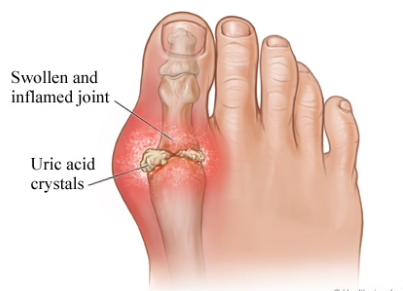


04SE17A

Can glyphosate's disruption of the gut microbiome and induction of sulfate deficiency explain the epidemic in gout and associated diseases in the industrialized world?\*

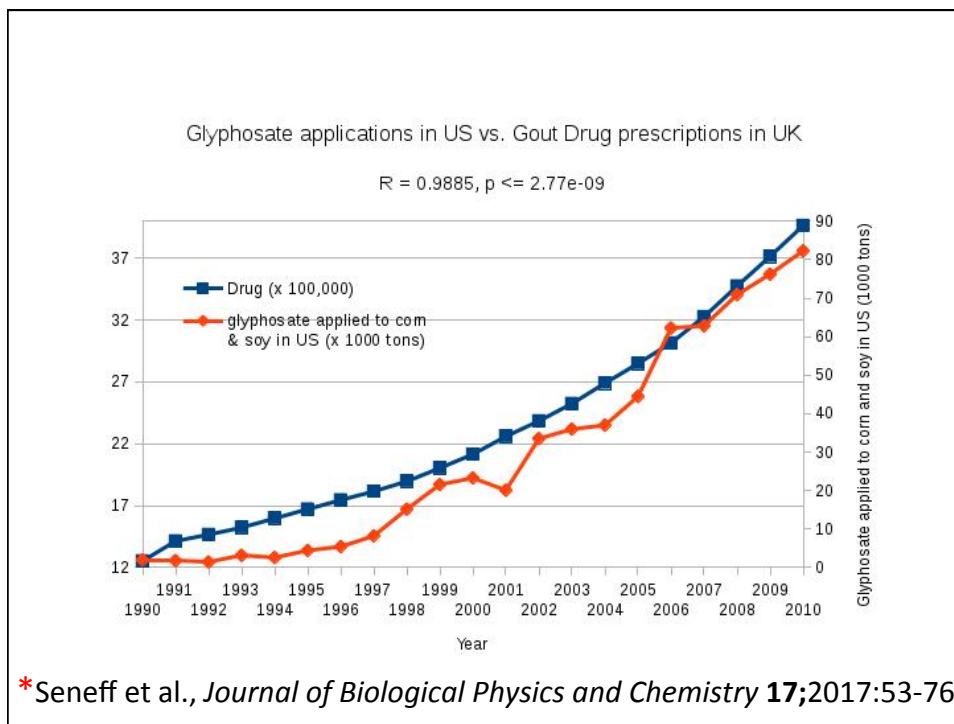
Stephanie Seneff,<sup>1,\*</sup> Nicholas J. Causton,<sup>2</sup> Gregory L. Nigh,<sup>3</sup> Gerald Koenig<sup>4,5</sup> and Dette Avalon<sup>6</sup>

Paper explains how the complex signaling cascade that takes place in the gouty toe joint is a carefully orchestrated plan to synthesize cholesterol sulfate and supply it to invading immune cells.



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\*Seneff et al., *Journal of Biological Physics and Chemistry* **17**;2017:53-76



## Heparan Sulfate Deficiency in Autism

### Humans:

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

### Mice:

“Hippocampus/amygdala alterations, loss of heparan sulfates, fractones and ventricle wall reduction in adult BTBR T+ tf/J mice, animal model for autism”\*\*

\*BL Pearson et al. *Behav Brain Res.* 2013; 243: 138–145

\*\*F Mercier et al. *Neurosci Lett* 2012;506(2):208-13.

## Review

**Is Encephalopathy a Mechanism to Renew Sulfate in Autism?**Stephanie Seneff<sup>1,\*</sup>, Ann Lauritzen<sup>2</sup>, Robert M. Davidson<sup>3</sup> and Laurie Lentz-Marino<sup>4</sup>

Chronic low-grade encephalopathy (brain inflammation) characterizes autism. Signaling cascade in the brain leads to taurine release and hypothesized synthesis of sulfate from taurine by microbes

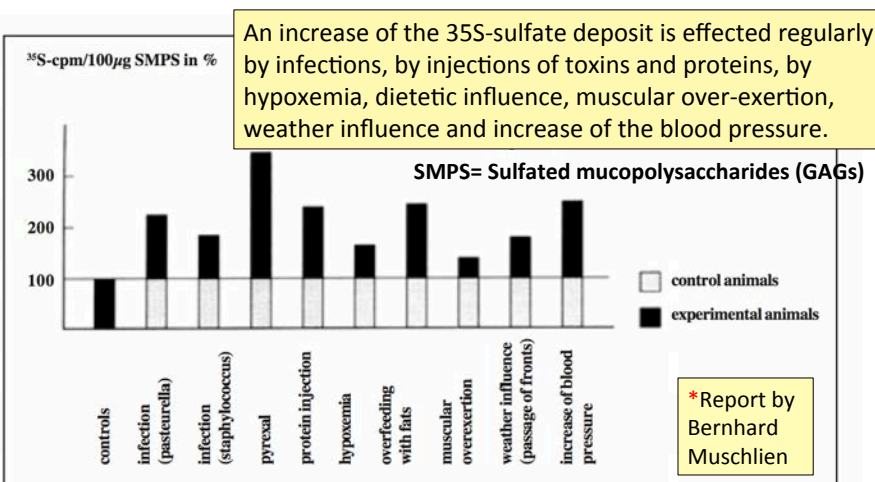
**Various Factors that Increase Sulfate\***

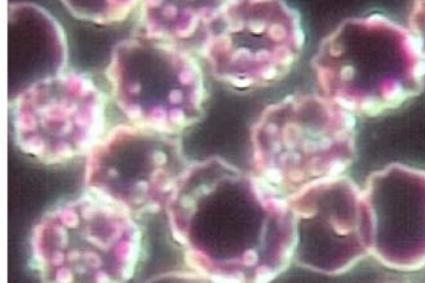
Fig. 2: Selected examples of factors that cause an increase of the SMPS synthesis, illustrated at the parameter of the <sup>35</sup>S-sulfate deposit in the connective tissue of various organs.

SMPS = Sulfated mucopolysaccharides = glycosaminoglycans

\* First published in the German language in the SANUM-Post magazine (17/ 1991)

## Chlamydia pneumoniae

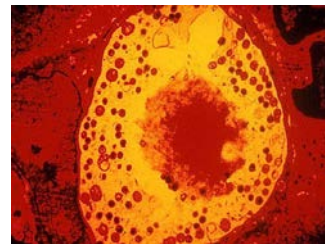
- Cause pneumonia when they infect the lungs
- Show up frequently in cardiovascular plaque
- Show up frequently in Alzheimer's plaque



*What are they doing there???*

## Chlamydia Produce Heparan Sulfate!\*

- Chlamydia are viable only inside host cells
- They set up housekeeping in vacuoles within the cell (e.g., a macrophage in the plaque)
- They produce a glucosamine-containing sulphated polysaccharide that is nearly indistinguishable from heparan sulfate
- They have a unique set of enzymes for this



\* S.J. Rasmussen-Lathrop et al, Cell Microbiol. 2000 Apr, 2(2), 137-44.

## Chlamydia Produce Heparan Sulfate!\*

- Chlamydia are viable only



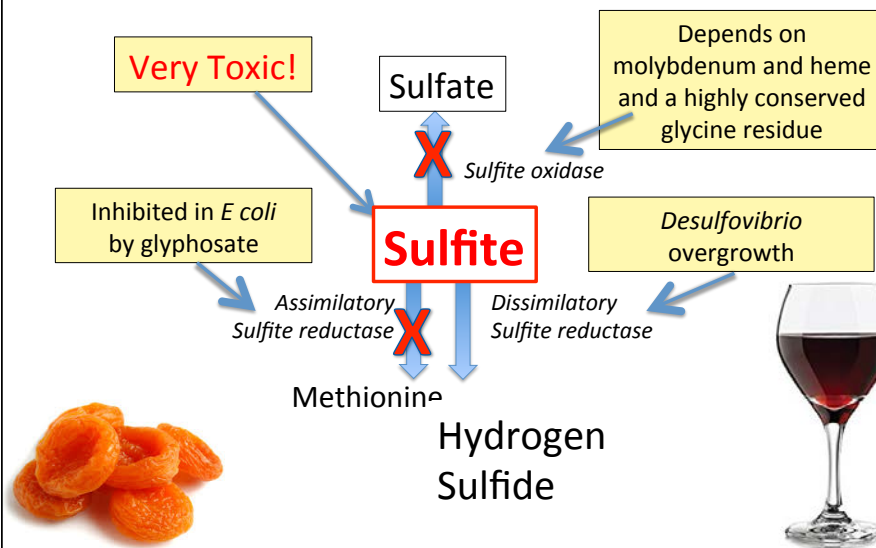
Are they assisting the host by boosting heparan sulfate levels in the artery wall?

(e.g., a macrophage in the plaque)

- They produce a glucosamine-containing sulphated polysaccharide that is nearly indistinguishable from heparan sulfate
- They have a unique set of enzymes for this

\* S.J. Rasmussen-Lathrop et al, Cell Microbiol. 2000 Apr, 2(2), 137-44.

## Sulfite Metabolism: Sulfur Sensitivity





## Sulfite Metabolism: Sulfur Sensitivity

Depends on

Desulfovibrio overgrowth is linked to autism.

Desulfovibrio convert mercury to a very toxic organic methylmercury metabolite.



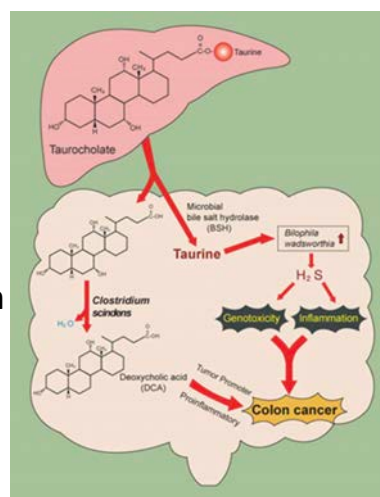
Methionine

Hydrogen  
Sulfide



## Colon Cancer\*

- Clostridia (overgrowth with glyphosate exposure) leads to inflammation in the gut
- Assimilatory sulfite reduction is disturbed by glyphosate, allowing overgrowth of sulfur-reducing bacteria and excessive production of hydrogen sulfide
- This increases risk to colitis and, over time, leads to colon cancer, an epidemic in America



\*JM Ridlon et al. Gut Microbes 2016; 7(3): 201-215.

## Curcumin and Other Flavonoids

### Curcumin Has Many Benefits\*

- Suppresses carcinogenesis in skin, stomach, colon, breast and liver
- Induces apoptosis in a wide variety of tumor cells
- Downregulates various proinflammatory cytokines



There is a low incidence of colorectal cancer in India where curcumin is heavily used in curries

\* SK Varid et al, *Cancer Epidemiol Biomarkers Prev* 2008;17:1411-1417.

## Curcumin Has Many Benefits\*

An intractable myeloma was sent into remission with curcumin therapy (8g/day) and hyperbaric oxygen



\*Zaidi A, et al. BMJ Case Rep April 16 2017. doi:10.1136/bcr-2016-218148

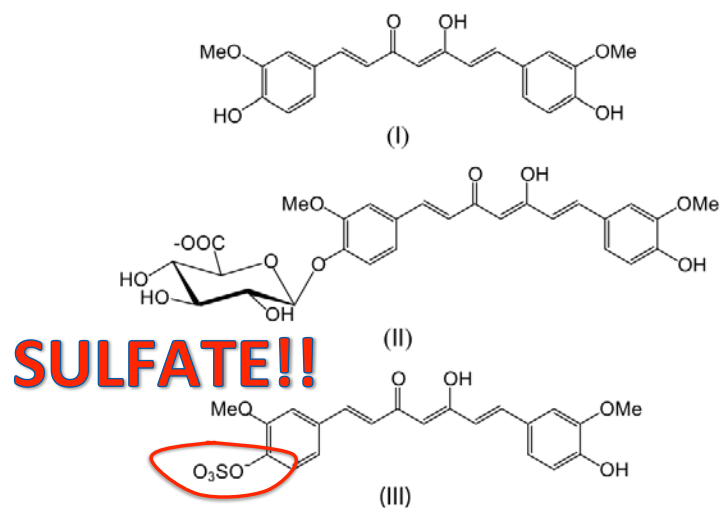
## Curcumin Has Many Benefits\*

- Loss of body fat and adipose-associated macrophages
- Reduced inflammatory-related atherogenesis
- Antidiabetic effect
  - Lower Hemoglobin A1c
- Lower total cholesterol and LDL-C
- Higher HDL-C.



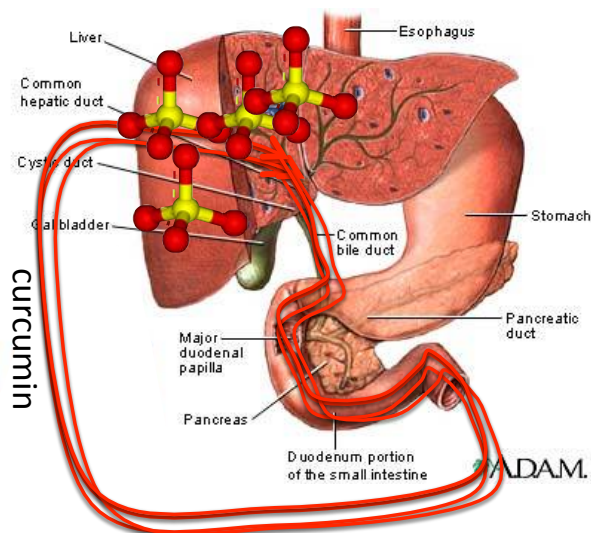
\*S Cuengsamarna et al., journal of Nutritional Biochemistry 25 (2014) 144–150.

## Three Forms of Curcumin\*



\* Figure 1 in SK Varid et al, *Cancer Epidemiol Biomarkers Prev* 2008;17:1411-1417.

## Curcumin Goes Around and Around Delivering Sulfate to Liver!



## Curcumin Prevents Diabetes\*

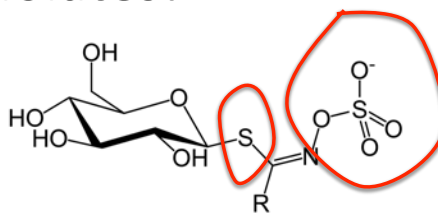
### CONCLUSIONS:

“A 9-month curcumin intervention in a prediabetic population significantly lowered the number of prediabetic individuals who eventually developed type 2 diabetes. In addition, the curcumin treatment appeared to improve overall function of [pancreatic] beta-cells, with very minor adverse effects.”

\*S Chuengsamarn et al., Diabetes Care 35, 2012, 2121-2127

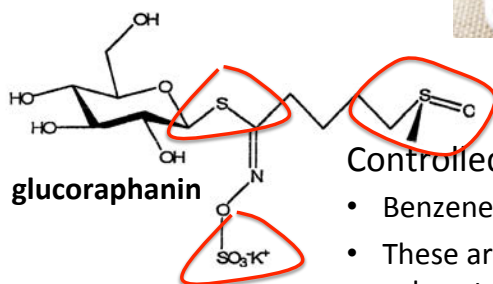
## Glucosinolates!

- Natural components of many pungent plants such as mustard, cabbage and horseradish
- Contribute to plant defense against pests and diseases



## Broccoli Sprouts\*

- Sprouts contain 30x nutrients of organic vegetables
- Grow your own and eat them raw!

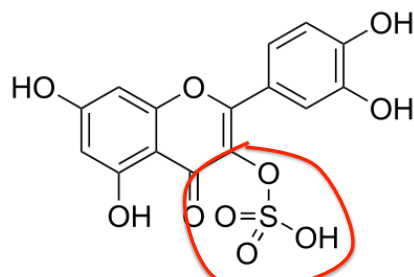
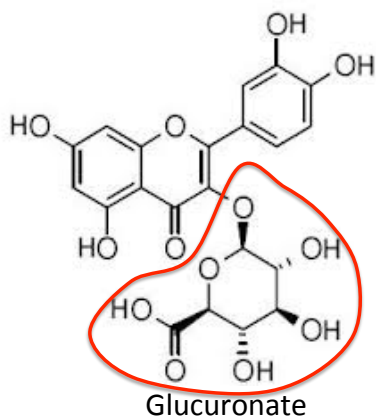


Controlled study in China:

- Benzene and acrolein detoxed into urine
- These are chemicals in dirty air from car exhaust and burning fuels

\*[articles.mercola.com/sites/articles/archive/2014/06/30/broccoli-sprout-detox.aspx](http://articles.mercola.com/sites/articles/archive/2014/06/30/broccoli-sprout-detox.aspx)

## Quercetin: A Sulfate Transporter\*



**Sulfate**

Net effect:  
gut delivers sulfate to the liver

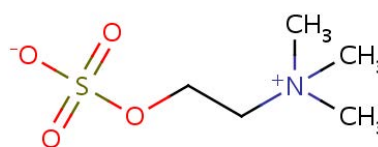


\*IR Rowland, Toxicol Pathol 1988 16:147-153.

## Choline sulfate!!\*

- Produced by plants, lichens, algae, fungi, and several bacterial species
- Experiment demonstrated that it had superior capabilities to inhibit amyloid formation in pancreatic beta cells

– Amyloid in beta cells is akin to amyloid beta in Alzheimer's disease and plays a major role in type-II diabetes



\*M. Hagihara et al., FEBS Open Bio 2 (2012) 20–25.

**Prevention of Disease  
through Diet and Lifestyle**

## Most Important: Go Organic!



## How Much Does it Cost?

Food	Organic	Conventional
celery	2.99	1.99
cauliflower	4.99	2.99
Bartlett pears	2.69	1.99
orange juice	3.99	2.99
eggs	5.69	3.99
milk	4.69	2.99
cereal	4.56	3.91
TOTAL	29.60	20.85

*increase bill by ~40%*



## Probiotics! – Maintain Healthy Gut



- Sauerkraut and apple cider vinegar contain acetobacter, one of the very few microbes that can metabolize glyphosate
- Yogurt and kimchi probably do too



## Are We Getting Enough Sulfur in Our Diet?\*

- Most abundant mineral element behind calcium and phosphorus
- Chondroitin sulfate, glucosamine sulfate, etc. used to treat diseases of the joints

“Out of this study came information that suggested that a significant proportion of the population that included disproportionately the *aged*, may not be receiving sufficient sulfur and that these dietary supplements, were very likely exhibiting their pharmacological actions by supplying inorganic *sulfur*.”

\*ME Nimni et al., *Nutrition & Metabolism* 2007, 4:24



## Some sulfur-containing supplements

- Biotin
- Taurine
- N-acetyl Cysteine
- Glutathione
- S-adenosyl Methionine
- Alpha Lipoic Acid
- DMSO (dimethyl sulfoxide)
- MSM (methyl sulfonyl methane)
- DMPS (chelating agent)
- Epsom Salts



## Flavonoids and Polyphenols!



## Escape to a sunny place in winter!



## If you Live in Canada, Use a Sunlamp!



## Epsom Salts!

Magnesium Sulfate in hot bath water is a cheap and easy way to get sulfate supply to the skin  
Infrared heat also beneficial!



## Treating Glyphosate Poisoning in Animals (e.g., cows) \*

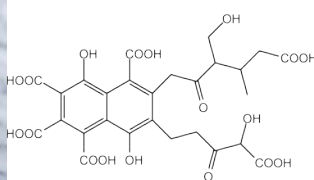


Sauerkraut Juice

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



## Summary

- *Cholesterol sulfate* is an essential molecule in the body to maintain vascular health
  - Produced in the skin upon sunlight exposure
- *Heparan sulfate* plays multiple roles in the body and its deficiency is linked to autism
- *Bile acids* play an essential role in supplying taurine to the body, and taurine is an essential storage form of sulfate
  - Taurine deficiency may be a key factor in autism
- *Glyphosate* is a pervasive toxicant that is causing a major health crisis in the US
  - Much of its toxicity relates to disruption of gut microbes
- An *organic whole foods diet rich in sulfur, cholesterol and polyphenols* has many health benefits
- It is essential to get abundant *sunlight exposure* to the skin without sunscreen

**Thank you for listening!**