

## ***Is Roundup the Toxic Chemical that's Destroying Our Health?***

Stephanie Seneff, CSAIL, MIT

Sunday, March 16, 2014

Physicians' Round Table, Tampa FL



## **Download These Slides**

<http://people.csail.mit.edu/seneff/glyphosate/SeneffTampaGlyphosate2014.pptx> (.pdf)

**“The price of anything is the  
amount of life you exchange for it.”**

Henry David Thoreau

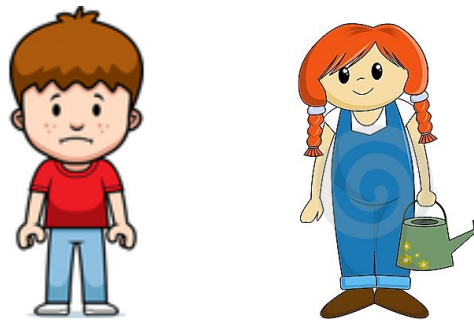
## **Outline**

- Autism Epidemic
- Digestive Disorders and Kidney Failure
- Endocrine Disruption, Cancer and Obesity
- Are We Exposed?
- Summary

## The Autism Epidemic in the U.S. (US CDC Data)



## One in Two in 2025?



The rate was 1 in 10,000 in 1970

## Some Conditions Associated with Autism

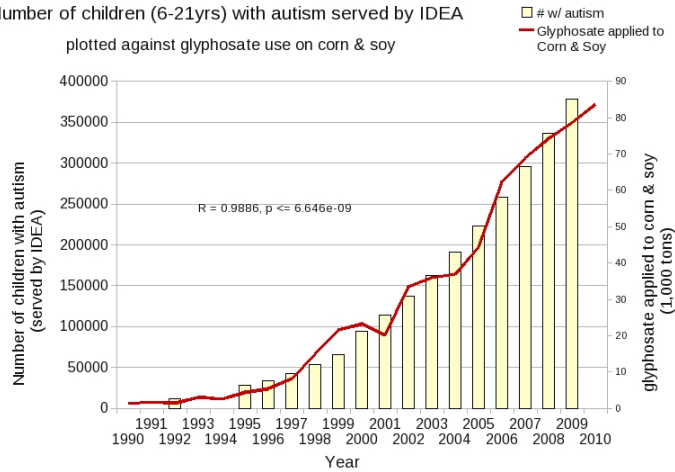
- Disrupted gut bacteria
- Depleted serotonin supply
- Deficiency in sulfur metabolites

Is there a toxic substance that is currently on the rise in our environment that could account for these comorbidities?



## Glyphosate and Autism\*

Number of children (6-21yrs) with autism served by IDEA plotted against glyphosate use on corn & soy

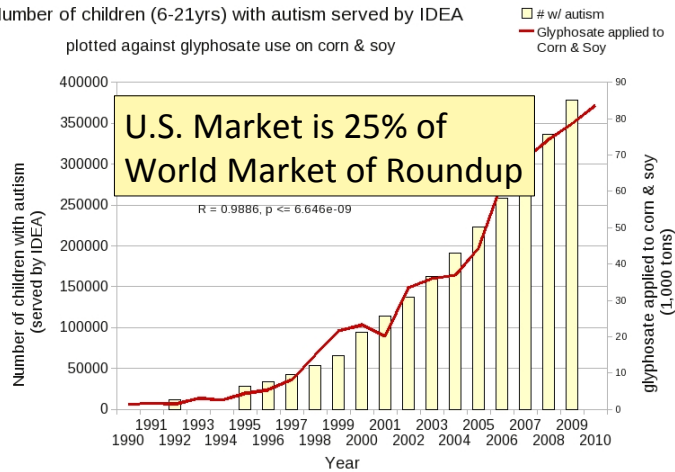


**Pearson Correlation Coefficient = 0.99**

\*Nancy Swanson, <http://www.examiner.com/article/data-show-correlations-between-increase-neurological-diseases-and-gmos>

## Glyphosate and Autism\*

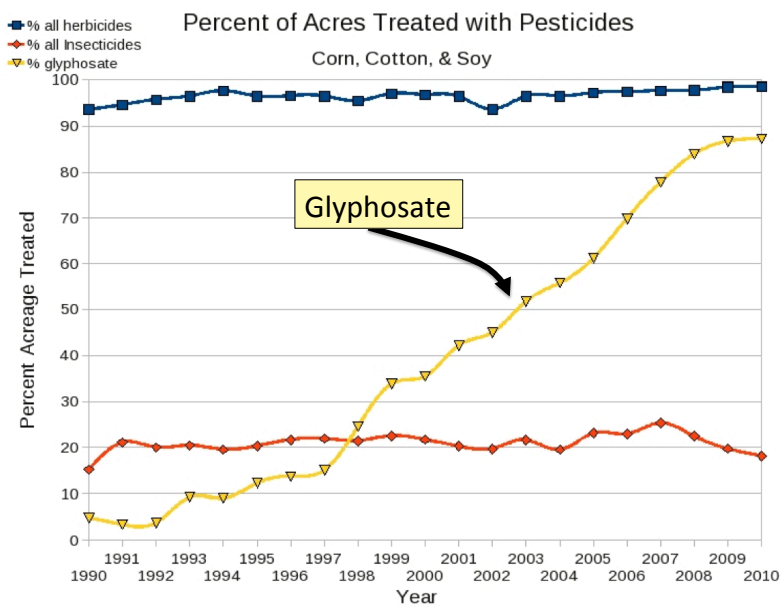
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## Glyphosate vs. Other Pesticides\*



## Recent Publication

*entropy*  
ISSN 1099-4300  
[www.mdpi.com/journal/entropy](http://www.mdpi.com/journal/entropy)

*Review*

**Glyphosate's Suppression of Cytochrome P450 Enzymes and Amino Acid Biosynthesis by the Gut Microbiome: Pathways to Modern Diseases**

**Anthony Samsel<sup>1</sup> and Stephanie Seneff<sup>2,\*</sup>**

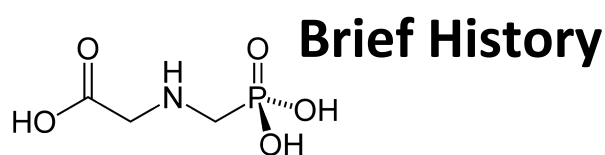
<sup>1</sup> Independent Scientist and Consultant, Deerfield, NH 03037, USA;  
E-Mail: [anthony.samsel@acoustictracks.net](mailto:anthony.samsel@acoustictracks.net)

<sup>2</sup> Computer Science and Artificial Intelligence Laboratory, MIT, Cambridge, MA 02139, USA

\* Author to whom correspondence should be addressed; E-Mail: [Seneff@csail.mit.edu](mailto:Seneff@csail.mit.edu);  
Tel.: +1-617-253-0451; Fax: +1-617-258-8642.

*Received: 15 January 2013; in revised form: 10 April 2013 / Accepted: 10 April 2013 / Published:*

**Abstract:** Glyphosate, the active ingredient in Roundup®, is the most popular herbicide used worldwide. The industry asserts it is minimally toxic to humans, but here we argue otherwise. Residues are found in the main foods of the Western diet, comprised primarily



- Glyphosate is now the #1 herbicide in use in the U.S. and is increasingly used around the world
  - Developed and patented by Monsanto in the 1970's
  - 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, sugar beet and canola crops has led to sharp increases in glyphosate usage in the last decade
- New practice of desiccation with Roundup on wheat, sugar cane and other crops contributes as well

### ***Is Glyphosate Nontoxic?***

- Monsanto has argued that glyphosate is harmless to humans because we don't have the shikimate pathway
- However, our gut bacteria DO have this pathway
  - We depend upon them to supply us with essential amino acids (among many other things)
- Other ingredients in Roundup greatly increase glyphosate's toxic effects
- Insidious effects of glyphosate accumulate over time
  - Most studies are too short to detect damage

## Glyphosate: Some Biological Effects\*

- Depletes aromatic amino acids and methionine
- Disrupts gut bacteria
  - Studies with chickens, cows and pigs show overgrowth of pathogens in gut
- Disrupts cytochrome P450 (CYP) enzymes which are involved in many biological functions
- Depletes important minerals
  - Calcium, manganese, zinc, cobalt, iron, ....
- Likely impairs sulfate synthesis and sulfate transport

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

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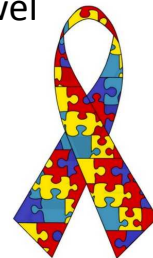


## Glyphosate: Some Biological Effects (cont'd)

- **Depletes aromatic amino acids and methionine**
  - Tryptophan → serotonin → melatonin
    - Serotonin deficiency is linked to obesity, autism, Alzheimer's disease, depression, and violent behavior
    - Melatonin controls sleep/wake cycle
  - Tyrosine → dopamine, adrenaline, melanin, thyroid hormone
    - Dopamine deficiency leads to Parkinson's disease
    - Melanin in skin protects from UV exposure
  - Methionine is an essential sulfur-containing amino acid
- **Disrupts cytochrome P450 (CYP) enzymes which are involved in:**
  - Activation of vitamin D, catabolism of retinoic acid
  - Bile acid production
  - Detoxifying environmental toxins
  - Stabilizing blood (hemorrhaging vs blood clots)

## Some Biomarkers for Autism

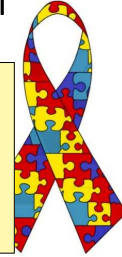
- Disrupted gut bacteria; inflammatory bowel
- Low serum sulfate
- Methionine deficiency
- Serotonin and melatonin deficiency
- Defective aromatase (CYP enzyme)
- Zinc and iron deficiency
- Vitamin D deficiency
- Impaired immune function
- Chronic low-grade inflammation in the brain



## Some Biomarkers for Autism

- Disrupted gut bacteria; inflammatory bowel
- Low serum sulfate

These can all be explained as potential effects of glyphosate on biological systems



- Vitamin D deficiency
- Impaired immune function
- Chronic low-grade inflammation in the brain

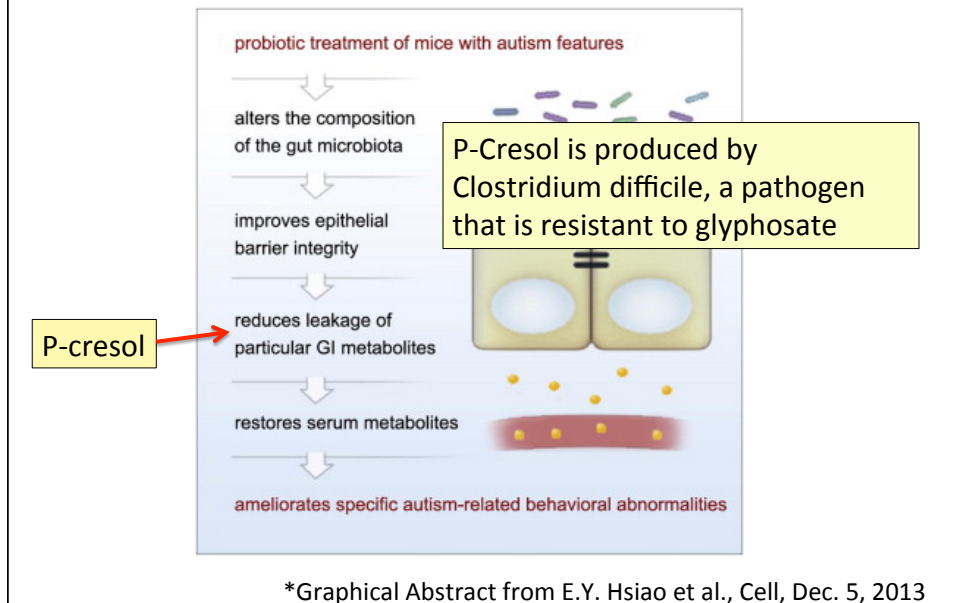
## Aromatase

“Aromatase protein is significantly reduced in the frontal cortex of autistic subjects relative to sex- and age-matched controls”\*

- Aromatase is a *CYP enzyme* that converts testosterone to estrogen
- Its association with autism explains the fact that boys are four to five times as susceptible as girls to autism.

\*T. Sarachana et al., PLoS ONE, Feb. 2011, 6(2):e17116

## Probiotics Treat Mouse Autism\*



*The FASEB Journal* • Review

Adapted from the FASEB J page proofs, 02/18/14

Estimated embargo date is February 26, 2014

Actual embargo date is the date it will appear on the FASEB J website.

Here is link of where the article will appear: <http://www.fasebj.org/content/early/recent>

### Vitamin D hormone regulates serotonin synthesis.

#### Part 1: relevance for autism

Rhonda P. Patrick<sup>1</sup> and Bruce N. Ames<sup>1</sup>

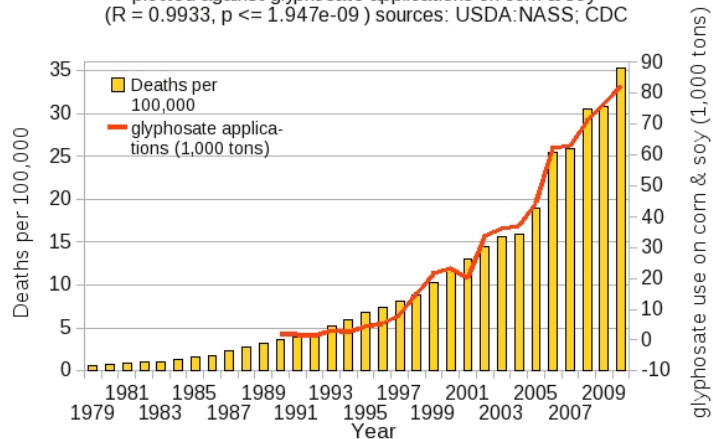
Glyphosate suppresses tryptophan synthesis by plants and gut bacteria

Oakland, CA

- Autism is associated with low activated vitamin D and low brain serotonin
  - Vitamin D activates serotonin receptors in the brain
- Estrogen rescues females by boosting serotonin levels in brain
- Recommendation is supplements in both vitamin D and tryptophan

## Dementia and Glyphosate\*

Deaths from Senile Dementia (ICD F01, F03 & 290)  
plotted against glyphosate applications on corn & soy  
( $R = 0.9933$ ,  $p <= 1.947e-09$ ) sources: USDA:NASS; CDC



\*Nancy Swanson, <http://www.examiner.com/article/data-show-correlations-between-increase-neurological-diseases-and-gmos>

## Recapitulation

- Autism rates have been increasing at an alarming rate in recent years, in step with increases in glyphosate application to GMO crops
- Autism is associated with disrupted gut bacteria, serotonin and vitamin D deficiency, methionine deficiency, excess p-cresol, etc.
- Most of the biomarkers associated with autism can be explained by known biological effects of glyphosate
- These effects can also explain many other modern diseases and conditions, including dementia

## Outline

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- *Digestive Disorders and Kidney Failure*
- Endocrine Disruption, Cancer and Obesity
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## Dr. Roy Dittman\*

“If the microbial world is the substrate for life, why are we waging war on it?”

“The same chemicals we use to sterilize our environment sterilize us.”

\*Talk at AutismOne Conference, May 25, 2013 Chicago, Illinois

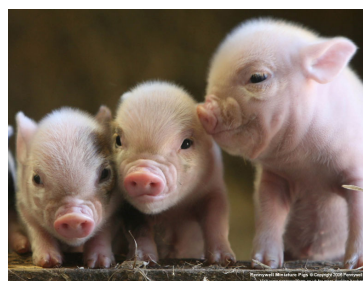
## Gut Microbes and Obesity

- Our microbes outnumber our own cells 10 to 1
- There are between 200 and 300 different species in a typical person.
- Glyphosate causes a loss of beneficial bacteria and an overgrowth of pathogens in the gut
  - Pathogens release toxic phenols (e.g., p-cresol)
  - This can lead to inflammatory bowel disease
    - And a direct path to obesity!
- Gut microbes from an obese person induced obesity in mice\*

\*N. Fei and L. Zhao, The ISME Journal, Online Publication Dec. 2012 wallpaperzz.com

### **Pigs Fed GMOs Develop Inflamed Gut\***

- Pigs have a similar digestive system to humans
- Digestive problems observed anecdotally in GMO-fed pigs
  - inflammation in stomach and intestine, stomach ulcers, thinning of intestinal walls, increase in haemorrhagic bowel disease



#### Follow-on Experiment:

- 168 just-weaned pigs fed "typical diet," soy and corn, until slaughtered
  - Half fed GMO versions, half organic.

\*J.A. Carman et al., Journal of Organic Systems, 8(1), 2013.

## Pigs Fed GMOs Develop Inflamed Gut\*

- Blind autopsies conducted
  - Female pigs' uterus 25% larger in GMO-fed pigs
  - Female pigs 2.2x more likely to get severe stomach inflammation on GMO diet
  - Males were 4x more likely



Photos kindly provided by Howard Vlieger

\*J.A. Carman et al., *Journal of Organic Systems*, 8(1), 2013.

## “Deformities, sickness and livestock deaths: the real cost of GM animal feed?”\*

"When using GM feed I saw symptoms of bloat, stomach ulcers, high rates of diarrhoea, pigs born with the deformities ... but when I switched [to non GM feed] these problems went away, some within a matter of days."



Quote from Ib Pedersen, producer of 13,000 pigs a year supplying Europe's largest pork company, Danish Crown

\*Andrew Wasley, Nov. 28, 2013, *The Ecologist*, [theecologist.org/News/news\\_analysis/2176082/deformities\\_sickness\\_and\\_livestock\\_deaths\\_the\\_real\\_cost\\_of\\_gm\\_animal\\_feed.html](http://theecologist.org/News/news_analysis/2176082/deformities_sickness_and_livestock_deaths_the_real_cost_of_gm_animal_feed.html)

## **America's Two-Headed Pig\***

Treating Nutritional Deficiencies and Disease  
in a Genetically Modified, Antibiotic Resistant  
and Pesticide Dependent World



\*book by Leah Dunham, [www.americastwoheadedpig.com](http://www.americastwoheadedpig.com), 2013

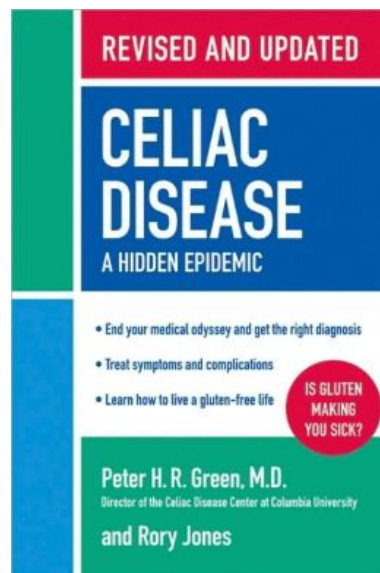
## **Human Digestive System Disorders**

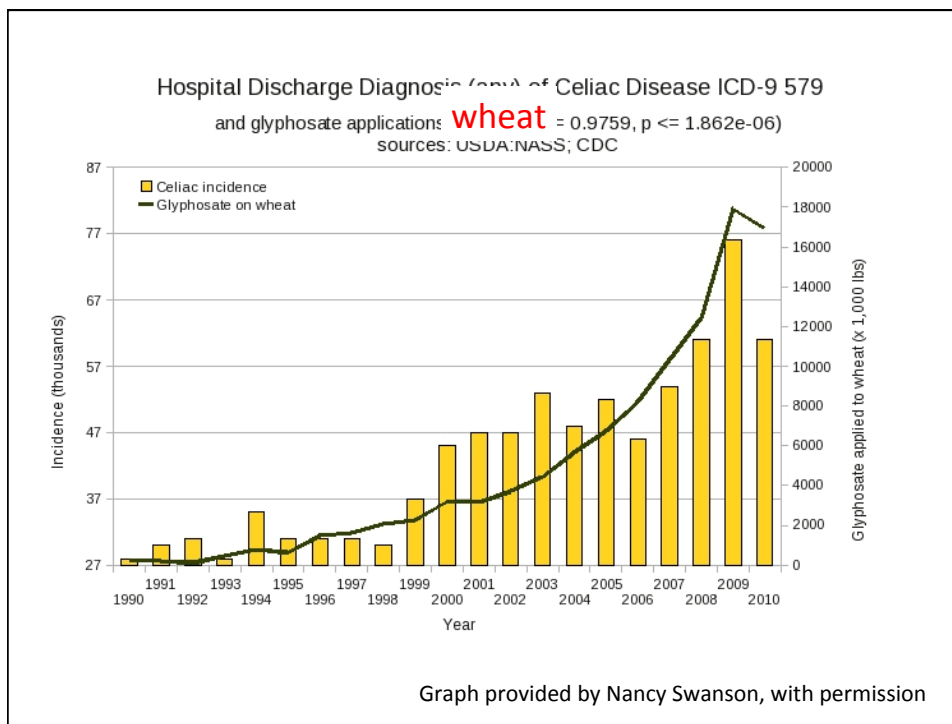
- We are seeing an alarming increase in the US in many diseases related to the gut
  - Crohn's disease, inflammatory bowel disease, colitis, acid reflux disease, gluten and casein intolerance, celiac disease, leaky gut
- The gut-brain axis links neurological disorders with gut disorders
- I believe that glyphosate is a major cause





## Celiac Disease has Quadrupled in the US in the Last 50 Years





## Human Dietary Experiment on Wheat & Inflammatory Bowel Syndrome\*

- Significant improvement in symptoms with dietary organic wheat from ancient source

- Abdominal pain ( $P < 0.0001$ )
- Bloating ( $P = 0.004$ )
- Stool consistency ( $P < 0.001$ )
- Tiredness ( $P < 0.0001$ )



- Reduced pro-inflammatory cytokines: IL-6, IL-17, interferon-gamma, VEGF

\*F. Sofi et al., Br J Nutr. 2014 Feb 13:1-8. [Epub ahead of print]

## Paper on Glyphosate and Celiac Disease

Interdiscip Toxicol. 2013; **Vol. 6**(4): 159–184.  
**doi:** 10.2478/intox-2013-0026  
 Published online in:  
[www.intertox.sav.sk](http://www.intertox.sav.sk) & [www.versita.com/it](http://www.versita.com/it)



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### REVIEW ARTICLE

## Glyphosate, pathways to modern diseases II: Celiac sprue and gluten intolerance

Anthony SAMSEL<sup>1</sup> and Stephanie SENEFF<sup>2</sup>

## Celiac Disease, Glyphosate and Non-Hodgkin's Lymphoma

- Bifidobacteria are depleted in celiac disease\*  
 – They convert gluten to less toxic form
- Glyphosate preferentially kills bifidobacteria\*\*
- Celiac disease is associated with increased risk to non-Hodgkin's lymphoma\*\*\*
- Glyphosate itself is also linked directly to non-Hodgkin's lymphoma\*\*\*\*

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

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

\*\*\*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.

## “Herbicide Resistant Ryegrass Troubling for Wheat Growers”\*

“If you see ryegrass at harvest following an Axial XL application, it may be resistant. And you can scatter seed all over the field with the combine.”

“A reduced-tillage approach, using a *burndown herbicide* ahead of planting in a stale seedbed, also holds promise for improved control.”

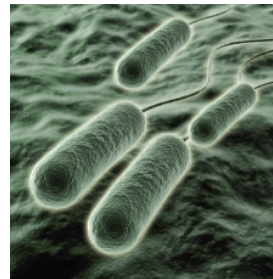
*“ ‘We may be able to knock out 80% to 90% of the resistant ryegrass with glyphosate.’ ”*

-- Jim Swart, integrated pest management specialist

\*Ron Smith, Western Farm Press, Mar. 23, 2013

## Pseudomonas and Glyphosate\*

- Pseudomonas aeruginosa, a gram negative bacterium, is a major problem today in hospitals due to its resistance to multiple antibiotics
- P. aeruginosa is one of only three bacterial species that can break down glyphosate.
  - It produces formaldehyde as a by-product
  - Formaldehyde is a well established neurotoxin



\*S. de Betzmann and P. Plésiat Environ Microbiol. 2011 Jul;13(7):1655-65.

## **“Dramatic Increase in Hospitalization of US Children With Inflammatory Bowel Disease”\***

- Study conducted at Case Western Reserve University School of Medicine
- > 11 Million hospitalization records examined
- Patients < 20 years old
  - 49% increase from 2000 to 2009 in Crohn’s disease discharges
  - 71% increase in ulcerative colitis discharges

\* Science Daily, June 25, 2013

## **Kidney Failure in Agricultural Workers\***

- Workers in sugarcane fields in Central America and in India are dying at a young age in record numbers from kidney failure
- Arsenic exposure from drinking water?
- Excess use of tylenol?

*Glyphosate disrupts the enzyme that breaks down tylenol, leading to tylenol toxicity*

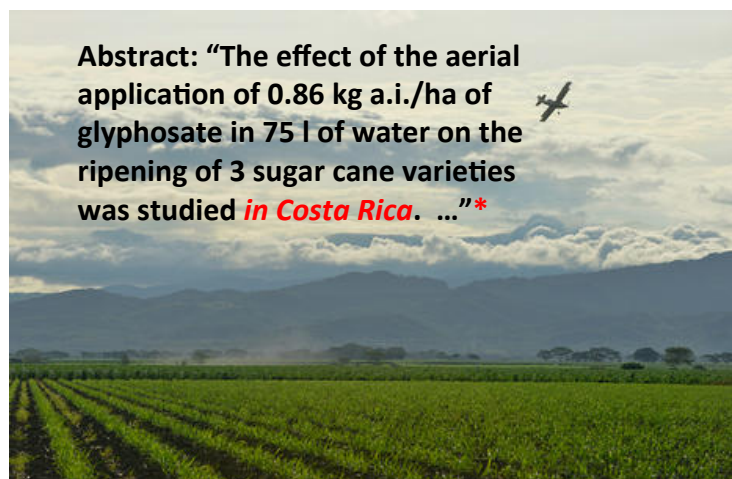
\*ticotimes.net, San Jose, Costa Rica, August 8, 2013.

## “What is killing the young men of Cañas?”\*



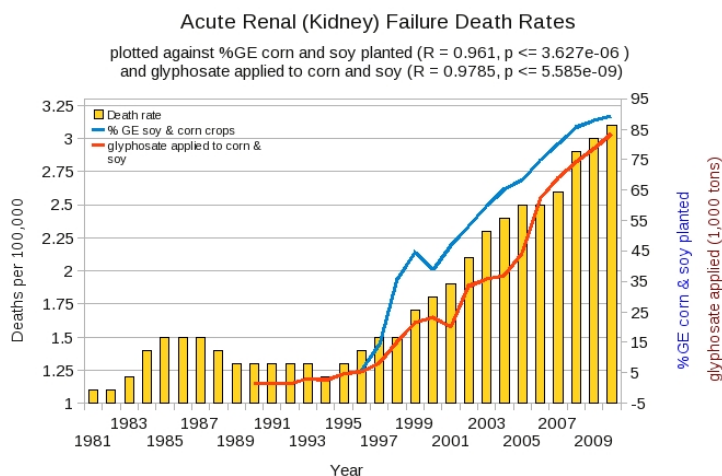
\*ticotimes.net, San Jose, *Costa Rica*, August 8, 2013.

## “What is killing the young men of Cañas?”



\*J.F. Subiros, The effect of applying glyphosate as ripener in three sugar cane varieties, Turrialba *1990*, 40(4), 527-534.

## Acute Kidney Disease Death Rate Plotted Against Glyphosate and GMOs\*



\*Plot prepared by Nancy Swanson from available data online

*Int. J. Environ. Res. Public Health* **2014**, *11*, 2125-2147; doi:10.3390/ijerph110202125

OPEN ACCESS

Sri Lanka is the first  
Country to Ban Glyphosate

International Journal of  
**Environmental Research and  
Public Health**  
ISSN 1660-4601  
www.mdpi.com/journal/ijerph

*Hypothesis*

**Glyphosate, Hard Water and Nephrotoxic Metals: Are They the  
Culprits Behind the Epidemic of Chronic Kidney Disease of  
Unknown Etiology in Sri Lanka?**

This problem did not exist in Sri Lanka prior to the 1990s.

## Another Country Responds to Kidney Failure in Agricultural Workers!



### Recapitulation

- We depend on our gut bacteria in many ways
  - Bacteria from an obese person induce obesity in mice
- Glyphosate is an antibiotic that preferentially kills the good bacteria
  - Pigs fed GMO corn and soy develop inflammatory gut
  - Humans are experiencing an epidemic in gut disorders like inflammatory bowel disease and gluten intolerance
  - Due to herbicide-resistant rye grass, farmers use glyphosate as a desiccant at harvest time
- Kidney failure among agricultural workers can be explained by glyphosate



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“More and more studies have revealed carcinogenic and endocrine disrupting effects of Roundup at lower doses than those authorized for residues found in Genetically Modified Organisms.”

-- Dr. Nancy Swanson

## Glyphosate is an endocrine disruptor that promotes breast cancer\*

- Low and environmentally relevant concentrations of glyphosate possess estrogenic activity
- Glyphosate caused human hormone-dependent breast cancer cells to proliferate at concentrations of *parts per trillion*
- Additive effect from genistein, a phytoestrogen in soybeans



\* S. Thongprakaisang et al., Food Chem Toxicol. 2013 Jun 8. S0278-6915(13)00363-3.

## Glyphosate and Anencephaly\*

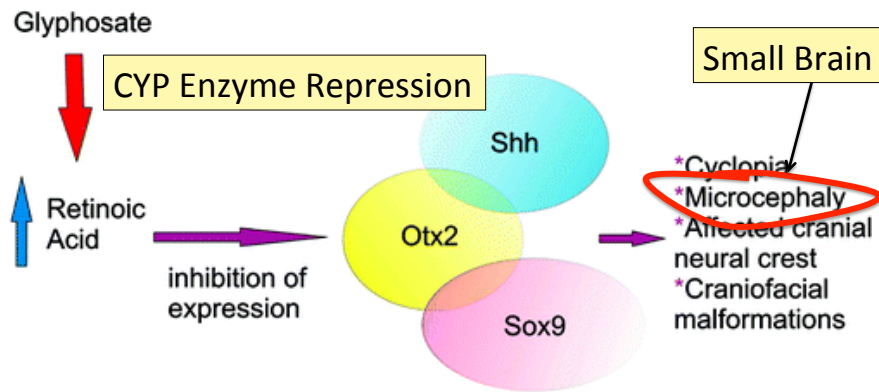
- Yakima, Benton and Franklin counties in Washington State have an unusually high number of pregnancies affected by the birth defect, anencephaly
- 75 pesticides were analyzed in studying contamination due to surrounding agriculture
  - 47 (63%) of these were detected
  - Glyphosate was applied in large amounts, but *was not studied*
- 5% solution of glyphosate was also used heavily around irrigation ditches to control weeds
  - Main herbicide recommended due to its “low toxicity”



***Glyphosate has been linked to anencephaly due to its effect on retinoic acid***

\*Barbara H. Peterson. Farm Wars, <http://farmwars.info/?p=11137>

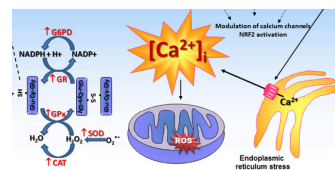
## Glyphosate Upregulates Retinoic Acid\*



\*A. Carrasco, Teratogenesis by glyphosate based herbicides and other pesticides. Relationship with the retinoic acid pathway. In Breckling, B. & Verhoeven, R. (2013) GM-Crop Cultivation – Ecological Effects on a Landscape Scale. Theorie in der Ökologie 17. Frankfurt, Peter Lang.

## Glyphosate's Effects on Sertoli Cells in Rat Testis\*

- Concentrations 10-fold more diluted than that recommended for herbicide action
- Several pathologies noted:
  - Depletes glutathione (essential antioxidant)
  - Enhanced lipid and protein oxidation
  - Activates calcium channels; promotes calcium release from ER (stress response); induces cell death
  - Increases mitochondrial membrane permeability to calcium and protons



**Necrotic Cell Death**

\*V.L. Oliveira Cavalli et al., Free Radical Biology and Medicine 65, Dec. 2013, 335-346.

## Fertility Rates are Dropping Worldwide\*

- Fertility rates are falling rapidly in countries around the world, often to below 2.0.
  - Cultural changes play a role
  - But glyphosate is likely contributing as well
- Sperm depend on cholesterol sulfate for decapitation and fertilization
- Cholesterol sulfate synthesis depends on cytochrome P450 (CYP) enzymes
- Glyphosate disrupts CYP enzyme function

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

## "Male fertility under threat as average sperm counts drop"\*

- Study of 26,600 men in France found sperm concentration had decreased by 32% since the 1990s.
- Numbers steadily dropped by 2% per year from 1989 to 2005.
- Proportion of normally formed sperm also declined by about 1/3.

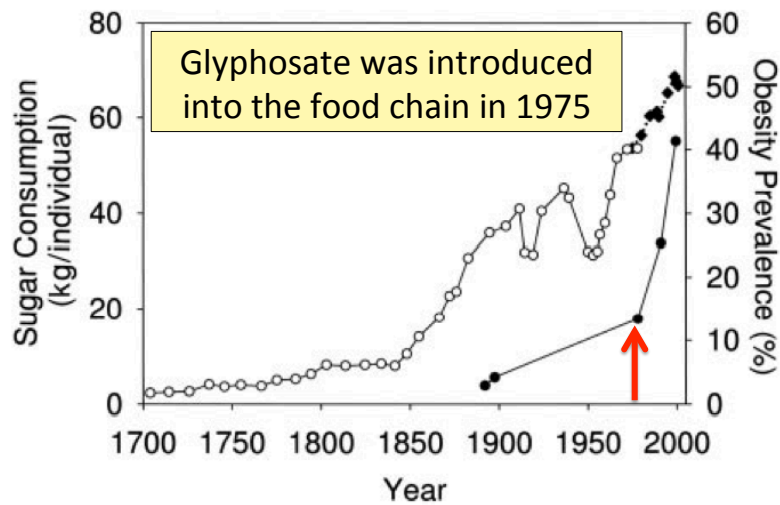


\* M. Rolland et al., Hum Reprod. 2013 Feb;28(2):462-70.

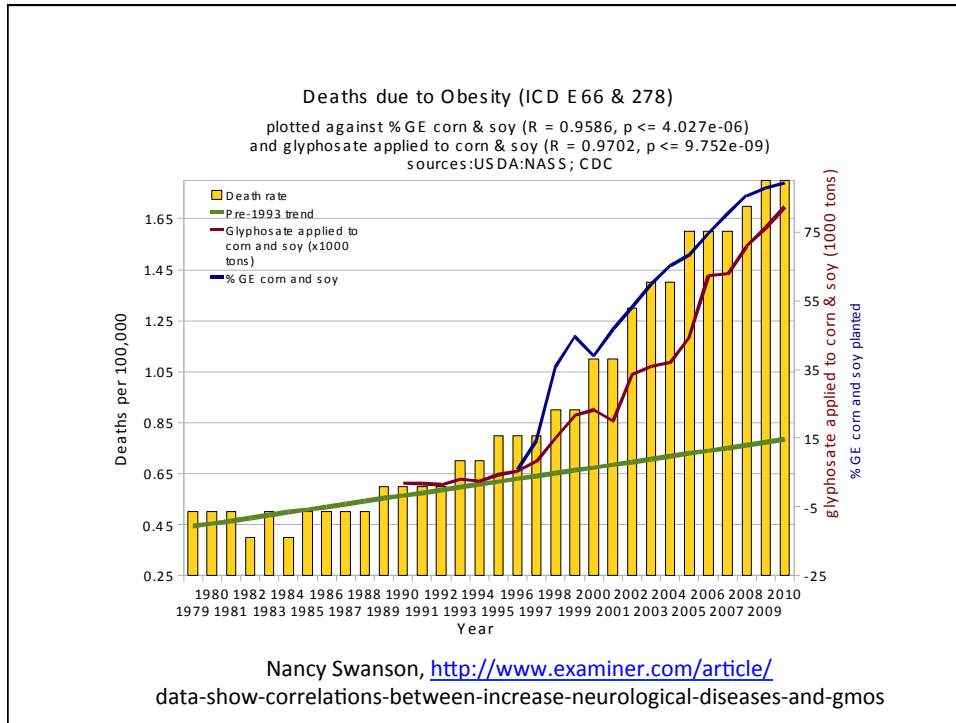
## Is Glyphosate Making Us Obese?



### Obesity in US over Time\*



\*Figure 1 in R.J. Johnson et al., Am J Clin Nutr 2007;86:899–906.



### Nancy Swanson's Data: Pearson Correlation Coefficients between Diseases and Roundup\*

	Glyphosate Application	
	Correlation	P-value
Obesity	0.9698	0.000000976
Diabetes (prevalence)	0.9818	$\leq 4.44E-009$
Diabetes (incidence)	0.9643	$\leq 1.42E-008$
End Stage Renal Disease (incidence)	0.8991	$\leq 5.45E-007$
End Stage Renal Disease (prevalence)	0.9520	$\leq 3.05E+008$
Autism (prevalence)	0.9886	6.65E-009
Alzheimer's (deaths)	0.9271	$\leq 1.29E-007$
Parkinson's (deaths)	0.8953	$\leq 6.52E-007$
Dementia (deaths)	0.9908	$\leq 6.31E-009$

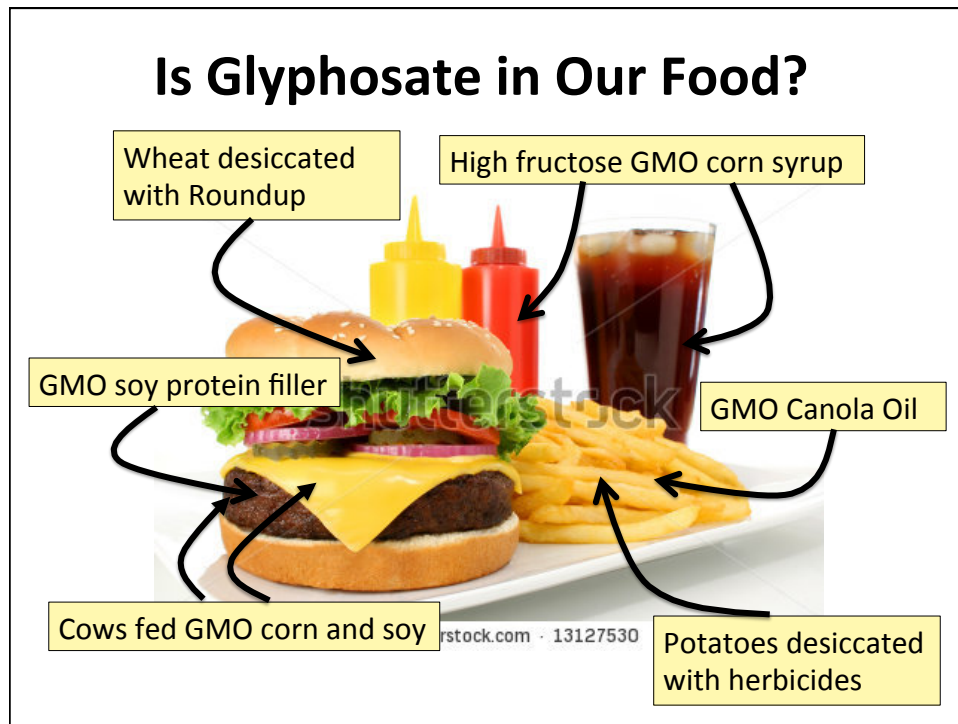
\*Nancy Swanson, personal communication

## Recapitulation

- Glyphosate is a known endocrine disruptor
  - Contributes to infertility and birth defects
  - Glyphosate causes breast tumor cells to proliferate at concentrations of parts per trillion
- Glyphosate upregulates retinoic acid which causes microcephaly and anencephaly
  - This could explain recent high incidence of anencephaly in Yakima, WA
- Many diseases and conditions on the rise today are strongly associated with glyphosate application on corn and soy

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## Testing for Glyphosate Residues in US Foods\*

- 195 page document
- Only one food item was tested for glyphosate: soy
- 271/300 samples tested contained glyphosate residues (**90.3%**)
- 287/300 contained AMPA (a breakdown product of glyphosate) (**95.7%**)

\*USDA Pesticide Data Program: Annual Summary, 2011



## “Determination of Glyphosate residues in human urine samples from 18 European countries”\*

- 182 urine samples from 18 European countries analyzed for glyphosate
  - city-dwellers who had never handled roundup or any herbicides.
- 44% of the samples contained quantifiable amounts of glyphosate
- 7% of the participants exceed 0.8 micrograms/Liter, the reference cutoff for "safety"
- Diet seems to be the main source of exposure
- These numbers would be much worse if they were measured in the U.S.



\*[https://www.foeeurope.org/sites/default/files/glyphosate\\_studyresults\\_june12.pdf](https://www.foeeurope.org/sites/default/files/glyphosate_studyresults_june12.pdf)

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  - Diet seems to be the main source of exposure
  - These numbers would be much worse if they were measured in the U.S.
- "Our testing highlights a serious lack of action by public authorities across Europe and indicates that this weed killer is being widely overused. Governments need to step-up their monitoring and bring in urgent measures to reduce its use. This includes rejecting any *genetically modified crops* that would increase the use of glyphosate."



\*[https://www.foeeurope.org/sites/default/files/glyphosate\\_studyresults\\_june12.pdf](https://www.foeeurope.org/sites/default/files/glyphosate_studyresults_june12.pdf)

## Glyphosate in Air and Rain\*

- Study conducted by the US Geological Survey in Mississippi
- 18-fold increase in glyphosate application since 1995



Glyphosate was the predominant new herbicide detected in both air (86%) and rain (77%) in 2007 (not measured in 1995)

\*M.S Majewski et al., Environ Toxicol Chem. 2014 Feb 19. Epub ahead of print.

## Species in Stress

Fungus Infection



Fungus Infection



Fungus Infection



Fungus Infection

\*R. Mason et al., Journal of Environmental Immunology and Toxicology 1:1, 3-12; 2013

***Roundup herbicide enhances the growth of aflatoxin-producing fungi\****

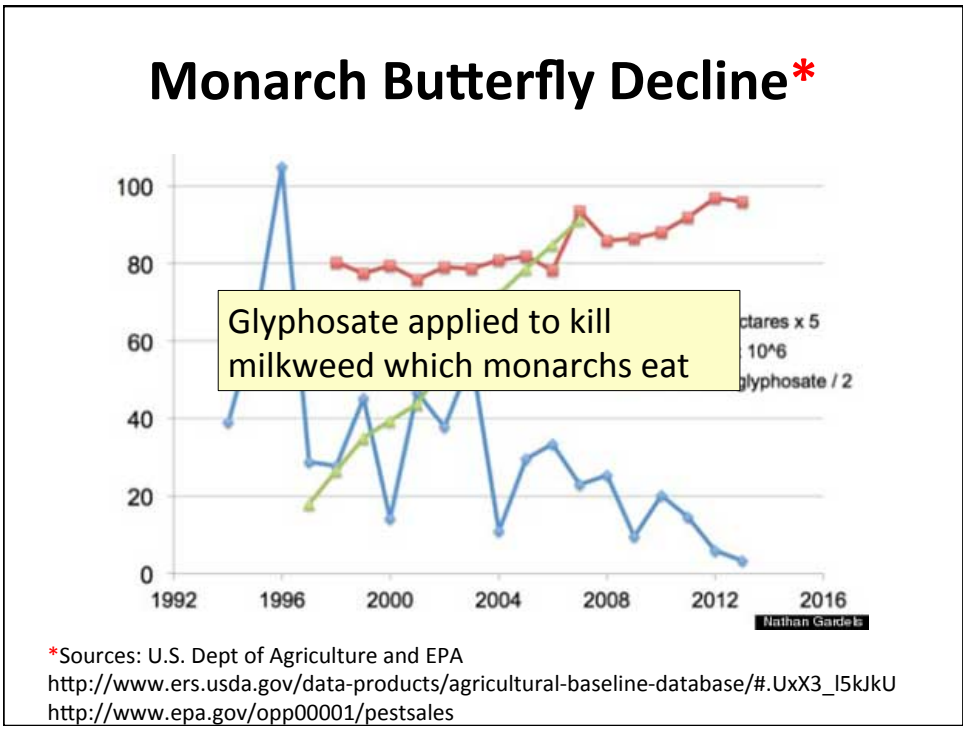
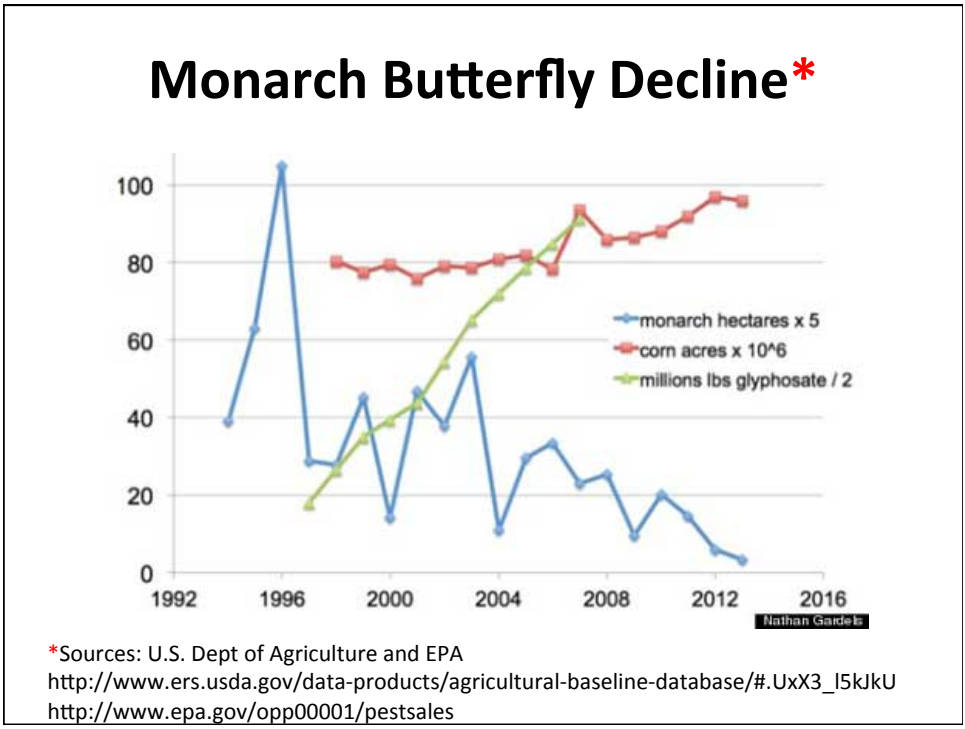


\*Barberis et al., Journal of Environmental Science and Health, Part B: Pesticides, Food Contaminants, and Agricultural Wastes. 2013, 48(12), 1070-1079.

***“Aflatoxins are mutagenic, carcinogenic, teratogenic, hepatotoxic, immunosuppressive, and they also inhibit several metabolic systems”\****



\*Barberis et al., Journal of Environmental Science and Health, Part B: Pesticides, Food Contaminants, and Agricultural Wastes. 2013, 48(12), 1070-1079.



## Prof. Don Huber on Glyphosate\*

“When future historians write about our time, they're not going to write about the tons of chemicals that we did or didn't apply. When it comes to glyphosate, they're going to write about our willingness to *sacrifice our children and jeopardize our existence*, while threatening and jeopardizing the very basis of our existence; *the sustainability of our agriculture.*”

\*Retired professor from Purdue University; Expert in plant pathology  
[articles.mercola.com/sites/articles/archive/2012/01/15/dr-don-huber-interview-part-2.aspx](http://articles.mercola.com/sites/articles/archive/2012/01/15/dr-don-huber-interview-part-2.aspx)



## Summary

- We should be very worried about glyphosate in the food and water supplies
- Glyphosate's disruption of gut bacteria, depletion of essential amino acids and minerals, and interference with cytochrome P450 enzymes have widespread consequences
- Glyphosate can explain health problems worldwide, including autism, diabetes, infertility, kidney failure, gluten intolerance, cancer, etc.
- Glyphosate needs to be removed from the market and we need to find the path to sustainable pesticide-free agriculture

