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Monsanto Roundup: The Impacts of Glyphosate Herbicide on Human Health. Pathways to Modern Diseases

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

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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 of sugar, corn, soy and wheat.

Glyphosate's inhibition of cytochrome P450 (CYP) enzymes is an overlooked component of its toxicity to mammals. CYP enzymes play crucial roles in biology, one of which is to detoxify xenobiotics.

Thus, glyphosate enhances the damaging effects of other food borne chemical residues and environmental toxins. Negative impact on the body is insidious and manifests slowly over time as inflammation damages cellular systems throughout the body. Here, we show how interference with CYP enzymes acts synergistically with disruption of the biosynthesis of aromatic amino acids by gut bacteria, as well as impairment in serum sulfate transport.

Consequences are most of the diseases and conditions associated with a Western diet, which include gastrointestinal disorders, obesity, diabetes, heart disease, depression, autism, infertility, cancer and Alzheimer's disease.

We explain the documented effects of glyphosate and its ability to induce disease, and we show that glyphosate is the "textbook example" of exogenous semiotic entropy: the disruption of homeostasis by environmental toxins.

Introduction

The foodstuffs of the Western diet, primarily grown by industrial agriculture, are increasingly being produced using a two-part system of engineered plant seeds and toxic chemical application.

Novel bacterial genes are incorporated through genetic engineering, and toxic chemical

residues are readily taken up by the engineered plants. Research indicates that the new bacterial RNA and DNA present in genetically engineered plants, providing chemical herbicide resistance and other traits, have not yet fully understood biological effects. This paper however, will only examine the effects of the chemical glyphosate, the most popular herbicide on the planet.

Glyphosate (N-phosphonomethylglycine), the active ingredient in the herbicide Roundup®, is the main herbicide in use today in the United States, and increasingly throughout the World, in agriculture and in lawn maintenance, especially now that the patent has expired. 80% of genetically modified crops, particularly corn, soy, canola, cotton, sugar beets and most recently alfalfa, are specifically targeted towards the introduction of genes resistant to glyphosate, the so-called "Roundup Ready® feature" In humans, only small amounts (~2%) of ingested glyphosate are metabolized to aminomethylphosphonic acid (AMPA), and the rest enters the blood stream and is eventually eliminated through the urine [1].

Studies have shown sharp increases in glyphosate contamination in streams in the Midwestern United States following the mid 1990s, pointing to its increasing role as the herbicide of choice in agriculture [2]. A now common practice of crop desiccation through herbicide administration shortly before the harvest assures an increased glyphosate presence in food sources as well [3–5]. The industry asserts that glyphosate is nearly nontoxic to mammals [6,7], and therefore it is not a problem if glyphosate is ingested in food sources. Acutely, it is claimed to be less toxic than aspirin [1,6]. As a consequence, measurement of its presence in food is practically nonexistent. A vocal minority of experts believes that glyphosate may instead be much more toxic than is claimed, although the effects are only apparent after a considerable time lapse.

Thus, while short-term studies in rodents have shown no apparent toxicity [8], studies involving life-long exposure in rodents have demonstrated liver and kidney dysfunction and a greatly increased risk of cancer, with shortened lifespan [9].

Glyphosate's claimed mechanism of action in plants is the disruption of the shikimate pathway, which is involved with the synthesis of the essential aromatic amino acids, phenylalanine, tyrosine, and tryptophan [10].

The currently accepted dogma is that glyphosate is not harmful to humans or to any mammals because the shikimate pathway is absent in all animals. However, this pathway is present in gut bacteria, which play an important and heretofore largely overlooked role in human physiology [11–14] through an integrated biosemiotic relationship with the human host. In addition to aiding digestion, the gut microbiota synthesize vitamins, detoxify xenobiotics, and participitate in immune system homeostasis and gastrointestinal tract permeability [14]. Furthermore, dietary factors modulate the microbial composition of the gut [15].

The incidence of inflammatory bowel diseases such as juvenile onset Crohn's disease has increased substantially in the last decade in Western Europe [16] and the Entropy 2013, 15 1418 United States [17]. It is reasonable to suspect that glyphosate's impact on gut bacteria may be contributing to these diseases and conditions.

However, the fact that female rats are highly susceptible to mammary tumors following chronic exposure to glyphosate [9] suggests that there may be something else going on.

Our systematic search of the literature has led us to the realization that many of the health problems that appear to be associated with a Western diet could be explained by biological disruptions that have already been attributed to glyphosate. These include digestive issues, obesity, autism, Alzheimer's disease, depression, Parkinson's disease, liver diseases, and cancer, among others. While many other environmental toxins obviously also contribute to these diseases and conditions, we believe that glyphosate may be the most significant environmental toxin, mainly because it is pervasive and it is often handled carelessly due to its perceived nontoxicity.

In this paper, we will develop the argument that the recent alarming increase in all of these health issues can be traced back to a combination of gut dysbiosis, impaired sulfate transport, and suppression of the activity of the various members of the cytochrome P450 (CYP) family of enzymes. We have found clear evidence that glyphosate disrupts gut bacteria and suppresses the CYP enzyme class. The connection to sulfate transport is more indirect, but justifiable from basic principles of biophysics.

In the remainder of this paper, we will first provide evidence from the literature that explains some of the ways in which glyphosate adversely affects plants, microbes, amphibians and mammals.

Section 3 will discuss the role that gut dysbiosis, arguably resulting from glyphosate exposure, plays in inflammatory bowel disease and its relationship to autism.

Section 4 argues that the excess synthesis of phenolic compounds associated with glyphosate exposure represents a strategy to compensate for impairments in the transport of free sulfate.

Section 5 will provide evidence that glyphosate inhibits CYP enzymes. Section 6 explains how obesity can arise from depletion of serum tryptophan due to its sequestering by macrophages responding to inflammation. Section 7 shows how extreme tryptophan depletion can lead to impaired nutrient absorption and anorexia nervosa.

Section 8 provides a brief review of all the roles played by CYP enzymes in metabolism. Section 9 discusses a likely consequence to glyphosate's disruption of the CYP-analog enzyme, endothelial nitric oxide synthase (eNOS). Section 10 shows how glyphosate's effects could plausibly lead to brain-related disorders such as autism, dementia, depression, and Parkinson's disease. Section 11 mentions several other health factors that can potentially be linked to glyphosate, including reproductive issues and cancer.

Section 12 discusses the available evidence that glyphosate is contaminating our food supplies, especially in recent years. Following a discussion section, we sum up our findings with a brief conclusion.

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