The Toxic Western Diet
What Parents Must Know To Protect Their Family

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by

Renee Dufault

First Edition: July 2015
Printed in the United States of America
ISBN: 9781633188648

For My Family and the Next Generation.

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Acknowledgement

This book is a long time coming but not overdue. The state of research is now at a point where I could write it with confidence. Many individuals have contributed to the mercury research, either directly or indirectly, or helped to disseminate the results in one way or another through the years. I would like to thank all of the following individuals for doing their part: Blaise LeBlanc, Ed Rau, Boyd Haley, Sree Kumar, Chuck Cornett, Alex and Lyudmila Romanyukha, Chad Mitchell, Bill Walsh, Walter Lukiw, Matt Amann, Don Demers, Martha Boss, Dennis Day, Art Dungan, Isaac Pessah, Peter Green, David Krabbenhoft, Cynthia Harris, Barry Lai, Roseanne Schnoll, Laura Schweitzer, David Wallinga, Fred and Alice Ottoboni, Jane Hightower, Lyn Patrick, Rao Ivaturi, Steven Gilbert, Raquel Crider, Leah Woodke, Amanda Hitt, Melinda Wenner, Scott Laster, Martha Herbert, Katsi Cook, David Carpenter, Matt Pamuku, Skip Kingston, Marcia Zimmerman, Daniele Pisanello, Ted Levine, David and Jamie Fletcher, Tom Devine, The Buss Family, Ivan Royster, Mari Eggers, Maureen Swanson, Marissa McInnis, Zara Berg, Erica Newland, Twila Martin-Kekahbah, Larry Wetsit, Wayne Two Bulls, Mesay Mulugeta Wolle, GM Mizanur Rahman, Alika Maunakea, Dan Laks, and the Fort Peck Community College (FPCC) students who participated in the recent clinical trial that focused on the prevention of type-2 diabetes through the elimination of toxic substances from the diet and increased intake of whole, healthy foods. Thank you also to my dear friends, Dawn Bradley, a talented artist, who helped me with the artwork for the cover and Marvelle Rau who served as a thoughtful reader of the manuscript to provide the parent's perspective.

Foreword

by **Steven G. Gilbert, Ph.D., D.A.B.T.**

We understand both more and less about the impact of what we eat on our health and wellbeing. There are several problems that cloud our vision and inhibit useful action. First, there has never been adequate research on understanding our basic nutritional needs. Furthermore, national nutritional guidelines are affected by food industry and political consideration. Second, the farm government subsidy program influences the price of the food we eat. For example, subsiding grain and corn makes the production of beef less expensive and sweetened beverages cheaper. Third, the mass production and distribution of food results in the use of more chemicals such as pesticides, preservatives, and other additives, which contaminate our food supply. The health effects of some of these chemicals have been studied but in most cases we lack basic research on the effects of these chemicals from conception through adulthood and aging. Fourth, we have become increasingly aware that kids are not little adults and that developing organ systems are more vulnerable to industrial chemicals. In addition, kids eat more, breath more, and drink more per body weight than adults, which mean they are both, exposed to more chemicals and receive a greater dose than adults. Fifth, there is a complex regulatory structure that attempts to ensure the safety and adequacy of the food supply but suffers from lack of funding while being buffeted by the competing interests of consumers, industry, and politics. Finally, the greatest challenge is empowering consumers with adequate knowledge and motivation to make choices that protect and promote the health and wellbeing of not only their families but also the greater environment. Even more salient is how to protect our children and ensure they have access to food that allows them to reach and maintain their full potential.

The essence of Renee Dufault's book *The Toxic Western Diet* is captured in the subtitle "What Parents Must Know to Protect Their Family." An admirable element of this book is that it is grounded in science and extensively referenced. If you want more details or background information, the references at the end of each chapter provide a starting point. This book does a fantastic job of connecting the dots between the science and everyday actions that can be taken to apply what you have learned – I hope every reader takes the time to do the recommended activities. The relentless focus on what we are eating and what's in what we are eating is essential to making changes in our diet and improving our health. Clearly after reading this book the conclusion has to be that the underlying science is complicated. However, Renee provides essential guidance and offers simple ways to alter your diet to reduce chemical and heavy metal exposures that will most certainly improve your and your family's health. I hope after reading this book and examining your diet that you have started on a journey that will lead to better health and a more sustainable environment.

Dr. Steven G. Gilbert *is a leading researcher in the field of toxicology. He is a successful author, dedicated educator and the founder and director of the Institute of Neurotoxicology and Neurological Disorders based in Seattle, Washington. Dr. Gilbert serves as a director on a number of non-profit organization boards to include among others the Food Ingredient and Health Research Institute and Physicians for Social Responsibility.*

Preface

It took nearly ten years but me and my collaborators were finally able to show a connection between processed food consumption and inorganic mercury exposure. During a clinical trial involving human subjects we were able to show the consumption of processed foods contributes to higher inorganic blood mercury levels [1]. These higher mercury levels increase your risk of type-2 diabetes by causing your blood sugar levels to rise [1]. It is my belief that a safe food supply should not contain toxic elements that lead to essential mineral loss or gene dysfunction resulting in the development of type-2 diabetes or any other disease. The Standard American Diet (SAD) is comprised of many unsafe food ingredients that impact the way your genes function. Food safety is a problem for most families in the United States, rich or poor, whether they know it or not. I know this basic fact because I have studied the SAD extensively, published my findings with collaborators in peer reviewed medical journals [1-5] and for many years worked at the agency responsible for food safety in the United States (US).

I transferred to the Food and Drug Administration (FDA) in 1999 as a Public Health Service (PHS) officer from the United States Environmental Protection Agency (EPA). My job at both the EPA and FDA involved the identification, assessment, mitigation and cleanup of toxic elements left behind on laboratory surfaces, in laboratory hood and ventilation systems, biosafety cabinets, and plumbing systems in research laboratories undergoing closure. At that time, my training and background was in environmental health and industrial hygiene. This means I was qualified to identify, assess, and control physical, chemical, biological or other environmental hazards in the workplace or community that could cause injury or disease. While doing my job at the FDA, my collaborators and I kept finding mercury in the plumbing systems of laboratories undergoing closure. We wondered where it came from.

Fortunately, my supervisor at the FDA gave me permission to determine the source of the mercury contamination in the plumbing systems. During my investigation, I uncovered the unsettling fact that many laboratory chemicals contain mercury residue. When mercury is part of a molecular compound or in its elemental form, it is heavier than water and tends to settle at low points in plumbing systems [6]. Before environmental regulations were developed by the EPA for the disposal of hazardous waste, researchers just poured waste chemicals down the laboratory drains and the mercury settled in the sink traps and sumps. This is the reason why we kept finding mercury in the plumbing systems of the laboratories undergoing closure at FDA. You may wonder how the mercury residue got into the laboratory chemicals in the first place. I did too.

I consulted with my peers working in the environmental field and asked if they knew how the mercury residue ended up in the laboratory chemicals. I interviewed a colleague at the EPA and found out the chlor-alkali chemical companies reported missing several tons of mercury from their manufacturing process every year to the EPA [7]. In 2000, the twelve mercury cell chlor-alkali plants in operation at the time reported to EPA there were approximately 65 tons of missing mercury [7]. The chemicals manufactured at the chlor-alkali plants were often the same ones used by FDA research laboratories. My EPA colleague informed me that there was only one mercury cell chlor-alkali chemical company that had provided EPA with information on where their missing mercury went. Out of the nine mercury cell chlor alkali chemical companies operating in 2004, Vulcan Chemical was the only one in the United States to achieve its goal of finding its missing mercury. Vulcan Chemical knew exactly how much mercury went into their manufacturing process to make chlorine, hydrochloric acid, sodium hydroxide, and potassium hydroxide chemical products and where it ended up. I suspected much of the mercury ended up in the chemical products FDA and other researchers used in their laboratories but needed to investigate further to see if my hunch was correct. I figured it would be best to go to the source and so I telephoned Vulcan Chemical. No one was available to talk with me. I left a message for management staff but they didn’t return my call.

The Vulcan Chemical mercury cell chlor-alkali manufacturing plant was located in Wisconsin and I knew the company would be required to comply with state environmental laws pertaining to toxic substance releases in wastewater and air. I submitted a request to the Wisconsin Department of Natural Resources (DNR) for information regarding the missing mercury from the Vulcan Chemical plant. The exact amounts were provided to me in an email from a wastewater specialist in the Wastewater Permits and Pretreatment Section [8]. Vulcan Chemical had provided this information to the DNR as part of their wastewater discharge permit application. The information is provided in the box below:

Missing mercury (Hg) found in Vulcan Chemical products in 1999

Chorine: 1 pound Hg/year in chlorine (Cl)

Sodium Hydroxide (caustic soda):
6 pounds Hg/year in caustic soda (NaOH)

Potassium Hydroxide (potash):
11 pounds Hg/year in potash (KOH)

Hydrochloric Acid (muriatic acid):
11 pounds Hg/year in muriatic acid (HCl)

I realized at this point that mercury residue would probably be found in all chemical products produced by the mercury cell chlor-alkali industry. Since the mercury was missing from this industry, obviously no one had been keeping track of it. This fact alarmed me greatly because mercury is known to be extremely toxic among public health professionals. What if the missing mercury ended up in products consumed by children? Mercury is a neurotoxin and by definition interferes with brain development. I knew the American Academy of Pediatrics had published a paper recommending the elimination of all mercury exposure from our children's environment [9]. The question that came to my mind was who else uses these mercury cell chemical products besides scientists working in research laboratories?

I didn't have to look far for an answer to this question. It was lurking on the Vulcan Chemical web-page. Mercury grade sodium hydroxide and hydrochloric acid were chemicals used primarily by the food color, citric acid, and high fructose corn syrup industries. Why would manufacturers use these mercury containing chemicals to make food ingredients? Maybe the corn syrup manufacturers would talk with me. After all I worked at the FDA.

The only corn refiner I could find who was willing to speak with me was the manager of an “organic” high fructose corn syrup (HFCS) manufacturing plant. The gentleman informed me that while the HFCS industry used both mercury cell sodium hydroxide and membrane grade sodium hydroxide in their manufacturing process to lengthen and enhance product shelf life, the mercury cell sodium hydroxide was preferred when it was available. I asked him if I could send out an FDA field investigator to collect samples of HFCS for mercury analysis and he said, “yes” as long as I agreed to keep his identity confidential. He was alarmed at the possibility there could be mercury residue in his product as a result of using mercury cell sodium hydroxide in his manufacturing process and wanted to be cooperative. I was alarmed that mercury cell sodium hydroxide was even allowed to be used in the HFCS manufacturing process in the first place. That year, in 2004, Americans were consuming 35.1 pounds HFCS per person which seemed like a lot of sweetener to me especially when the substance could be contaminated with mercury [10]. I contacted someone at the Chlorine Institute, the trade association that represented the chlor-alkali chemical manufacturers, to find out why food manufacturers could buy and use their mercury cell chemical products.

The President of the Chlorine Institute at the time, Art Dungan, was most cooperative and provided me with information on the allowable levels of mercury in “food grade” chlor-alkali chemicals [11]. He explained the amount of mercury residue in mercury cell chlor-alkali products varies, depending on the manufacturing process at each plant [11]. Manufacturers of mercury cell chlor-alkali chemicals are required to provide information regarding the amount of mercury found in their products on their product specification sheets [11]. Mr. Dungan explained the allowable levels of mercury and lead in food grade chemicals are established by the Food Chemicals Codex, the internationally recognized food ingredient safety standards, now owned and published by US Pharmacopeia Convention, otherwise known as the USP [12]. After doing some digging, I learned the USP was founded in 1820, long before FDA, and is essentially the trade association for the pharmaceutical industry [13]. According to the

Vulcan Chemical web page, the two largest purchasers of mercury cell chlor-alkali chemicals were the pharmaceutical and high fructose corn syrup manufacturers! It appeared to me that mercury residue was purposely being added to both medicines and food ingredients. Why? What do food and medicine have in common?

Further research revealed mercury has historically been used as a biocide in medicines designed to kill germs or other pathogenic organisms and as a pesticide in chemical products designed for killing mold on seeds and grains [14]. In medicine, it was incorporated in de-worming agents, teething powders, and diaper rash creams [14]. Prior to being taken off the market, mercurochrome was used routinely to treat sore throats and prevent infection in wounds [14]. In fungicides, mercury was an element used in agents designed to kill mold in and on grains [15]. Mercury compounds were used extensively in agriculture and in food production [15].

The purpose of using mercury cell chlor-alkali chemicals to manufacture food ingredients is clear to me now. It makes sense that mercury residue in any food ingredient should kill mold and bacteria and lengthen product shelf life. The longer a product stays fresh on the grocery shelf without spoiling, the better for food manufacturers because product losses are minimized and profits are maximized increasing net earnings. I became increasingly aware of how many food products contained high fructose corn syrup. I still could not believe mercury containing chlor-alkali chemicals were intentionally being added to HFCS during the manufacturing process to enhance product shelf life. I wondered if HFCS manufacturers were touting their food ingredient's ability to prevent food product spoilage by killing bacteria or mold.

A quick visit to the Corn Refiner Association's web page revealed high fructose corn syrup was indeed being marketed as an ingredient capable of enhancing product shelf life by "creating freshness" or allowing manufactures to produce foods that stay fresh [16]. After viewing manufacturer's and distributor's websites, I read HFCS could be added to bread to "prevent mold." Some websites even touted the ingredient's use as a preservative. It was not approved by FDA for use as a preservative. How much mercury was in this ingredient anyway?

To find out, I asked an FDA field investigator to visit a number of high fructose corn syrup manufacturers and collect samples for analysis. These samples were sent to a researcher's laboratory at a different agency that had analytical equipment that could detect the lowest levels of mercury; they were then placed in cold storage for safekeeping. I obtained another set of samples direct from the manufacturers and sent them to an analytical chemistry lab at the National Institute of Standards and Technology (NIST) and a University of California laboratory for analyses.

The researchers at NIST analyzed the HFCS samples and found trace amounts of mercury in all of them as did the researchers who analyzed the samples at the University of California laboratory. It was time to report my findings to the FDA Center for Food Safety and Applied Nutrition (CFSAN). The University of California researcher sat in at the meeting with CFSAN staff and together we reported the findings. To my amazement, after the meeting, I was ordered by senior FDA management to stop my investigation. Later when I tried to publish the findings provided to me in an official report by the researchers at NIST [17], I was informed by FDA management staff that I could not use the results in the official NIST report because they were not meant for "public distribution."

It became increasingly clear to me that in order to finish the investigation and report the findings I would have to retire early from the Public Health Service. As a Commander in the Public Health Service, if I disobeyed the direct order to "stop investigating" I could be prosecuted under the Uniform Code of Military Justice. Since I would not be allowed to continue the investigation, I asked my supervisor if I could tell the researcher who was safekeeping those HFCS samples sent to him by the FDA field investigator to do whatever he wanted with them. To my relief, my supervisor said, "yes." I immediately made plans to retire early to continue the investigation and find out the truth about the use of mercury as a preservative in our food supply.

Since my retirement, I have continued the investigation with collaborators at research institutions and universities throughout the United States. We publish our findings in peer reviewed medical journals. Now I serve as the Founding Director and Principal Investigator at the Food Ingredient and Health Research Institute

(FIHRI), the only federally recognized 501 (c) (3) non-profit organizations in the United States (US) devoted entirely to food ingredient safety, consumer education and research [18, 19]. There is no other organization in the U.S. devoted to conducting research on food ingredients such as HFCS that are generally recognized as safe by the FDA. There are numerous food additives and ingredients recognized as safe by the FDA in our food supply that recent research indicates are factors in the development of autism, attention deficit-hyperactivity disorder and chronic diseases such as obesity and diabetes.

This book is a compilation of the research findings conducted by FIHRI, U.S. government scientists, and other researchers at universities across the world in consumer friendly terms. The research on food ingredients to date is science based and the findings will guide you in creating a safe food supply for your family. It is my hope that you will be able to take what you learn from this book and apply it in your own life to improve the quality of food at your dinner table. In creating a nutritionally adequate and safe food supply for your family members, you will not only enhance their quality of life but also improve their chances of remaining healthy during their life span.

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Chapter 1

How food regulates and supports gene function

Each of us is born with a set of genes. Identical twins have the same set of genes but their genes will not necessarily behave the same way [1]. Specific genes turn off and turn on. Genes that cause cancer are called oncogenes. If an oncogene keeps turning on and on and won't stop expressing itself, you will develop a tumor which is basically unregulated cell growth. For example, in skin cancer, you get growths on or under your skin that get larger as the skin cells continue to grow uncontrollably. When tumor suppressor genes turn on they produce a protein that encourages the death of cancer cells effectively stopping their proliferation. Everyone has the potential to develop cancer because we all have the kind of genes that can grow uncontrollably if we are overexposed to the sun, toxic substances, viruses or other cancer causing agents in our environment. In a healthy body, cancer genes are regulated by diet and nutrition.

For example, scientists recently found that vitamin D status influenced by diet significantly affected the expression of 291 different genes [2]. Some genes turned on and some turned off but the data showed that any improvement in vitamin D status will improve the regulation of genes associated with cancer, cell differentiation, and immune function [2]. No matter what genes you are born with, how they function depends on the environment you create in your body. This is an important concept because gene function determines body function. If your child has attention deficit hyperactivity order (ADHD), his genes are functioning in response to his environment. If you have developed type-2 diabetes, it is because your genes have responded to the environment you created in your body. The study of how genes respond to or interact with their environment is called epigenetics. This relatively new field of study is found in the biology discipline. “Epi” is a prefix that means outside of or above.

“Epi” is a prefix meaning on, upon, outside of, or above. There are approximately 330 words starting with “epi.”

Epigenetics: interactions occurring above the gene

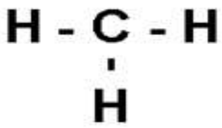
Epidermis: the outer layer of the skin

Epigenome: all of the chemical compounds that regulate gene activity

Epigenomic changes: can be passed on from parent to child or modified through dietary changes or exposures to toxic substances

Gene regulation occurs when chemical compounds are added to single genes modifying their behavior; these modifications are known as epigenetic changes [3]. The food you eat, the water you drink and the air you breathe provide the fuel and the individual atoms for constructing these chemical compounds. All of the chemical compounds that regulate gene behavior make up what is known as the epigenome. How a body functions is a direct result of the epigenomic changes or modifications that remain as cells divide. In some cases these functional changes can be passed on from parent to child. For example, children with Asperger Syndrome function very much like their parents from both a psychological and anatomical perspective [4, 5, and 6]. They inherited the way they function from their parents. Asperger Syndrome is considered a state of high functioning autism.

Methylation is the most common type of epigenomic modification and involves the transfer of a methyl molecule to a gene [3]. When a methyl molecule or “methyl group” is added to a gene, the gene is turned off or silenced [3]. Once the gene is silenced, no protein can be produced from that gene [3]. A methyl group is made up of one carbon atom and three hydrogen atoms. Your body needs methyl groups to turn genes off and then back on again as needed.



The methyl group pictured above is sometimes referred to as a hydrocarbon. You can see the hydrogen atoms that are bonded or attached to the carbon atom.

Children with autism have decreased capacity for methylation [7, 8]. This means their bodies do not have enough methyl groups for use in carrying out bodily functions and some of their genes are habitually turned off. Research has shown that these genes can be turned back on to produce the proteins needed by the child's body to significantly improve their language, communication, personal living skills, interpersonal social and coping skills and overall behavior [9]. Switching these genes back on to improve child health requires more methyl groups for the methylation process.

Methylation capacity building is complicated but food is a factor in the production of methyl groups [10, 11, and 12]. In the human diet, methyl groups come from foods that contain methyl donating nutrients such as methionine, choline, and folic acid or folate [10, 11, and 12]. Diets deficient in methyl donating foods will impact gene function via hypomethylation [10]. Epigenetic changes can occur in the womb and even after a child is born as a result of maternal and family diet via hypomethylation [13]. Several diseases are associated with the condition of hypomethylation including autism, cardiovascular disease, low high-density lipoprotein (HDL) cholesterol, atherosclerosis, hypertension, hyperglycemia and type-2 diabetes [13, 14, 15].

Hypomethylation is defined simply as a decrease in normal methylation activity.

To prevent diseases of hypomethylation, one thing families can do is increase their intake of methyl donating foods. Following is a table which lists foods high in methyl groups [11].

Methyl Group Donating Nutrient	Type of Food
Methionine	Sesame seeds, brazil nuts, fish, peppers, spinach
Folic Acid [Folate]	Leafy vegetables, sunflower seeds, baker's yeast, liver
Vitamin B-12	Meat, liver, shellfish, milk
Vitamin B-6	Meats, whole grain products, vegetables, nuts
Choline	Egg yolks, liver, soy, cooked beef, chicken, veal and turkey

Activity Break: Survey your refrigerator and freezer. Do you see any of the foods listed in the methyl group table above? Do you and your family eat any of these foods daily and at every meal?

In addition to methyl groups, diet also provides the micronutrients needed by the body to build the proteins and enzymes expressed by our genes. Proteins that promote learning and enhance memory are produced or expressed by genes in brain cells or neurons. Brain derived neurotrophic factor (BDNF) is an example of such a protein produced by the BDNF gene [16, 17]. BDNF regulation and production relies both on methylation and calcium. You can think of the BDNF protein as the glue that attaches our memories to our brain cells. Recently scientists determined BDNF protein levels in the blood of children with autism were significantly lower compared to healthy children of the same age [18]. Another group of researchers found that children with autism were less likely to eat foods providing adequate levels of calcium and folate compared to healthy children [19]. The lesson here is that your child needs to eat foods high in methyl groups and calcium in order for his genes to produce and express the BDNF protein needed to retain memories. Children will not be able to remember their math facts or the sounds that different letters of the alphabet make if their BDNF gene is unable to express enough protein to retain your child's memory of the lessons learned from one day to the next.

PON1 is another gene dependent on calcium for expression [20]. When it is expressed, it produces the enzyme paraoxonase which is needed by your body to break down and metabolize the organophosphate pesticide (OP) residues found on various fruits, vegetables, and grains [21, 22]. PON1 is made in your liver and secreted in your blood where it is incorporated into "good" high density lipoprotein (HDL) cholesterol [23]. Inadequate dietary intake of Ca or consumption of harmful food ingredients may impact paraoxonase-1 (PON1) gene expression [21]. The availability and activity of PON1 are impaired in many children with autism making them more susceptible to the toxic effects of organophosphate pesticide residues which are most frequently found in grain [21, 24, and 25]. Researchers have determined that PON1 enzyme levels are lower in children with autism [24, 26].

PON1 enzyme activity has been extensively studied in humans and there are a number of factors known to modulate or alter its expression including, but not limited to, mercury (Hg) exposure, sex, and age [23, 27]. Age plays the most important role, as PON1 activity is very low before birth and gradually increases during the first few years of a child's life [27]. PON1 activity is also lower in boys compared to girls [23, 27]. This fact might explain why autism is more common in boys than girls. Due to their lower PON1 enzyme production, boys are at much higher risk of the neurological impairment that may occur from exposures to organophosphate pesticides. It is important for you and your family members to eat a diet high in calcium to ensure their PON1 genes are functioning properly. Expectant mothers must ensure their dietary calcium intake is sufficient.

The table below provides a list of foods that are high in calcium from the United States Department of Agriculture (USDA) National Nutrient Database [28].

Calcium content in milligrams (mg)	Measure	Calcium Rich Foods
452 (mg)	8-oz. container	Yogurt, plain, skim milk, 13 g protein
357 (mg)	1 cup	Collard greens, frozen, chopped, cooked, boiled, without salt
345 (mg)	8-oz. container	Yogurt, fruit, low fat, 10 g protein
325 (mg)	3 oz.	Fish, sardine, canned in oil, drained solids with bone
293 (mg)	1 cup	Milk, reduced fat, fluid, 2% milkfat, with added vit A and vit D
291 (mg)	1 cup	Spinach, frozen, chopped, or leaf, cooked, boiled, without salt
224 (mg)	1 oz.	Cheese, swiss
204 (mg)	1 oz.	Cheese, white cheddar
183 (mg)	3 oz.	Fish, salmon, pink, canned
94 (mg)	1 cup	Peas, frozen, cooked, boiled, without salt
75 (mg)	24	Almonds
73 (mg)	1 cup	Raisins, seedless
62 (mg)	1 cup	Broccoli, cooked, boiled, without salt

Activity Break: Survey your refrigerator, freezer, and cupboards. Do you see any of the foods listed in the calcium table? Do you and your family eat any of these foods daily and at every meal?

Children with ADHD and pervasive developmental delay (PDD) tend to collect lead if their diets lack calcium when they are exposed to lead in the environment [29, 30, and 31]. Environmental lead exposure may occur in older homes painted with lead based paint or when drinking water is impacted by lead in plumbing systems. Lead is also routinely found in air and soil. In a child’s body, lead and calcium atoms compete for the same docking stations on molecules so if your child's diet is deficient in calcium, those docking stations will attract lead. It is important for families to eat foods rich in calcium to prevent the bioaccumulation of lead in family members and to support proper PON1 and BDNF gene expression.

Some genes are dependent on micronutrients other than calcium for building their proteins. For example, metallothionen (MT) genes are dependent on zinc to produce the molecules that make up the metallothionein proteins. MT proteins are metal transporters. They perform a metal clearing function in your body. These important proteins allow your body to excrete a number of toxic heavy metals including mercury, copper, cadmium, lead, silver, and bismuth [32]. Scientists have published strong evidence that shows one cause of autism may be a result of a biochemical abnormality that disables the metal clearing function of the metallothionein (MT) protein [33, 34, 35 and 36]. A zinc nutritional deficiency resulting from diet or other mechanisms are involved in creating this abnormality [33, 36].

Strong evidence shows dietary zinc deficiency plays a role both in both autism and ADHD [37, 38, and 39]. MT genes must function properly in order for your body to excrete heavy metals. If your child is deficient in zinc or eating too much of a food ingredient known to deplete zinc, then he may not be able to build the MT protein molecules needed by his body to excrete the heavy metals he is exposed to in the air he breathes and the food he eats [33, 39]. When children with autism are zinc deficient and their MT genes are dysfunctional, their little bodies end up storing heavy metals that lead to neurological impairment. Children with ADHD are also often zinc deficient but there is no evidence to suggest they have MT dysfunction. It is important for families to eat foods rich in zinc to prevent the bioaccumulation of the neurotoxic heavy metals via MT gene dysfunction. The following table provides a list of foods that are high in zinc according to the USDA National Nutrient Database [28].

Zinc content in milligrams (mg)	Measure	Zinc Rich Foods
74 (mg)	3 oz.	Oysters, smoked, in olive oil
8.73 (mg)	3 oz.	Beef, chuck, lean, roast, all grades, fat trimmed, cooked
6.48 (mg)	3 oz.	King Crab, cooked
6.21 (mg)	3 oz.	Lamb, shoulder roast, arm, lean, fat trimmed, cooked
6.13 (mg)	1 cup	Chicken, giblets, cooked
5.79 (mg)	1 cup	Beans, cooked plain
5.43 (mg)	1 cup	Crab, canned
5.36 (mg)	3 oz.	Beef, ground, 85% lean, 15% fat, patty cooked
4.34 (mg)	1 cup	Turkey, meat, cooked, roasted
2.92 (mg)	1 cup	Oat bran, raw
2.2 (mg)	8-oz. container	Yogurt, plain, skim, 13 grams protein
1.93 (mg)	1 cup	Mushrooms, shiitake, cooked, without salt
1.83 (mg)	1 oz.	Nuts, pine nuts, dried

Activity Break: Survey your refrigerator, freezer, and cupboards. Do you see any of the foods listed in the zinc table? Do you and your family eat any of these foods daily? It is important for family members to eat a diet rich in zinc so their bodies can excrete heavy metals.

The bioaccumulation of one or more heavy metals accompanies a number of western diseases and neurodevelopmental disorders. The most common symptom exhibited by a child who is having difficulty excreting heavy metals is "pica." A child with pica will often chew on objects or compulsively eat particular foods or nonnutritive substances [40] and may suffer from abdominal pain [41]. Complications of pica include lead and mercury poisoning [40]. Pica is associated with zinc deficiency, iron deficiency, and developmental delay [40]. As a parent, you need to know that pica is common in children with autism and ADHD but often under-diagnosed [40, 42, 43, and 44]. Under-diagnosis occurs because most physicians are not trained in nutrition or toxicology. It is so important to prepare meals that provide your family with a zinc rich diet.

Diets leading to zinc insufficiency or deficiency may compromise the body's ability to process the mercury found in processed foods [33]. Inorganic mercury (Hg) found in processed foods can impair a number of the body's processes. For example, inorganic Hg may prevent the activation of the PON1 gene in the liver impairing the body's ability to protect itself against organophosphate pesticides resulting in the development of autism or developmental delay [23, 27]. Inorganic mercury exposure from processed food consumption may also alter glucose metabolism by suppressing the GLUT gene that is responsible for regulating glucose levels [45]. This epigenetic change will then increase your risk of developing type-2 diabetes by elevating your blood sugar level [45].

In addition to diet, environmental influences can impact gene expression. For example, pesticide exposure from inhalation of mists being sprayed by the farmer next door can cause epigenetic changes that impact a child's brain development. Exposure to organophosphate pesticides prior to and after birth is associated with the development of both autism and ADHD (46-53). What you eat determines how your genes react to these environmental exposures. If food is the body's only defense against these environmental exposures, then we need to understand what kind of food we are eating. In Chapter 2, we will take a look at what Americans and their families eat on an annual basis and determine if there has been a change in the type and amounts of foods eaten over the past forty years to account for the increasing prevalence of learning disorders and chronic diseases.

Recommended Videos

Holt, S., & Paterson, N. (2006). *Ghost in your genes*. [DVD]. Available for purchase from http://teacher.shop.pbs.org/product/index.jsp?productId=2916431

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Chapter 2

What we eat or don't eat leads to disease

While the chemical makeup of human genes or the genome has remained stable for hundreds of years, what we eat has changed drastically over the last forty years [1, 2]. The dietary changes have impacted the way human genes behave making us more susceptible to disease [2, 3]. In this chapter we will look at the dietary changes that have occurred in the United States. Many of these same changes are occurring in other developed and developing countries all over the world and along with them, there is an increase in the number of people suffering from the so called "western diseases."

Public health agencies are tracking the increasing prevalence of western diseases in each country that has adopted the western diet. In addition to neurodevelopmental disorders [4], the western diet is responsible for the increased prevalence of diabetes, heart disease, cancer, asthma, allergies, dementia, chronic joint disease, skin and digestive disorders, and Alzheimer's disease [2, 3]. In the United States (US), the western diet is also known as the Standard American Diet or SAD and it is characterized by the intake of *processed foods* containing high amounts of refined sugar, fats, oils, and refined grains [1, 3].

After many years and several generations of eating the SAD, children in the US are now being diagnosed with the chronic western diseases once seen only in adults. Increasing numbers of prescriptions are being filled by physicians to treat children as young as 6 years of age with conditions of hypertension, high cholesterol and type-2 diabetes [5]. Unhealthy diet is what leads to the development of these chronic disease conditions in adults and their children along with obesity. Obesity is a condition of transgenerational malnutrition because nutritional deficits that occur when eating the SAD impact gene regulation and function from one generation to the next [6]. Obese and overweight women will essentially give birth to babies who are metabolically programmed to become obese and more likely to suffer from chronic western disease conditions as they age [7].

Because neurodevelopmental disorders are also associated with nutritional deficits found in the SAD, learning disabled children are at risk of becoming obese or overweight by the time they reach the age of twelve [8]. Centers for Disease Control (CDC) researchers looked at the prevalence of obesity and overweight in US children between the ages of 12 and 17 and found that children diagnosed with autism, ADHD, and developmental delay are more likely to be obese or overweight than their non-disabled peers [8]. This means that if your learning disabled child under the age of twelve continues to eat the SAD, he may eventually become obese or overweight and this will put him at higher risk of hypertension, heart disease, type-2 diabetes [8]. These health outcomes are expensive and will impact his over-all quality of life.

By now, hopefully, you will want to have more details on the SAD. Are you wondering “what do families typically eat when they consume the SAD?” The US Department of Agriculture (USDA) keeps track of how much and what each American eats every year [9]. This USDA data is reported in terms of *per capita* which simply means “per person.” I have consolidated this information for you.

The following table shows the changes in refined sugar consumption over the last forty years in the US. The data was extracted from the USDA food availability system and is adjusted for loss or spoilage so it more nearly reflects actual consumption [9].

Refined Sugar Consumption in the United States			
Commodity	**1970 per capita consumption (lbs/year)**	**2012 per capita consumption (lbs/year)**	**Percent increase or decrease (rounded)**
Cane & beet sugar	59.8	39.0	- 35%
Total corn sweeteners, including HFCS	9.3	36.1	**+ 288%**
TOTAL refined sugar	69.1	75.1	**+ 8.7%**
High fructose corn syrup (HFCS)	0.3	27.1	**+ 8,933 %**

In 1970, the type of sugar consumed in the US was primarily cane and beet sugar and along with corn sweeteners, the average American ate 69.1 pounds per year of refined sugar. With the introduction of new processing technology leading to the manufacture of the corn sweetener high fructose corn syrup (HFCS) in the mid 1980's, sugar use switched from cane & beet sugar. HFCS was inexpensive to make and so food manufacturers began adding HFCS to beverages and other *processed foods* instead of sugar derived from sugar cane and beets. In 2012, the average American consumed 75.1 pounds per year of refined sugar, increasing their overall intake of refined sugar by 8.7% compared to 1970. This increase in overall refined sugar consumption does not seem that great but when you look at the changes in the *type* of sugar being consumed, it becomes clear there has been a tremendous change in corn sweetener consumption from 1970 to 2012. Per capita consumption of HFCS increased 8,933% from 1970 to 2012.

In chapter four we will discuss how this tremendous change in HFCS consumption has contributed to the development of neurological disorders and other chronic disease conditions. Until then, it is important for you to note that consumption of HFCS in processed food is reported to be a source of dietary inorganic mercury exposure [10, 11, and 12] and this exposure may impact gene function [13, 14]. Also important is the understanding that refined sugars, including HFCS, do not contain any vitamins or minerals and their consumption may actually lead to reductions in the dietary intake of life sustaining vitamins and minerals [1].

Activity Break: Survey your refrigerator and cupboards. Look at the food ingredient labels of the processed foods. How many food products contain high fructose corn syrup? How often do you and your family eat these food products (e.g. daily, several times a week)?

In addition to refined sugars, processed foods often contain vegetable oils or fats. The table below shows the changes in refined vegetable oil and fat consumption over the last forty years in the US. The data was extracted from the USDA food availability system and is adjusted for loss or spoilage so it more nearly reflects actual consumption [9].

Refined Vegetable Oil and Fat Consumption in the United States

Commodity	1970 per capita consumption (lbs/year)	2012 per capita consumption (lbs/year)	Percent Increase or decrease (rounded)
Butter	3.3	3.4	+ 3%
Shortening	8.9	7.9	-11%
Margarine	6.6	2.1	-68%
Salad & cooking oil (vegetable including soybean, cottonseed, sunflower seed, canola, peanut)	10.3	36.0	+ 250%
TOTAL	29.0	49.4	+ 70%

In 1970, the average American ate 29 pounds per year of refined vegetable oils and fats. By 2012, per capita consumption of oils and fats increased by 70% to 49.4 pounds per year. During the 1970-2012 time period, shortening and margarine consumption decreased by 11% and 68% respectively while butter consumption increased by a mere 3%. Refined vegetable oil consumption, on the other hand, increased by 250%.

In chapter three, we will discuss how the drastic change in American refined vegetable oil consumption has contributed to the development of ADHD, autism, and other chronic western disease conditions. Until then, it is important for you to note that the manufacturing process of vegetable oils involves the extensive use of at least two chlor-alkali chemicals [15, 16, 17] that may be a source of dietary inorganic mercury exposure [18] and this exposure may impact gene function [13, 14]. Consumption of processed foods containing vegetable oils so commonly found in the western diet may also lead to vitamin and mineral deficiencies when family members eat these foods instead of nutrient rich vegetables and fruits [1].

Dietary vitamin and mineral deficiencies that result from eating the western diet are common and problematic in the US [1]. In 2009, USDA scientists reported the finding that almost half of all Americans over the age of one do not meet their average daily dietary requirement for magnesium [19]. More currently, the National Institutes of Health reports that dietary surveys of Americans consistently show intakes of magnesium are lower than recommended amounts across all age groups [20]. It is not surprising that the western diseases of hypertension, heart disease, type-2 diabetes, and ADHD are all associated with magnesium deficiencies [20, 21]. In the US where the average citizen consumes 27 pounds of high fructose corn syrup (HFCS) each year, these reports are alarming because USDA scientists warned years ago that when dietary magnesium intake is low, consumption of HFCS leads to lower calcium (Ca) and phosphorus (P) levels adversely affecting the human body's ability to maintain its internal balance [22].

Consumption of any food ingredient leading to lower calcium levels may drastically alter gene regulation and function as we learned in Chapter 1. The PON1 and BDNF genes are both calcium dependent and must function properly in learning disabled children with autism and ADHD. Your child needs his PON1 gene to activate and express the paraoxonase enzyme to break down the neurotoxic organophosphate pesticide residues routinely found in the SAD. He also needs his BDNF gene to express itself so his memories of lessons learned from one day to the next stay intact. Your child needs to eat a diet that is free of high fructose corn syrup (HFCS) because USDA scientists have provided the warning that its consumption may lead to calcium loss [22]. While reducing your family's intake of HFCS, it is important to plan meals so that your child's diet includes enough calcium to support proper gene regulation and function. You want to avoid creating a food environment that leads to calcium loss or insufficient dietary intake of calcium. If you don't take these precautions, calcium dependent genes crucial for your child's healthy brain development may not function properly.

Insufficiencies in dietary calcium among children in the US have already been documented by scientists at the Centers for Disease Control (CDC) and Prevention [23]. CDC scientists reported in 2008 that 80% of adolescent girls currently do not eat enough foods high in calcium [23]. In addition to this finding, the scientists reported that adolescent girls have reduced their milk consumption by 36% while increasing their average daily soft drink consumption from 50% to 75% [23]. These are unfortunate findings since these girls may eventually become pregnant and calcium deficiency in pregnancy results in the birth of babies born prematurely or with low birth weight [24, 25]. High power studies have shown that low birth weight babies are at significantly higher risk of developing autism and ADHD [26, 27, and 28].

While it is important to track the dietary calcium intake of adolescent girls due to their child bearing capacity, it is equally important to determine the calcium intake of children under the age of 12. Adequate calcium intake is crucial for the detoxification of lead which is commonly found in the environment. Exposure to lead may cause brain damage and impair learning. CDC estimates that four million households in the US have children living in them that are being exposed to high levels of lead [29]. You may be wondering by now if dietary calcium intakes in US children are adequate to detoxify the lead found in their environment.

In the late 90's, one group of scientists did conduct a study of the dietary calcium intake in three hundred fourteen US children ranging in age from 1 to 8 years living in the New Jersey area [30]. They found that 31.4% of the children in the 1-3 year old age group and 59% of the children in the 4-8 year old age group had calcium intakes below the recommended dietary guidelines [30]. This was an important study because it raised a red flag indicating that dietary calcium intake among young children in the US may be too low for proper gene regulation and function and for metabolizing and excreting lead from the body [30, 31]. Remember in chapter one, I mentioned that children with ADHD and pervasive developmental delay (PDD) tend to collect lead and this bioaccumulation may be due to a diet deficient in calcium [30, 31, 32, and 33]. Intuitively you may now be thinking that dairy consumption among children in the US has probably declined over time.

With the rising prevalence of ADHD and autism, it is thus important to determine if there have been changes in the American diet that might explain the reductions in calcium intakes among children in the 4-8 year old age group. I have extracted data from the USDA food availability system and determined these changes for you. The following table shows the changes in the consumption of foods rich in calcium over the last forty years in the US. The foods included in the analysis are those that are free of added sugars and relatively high in calcium compared to other foods. The data is adjusted for loss or spoilage so it more nearly reflects actual consumption [9].

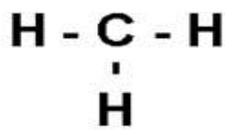
Consumption of Calcium Rich Foods in the United States		
Commodity	**1970 per capita consumption (lbs/year)**	**2012 per capita consumption (lbs/year)**
Refrigerated yogurt	0.6	9.8
Fish, sardine, canned in oil, drained	0.2	0.1
Milk, total, plain, whole and lower far milk, unflavored milk	178.6	107
Spinach, frozen	0.31	0.39
Spinach, fresh	0.14	0.73
Cheese, Swiss	0.42	0.52
Cheese, cheddar	4.8	7.9
Fish, salmon, canned	0.5	0.1
Peas, frozen	1.26	1.19
Almonds	0.3	1.5
Raisins, seedless	0.88	0.85
Broccoli, fresh	0.21	2.50
Broccoli, frozen	0.6	1.59
TOTAL	**188.82**	**134.17**
Percent Change (decrease)	**-29%**	

From my analysis of the data provided in the table above, it appears that over the last forty years Americans have reduced their consumption of healthy calcium rich foods by 29%. I believe this reduction in dietary calcium and the increased intake of HFCS are important factors in the development of neurodevelopmental disorders such as ADHD and those found in the autism spectrum.

Activity Break: Survey your refrigerator, freezer, and cupboards. Do you see any of the foods listed in the calcium table above? Do you and your family eat any of these foods daily and at every meal?

Although there are no human studies available to support my belief, scientists recently reported that pregnant rats fed a diet deficient in calcium gave birth to hypomethylated pups [34]. In Chapter 1 we discussed the fact that hypomethylation is a characteristic of several western diseases including autism, type-2 diabetes, and hypertension. In the case of autism, the evidence suggests that day to day hypomethylation may be corrected in part by increasing the intake of foods high in methyl group donating nutrients while at the same time reducing exposures to environmental toxins found in the food supply such as inorganic mercury and organophosphate pesticides [35, 36].

But before we move on to the specific locations of environmental toxins in the food supply, let's briefly discuss whether there have been any changes in the American dietary intake of foods containing methyl group donating nutrients. There are a variety of foods known to contain nutrients that donate methyl groups. Any reduction over time in the intake of these methyl group rich foods could certainly explain some of the hypomethylation we are seeing with the western diseases. Before I started my investigation, I did not know that such a small molecule could be so important to human health!



Because the USDA food availability system does not collect consumption data for *all* foods high in methyl group donating nutrients, determining these changes for you proved to be difficult but not impossible. I was restricted to collecting only the data that was available from the USDA food availability system. The data I prepared for you in the following table was adjusted for loss or spoilage and reflects actual consumption of the listed foods containing methyl group donating nutrients [9].

Consumption of Methyl Group Donating Foods in the United States

Commodity	**1970 per capita consumption (lbs/year)**	**2012 per capita consumption (lbs/year)**
Fish, canned salmon	0.5	0.1
Shellfish, fresh/frozen	1.3	2.7
Turkey	4.0	7.9
Chicken	22.4	46.2
Veal	1.2	0.2
Eggs	23.9	19.0
Beef	60.9	41.7
Plain milk, whole & lower fat, unflavored	178.6	107
Spinach, frozen	0.31	0.39
Total tree nuts	1.4	3.2
Spinach, fresh	0.14	0.73
Peppers	0.79	4.26
Broccoli, frozen	0.60	1.59
Broccoli, fresh	0.21	2.50
TOTAL	**296.25**	**237.47**
Percent Change (decrease)	**-20%**	

From my analysis of the data provided in the table above, it appears that over the last forty years, Americans have reduced their consumption of foods high in methyl donating nutrients by approximately 20%. I believe this reduction in intake of methyl donating nutrients is a factor in the increasing prevalence of diseases associated with hypomethylation.

Activity Break: Survey your refrigerator, cupboards, and freezer. Do you see any of the foods listed in the methyl group donating food table? Do you and your family eat any of these foods daily and at every meal?

In Chapter 1 we discussed the role of methyl groups in gene regulation and function. It is crucial to include foods in the family diet that contribute methyl group donating nutrients. Study after study shows that children with autism and ADHD and adults suffering from the type-2 diabetes, hypertension, fatty liver, obesity, and heart disease all suffer from nutritional deficiencies that can be traced back to the inadequate intake of foods that provide essential methyl group donating nutrients [37, 38, 39, 40, 41 and 42]. Methyl groups are needed by the body to turn the genes on that produce the proteins and enzymes required to rid the body of environmental toxins that are associated with the development of these disease conditions. Mercury, pesticides, lead, arsenic, are all examples of the toxins found in your family's environment every day. Exposure to these environmental toxins may occur in the air you breathe, the water you drink and especially the food you eat.

Recommended Videos

Spurlock, M. (2004). *Super size me*. Available free on Hulu at http://www.hulu.com/watch/63283

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Chapter 3

Ingredients that add heavy metals to your body

In the previous chapter, we examined the changes in food availability and consumption that have occurred in the US and other countries that have adopted the western diet made up of foods rich in refined sugars and vegetable oils. We learned that consumption of processed foods containing refined sugar and vegetable oil ingredients has increased while consumption of whole, healthy foods rich in calcium, magnesium, and methyl group donating nutrients has decreased leading to conditions of disease. We discussed how some of these changes in dietary pattern may have impacted our gene function over time creating conditions for the development of western disease conditions.

In this chapter we will focus on how some food ingredients may impact health and contribute to the development of disease by depositing toxic heavy metals into our bodies. Preservatives, vegetable oils and food colors are examples of common ingredients found in processed food products that will contribute to your family's burden of heavy metal exposure. Although few studies have been conducted to determine the concentrations of heavy metals in food products, there seems to be some evidence to suggest the most common toxic heavy metals found in the food supply are inorganic mercury, lead, cadmium, and arsenic [1, 2, 3, and 4].

Scientists have determined the concentrations of heavy metals in food stuffs eaten by adults and children correlate with the heavy metals found in their bloodstream [5]. This is an important finding because some western diseases are associated with elevated levels of lead, mercury, cadmium, or arsenic in the bloodstream [6, 7, and 8]. The greater the dietary exposure to these heavy metals, the more elevated they become in the blood stream. Elevated levels of lead, arsenic, cadmium and/or mercury in the bloodstream have been found to increase risk of developing obesity, diabetes, and/or heart disease [6, 7, and 8]. To reduce your family's risk of developing these chronic diseases, you will want to avoid feeding them food ingredients allowed to contain these heavy metal impurities.

With respect to learning disabilities, children with autism have recently been found to have significantly higher mercury and lead levels in their blood cells compared to healthy children [9]. One group of scientists found the higher the mercury or lead levels in the autistic child's blood, the greater their social and cognitive impairment [9]. Another group of scientists recently found that dietary patterns involving the consumption of processed meat, snacks, beverages, fast food, and condiments increased exposures to mercury and lead and correlated to increased risk of ADHD in children [10]. In the previous chapters, we discussed the role of lead exposure in children with ADHD. If you have a learning disabled child with autism or ADHD, you will want to reduce his dietary intake of food ingredients known to contain trace amounts of lead, and/or mercury so that he can improve his social and cognitive functioning.

Inorganic mercury is introduced to food ingredients unintentionally and on purpose [11]. For example, vegetable oils processed with mercury cell chlor-alkali chemicals may contain trace amounts of mercury. How do we know this? A crucial report was recently published as a reference document by FEDIOL, the trade organization for members of the European Union (EU) vegetable oil and protein meal industry [12]. FEDIOL conducted a risk assessment of the chain of vegetable oil products manufactured using the common *alkali* refining process and found a moderate risk of mercury contamination. During this process, the chlor-alkali product sodium hydroxide (caustic soda) is added to the older, degraded vegetable oils to remove free fatty acids [12]. These acids must be removed to enhance the value and taste [12] of the oils; otherwise there would be a bitter or rancid flavor in food products containing these vegetable oils [12]. The following table provides a list of the vegetable oils at risk of mercury contamination due to the alkali refining process [12, 13, and 14] and their common uses in food products.

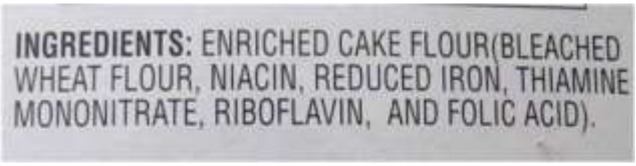
Vegetable Oils at Moderate Risk of Mercury Contamination and Some Food Products Potentially Impacted	
Vegetable Oil Type	**Common Uses in Food Products**
Coconut oil	Baked goods, pastries
Rape seed (canola) oil	Chips, mayonnaise, frozen fish sticks, frozen French fries, salad dressings, crackers, peanut butter
Soybean oil	Mayonnaise, frozen fish sticks, frozen French fries, Frozen tv dinners, bread, salad dressings, horse radish, tartar sauce, crackers, cookies, peanut butter
Palm oil	Almond butter, cookies
Sunflower oil	Chips, frozen French fries, crackers
Olive oil	Salad dressings

As was mentioned in Chapter 2, the average American consumes 36 pounds of vegetable oils per year. Overconsumption of these oils not only contributes to your family's mercury exposure but also promotes the development heart disease and diabetes [15]. The consumption of vegetable oils adds omega-6 fatty acids to the family diet but does not provide the more important omega-3 fatty acids which have strong healing anti-inflammatory properties. While both kinds of fatty acids influence gene expression, vegetable oils high in omega-6 tend to irritate or inflame the body creating conditions for disease [15]. Such inflammation is a characteristic of children with autism and ADHD [16].

As a parent, it is important to understand that vegetable oils do not have to undergo the alkali refining process. They may be consumed in the unrefined state and in many countries they are consumed in this way [17]. Vegetable oils that may be consumed in the unrefined state include peanut, coconut, olive, palm, mustard seed, rapeseed, sesame seed and palm [17]. To reduce your child's mercury exposure and blood mercury levels, you may purchase and use the unrefined vegetable oils at the health food store. Unrefined coconut oil is great for frying or baking and cold pressed olive oil is good for making salad dressing and mayonnaise. It is important for your family to eat mercury free vegetable oils in moderation.

Activity Break: Survey your refrigerator, freezer, and cupboards. What kind of vegetable oils did you find? Did you see any food products that list any vegetable oils on the ingredients label? How often do you and your family eat these food products (e.g. daily, several times a week)?

Mercury in vegetable oil that has undergone alkali refining is just one example of how mercury may be unintentionally added to food ingredients or food products. In the preface of this book, I mentioned the extensive use of the mercury cell chlor-alkali chemical products sodium hydroxide (caustic soda), hydrogen chloride, potassium hydroxide, and chlorine in food manufacturing processes. These chlor-alkali chemicals always contain mercury residues [18, 19, and 20]. Mercury cell sodium hydroxide (aka "caustic soda") and hydrogen chloride are used routinely to regulate the acidity or pH of food products during manufacturing processes. Current international food standards thus allow one microgram (µg) of mercury in each gram (g) of caustic soda used to process or manufacture food [19, 20]. One µg/g is the same as 1 part per million (ppm). There is no standard for mercury in food grade hydrochloric acid [21]. The US Food and Drug Administration (FDA) considers hydrochloric acid to be generally recognized as safe (GRAS) for use as a neutralizing or buffering agent in food manufacturing processes [21]. Mercury cell chlorine is also expected and allowed to contain a small amount of mercury residue; hence there is an international standard for the amount of mercury in the chlorine used to bleach flour [22]. The standard for mercury in this chlorine is 1 ppm [22]. If you have a child and want to limit his mercury exposure, it would be best to avoid food products containing the ingredient “bleached flour or bleached wheat flour.”



Food colors made from chemicals derived from sodium hydroxide and petroleum may also contain allowable levels of mercury and other heavy metals. Petroleum comes from the ground where heavy metals are found. These food colors are expected to contain trace amounts of the heavy metals mercury, lead, and/or arsenic as a result of their extraction and manufacturing processes [23]. In the US, the Food and Drug Administration (FDA) requires these synthetic food colors be tested and certified to ensure they only contain up to the allowable levels of mercury, lead or arsenic [23]. In the European Union (EU), food products containing some of these colors must carry the mandatory warning on the label “*may have an adverse effect on activity and attention in children*.” [24]. The only difference between the food colors used in the US and the UK is the identification numbers used by the food manufacturers. For example, on food products produced in the US, sunset yellow is denoted as “yellow 6” on the food ingredient label but if the product is sold in the EU, sunset yellow is denoted as “E-110” and the food package must carry the mandatory warning to parents.

Please study the following table I have prepared for you that shows the FDA certification specifications for heavy metal impurities in common food colors. The table also provides examples of food products in which these colors are commonly found as food ingredients. Please note the food colors with an asterisk * beside them.

Specifications for Common Food Colors in the United States Requiring Certification by FDA		
Color Names, Synonyms	**Allowable Impurities**	**Common Uses**
Blue 1	Chromium ≤ 50 ppm Arsenic ≤ 3 ppm Lead ≤10 ppm	Colored ice cream cones, power drink, soft drink, cheese flavored snack, spicy corn chip, sugar sweetened cereal, chocolate and strawberry syrups, candy
Blue 2	Lead ≤10 ppm Arsenic ≤ 3 ppm Mercury ≤ 1 ppm	Energy drinks, candy
Yellow 5, E-102*, tartrazine	Lead ≤10 ppm Arsenic ≤ 3 ppm Mercury ≤ 1 ppm	Butter, cheese, ice cream, sweet pickle relish, soft drinks, cheese flavored snacks, barbeque flavored snack, spicy corn chips, boxed macaroni and cheese, candy, vitamin water
Yellow 6, E-110* sunset yellow	Lead ≤10 ppm Arsenic ≤ 3 ppm Mercury ≤ 1 ppm	Ice cream, power drinks, cheese flavored snacks, pudding snack, sugar sweetened cereal, sugarless gum, chocolate syrup
Red 40, E-129*, allura red	Lead ≤10 ppm Arsenic ≤ 3 ppm	Cotton candy, soft drinks, children's cough medicine, liquid aspirin, cherry pie filling, ice cream, energy drink, gelatin mix and snack, canned cherries, strawberry cake mix, sugar sweetened cereal, vitamin water

Food products containing the colors in the table above denoted by the asterisk ***** must carry the mandatory warning label if they are sold in the EU [24].

<u>Activity Break</u>: Survey your refrigerator, freezer, and cupboards. Do you see any food products that list any of the certified food color ingredients that require warning labels in Europe (e.g. yellow 5, yellow 6, red 40)? How often do you and your family eat these food products (e.g. daily, several times a week)?

By now you are probably wondering why parents in the US are not provided with a warning about the adverse effects on child behavior that occur with the consumption of certain food colors. To my knowledge, there has not been any research funded in the US on food color safety. In Europe, several human studies have been conducted by researchers that show consumption of yellow #5 and/or yellow #6 negatively impacts child health [25, 26]. Dr. Neil Ward determined the effect of yellow #5 and yellow #6 on children with and without hyperactivity [25, 26]. He found that only hyperactive children showed significant losses in zinc after drinking beverages containing yellow #5 and yellow #6 [25, 26]. The children who were not hyperactive showed no changes in their zinc status after consuming the same beverages [25, 26]. What this means is the there is something in these yellow food colors that creates conditions for zinc loss in children with ADHD. I believe it is the allowable heavy metal impurities.

Unfunded research does occur in the US. My collaborators and I followed up on Dr. Ward's work and published a peer reviewed model explaining how zinc losses may occur from the consumption of food colors containing allowable levels of mercury [2]. We explain how these losses may impact MT gene function weakening the child's immune system and ability to learn [2]. Mercury and other heavy metals are able to displace zinc from the binding sites on the metal transporter protein metallothionein (MT) produced by the MT gene [2]. The end result of this displacement may be an overall loss of zinc from the child's body via urinary excretion. The zinc must go somewhere once it is replaced by a heavy metal on the metallothionein protein molecule.

The more heavy metal exposure your child may have the more likely he will become zinc deficient as the zinc is released from his body and heavy metals are transported through the circulatory system by the MT protein to body tissues for storage and/or accumulation [2, 27]. Zinc deficiency is common among children with autism [28] and ADHD [29] who may at times become hyperactive. Scientists do not yet know the exact cause of hyperactivity but it is likely a combination of factors arising from the consumption of yellow food colors to include zinc deficiency and/or the accumulation of heavy metals in the child's blood and body tissues. As we discussed in Chapter 1, a clear sign of heavy metal accumulation is the symptom of "pica." If your child frequently chews on objects, then s/he may have difficulty excreting heavy metals and is likely zinc deficient. It is important for you to eliminate food colors from the family diet that contain allowable levels of mercury and may lead to zinc losses. Avoid purchasing foods with the food color ingredients of concern that may contain allowable heavy metal impurities.

Picture provided by Linda Bonvie

In addition to the FDA certified food colors there are some other food color ingredients on the market that may contain allowable levels of the heavy metals arsenic, lead and mercury. These colors are exempt from FDA certification because they are not made from petroleum; they are instead derived from plants or minerals [30] found in the natural environment. Beware of buying food products that claim they are made from “natural” ingredients, however. These products may contain food colors that will contribute to your child’s heavy metal burden. These food color ingredients are not safer for your child to consume [31]. The following table provides information found in the United States Code of Federal Regulations about the FDA exempt food colors and their allowable impurity levels [32].

Specifications for Less Common Food Colors in the United States – Exempt from Certification Requirements

Color Names, Synonyms	Allowable Impurities	Common Uses
Caramel	Arsenic ≤ 3 ppm Lead ≤ 10 ppm Mercury ≤ 0.1 ppm	Canned peppers, ice cream, soft drinks, lunch meat, beef gravy, chocolate syrup, candy, pancake syrup, spice rub
Annatto	Lead ≤ 10 ppm Arsenic ≤ 3 ppm,	Sugar sweetened cereal, cheddar cheese, ice cream, cheese spread, buttery spread
Carmine, cochineal extract	Lead ≤ 10 ppm Arsenic ≤ 3 ppm	Canned fruit cocktail
Spirulina	Lead ≤ 2 ppm Arsenic ≤ 2 ppm Mercury ≤ 1 ppm	Health food products
Titanium dioxide	Lead ≤ 10 ppm Arsenic ≤1 ppm Mercury ≤ 1 ppm	Vitamins and supplements
Beta carotene	Lead ≤ 10 ppm Arsenic ≤ 3 ppm	Vegetable oil spread, canned tropical fruit, fat-free and cholesterol free liquid egg product

It is a shame that spirulina may contain these harmful heavy metals because it is a super food [33] that provides vitamins and minerals needed for proper gene function. I cannot recommend feeding this food to your child because researchers did verify in a recent study the consistent finding of mercury in twenty five different products containing the spirulina ingredient [34]. The American Academy of Pediatrics recommends eliminating all sources of mercury exposure that may cause harm to child health [35]. To avoid mercury and other heavy metal exposure that creates conditions for zinc loss and deficiency in your child, you can eliminate the food colors in the table that contain heavy metals from your family's diet.

Activity Break: Survey your refrigerator, freezer, and cupboards. Do you see any food products that list any of the food colors in the above table on the ingredients label? How often do you and your family eat these food products (e.g. daily, several times a week)?

The connection between the dietary intake of food colors and hyperactivity in children continues to be studied by researchers in Europe. While Dr. Ward [25, 26] studied the metabolic impact of zinc loss in hyperactive children who consumed food colors yellow #5 and #6, other researchers have focused their studies on the impact of food color consumption on the behavior of children in the *general population*. In the UK, researchers led by Bateman found a negative effect on the behavior of 1,873 three year olds when parents reported their children became hyperactive after consuming a drink containing a mixture of food colors and sodium benzoate [36]. It was unclear, however, whether the food colors or the sodium benzoate caused the hyperactivity in the children [36].

To clarify the findings, a new study was conducted by a different group of researchers in the UK led by Donna McCann and the results were published in 2007 [37]. This time both three year old and eight year old children from the *general population* were included in the study [37]. The children were divided into three groups and given different beverages to drink; one group consumed a beverage mixed with sodium benzoate alone, another group consumed a beverage with food colorings and the remaining group consumed a placebo beverage with no exposure to sodium benzoate or food colors [37]. The results of the new study confirmed the consumption of beverages containing food colors or sodium benzoate by children in both age groups resulted in increased hyperactivity [37]. Both parents and teachers reported observing the increased hyperactivity in the children after drinking the beverages containing food colors or sodium benzoate [37].

The McCann et al. (2007) study included children in the general population, not just hyperactive children, and the results made it clear that the dietary intake of food colorings or sodium benzoate may affect the behavior of all children [37]. It was this study that led to the requirement in the EU that food products containing certain food colors must carry the mandatory warning on the label "*may have an adverse effect on activity and attention in children*." [27]. In the US there are no such warning labels on products containing the food color or sodium benzoate ingredients found to cause hyperactivity in children. To prevent hyperactive behavior in your child, you will want to eliminate most food colors and sodium benzoate from the family diet. As the list of harmful food ingredients grows longer with the addition of sodium benzoate, you may be wondering which heavy metal is found in sodium benzoate to cause hyperactivity in children. Where does sodium benzoate come from anyway?

Sodium benzoate is not found naturally in the environment [38]. The food ingredient is manufactured three different ways, one of which involves the neutralization of benzoic acid with sodium hydroxide [38] which may contain mercury residue [18, 19, and 20]. The chemical is used as a food additive to control microbial growth (preservative) and a flavoring agent and most commonly found in soft drinks and cough syrup. In soft drinks, the chemical can combine with ascorbic acid (vitamin C) to form benzene which may cause cancer. When used as a preservative, sodium benzoate must not legally contain more than the allowable level of 2 ppm lead [39, 40]. Manufacturing product specification sheets indicate food grade sodium benzoate may contain up to 1 ppm mercury [41]. So now you know sodium benzoate may be a source of dietary lead or mercury exposure and you will want to eliminate this ingredient from your family's diet.

There are a many other food ingredient chemicals used as additives in the food supply that are allowed to contain small amounts of heavy metals [42]. The most common heavy metal allowed in these food ingredients is lead. Lead exposure can and does interfere with your child's learning process by creating conditions for hyperactivity and attention deficit. You may remember from our discussions in Chapters 1 and 2 that lead is a factor in the development of ADHD and pervasive developmental delay especially when the family diet is deficient in calcium [43, 44, 45, and 46]. You will want your family to avoid or reduce its consumption of food ingredients allowed to contain small amounts of lead. In addition to sodium benzoate, several other ingredients containing lead are approved for use as preservatives. Following is a table with the more common food additives used as preservatives and the allowable heavy metal impurity levels [42, 47, 48, and 49].

Limits for Heavy Metals in Food Additives Used as Preservatives		
Preservative Name	**Allowable Impurities**	**Common Uses**
Calcium chloride	Lead ≤ 2 ppm	Power drink, sweet pickles, dill relish, sweet pickle relish, frozen tv dinner, canned vegetable, organic frozen pizza
Potassium chloride	Lead ≤ 2 ppm	Ham in a can, frozen tv dinner
Sodium benzoate	Lead ≤ 2 ppm Mercury ≤ 1 ppm	Ginger ale, tonic water, soft drinks, soy sauce, salad dressing, lunch meat
Sodium diacetate	Lead ≤ 2 ppm	Lunch meat, hot dogs
Sodium nitrite	Lead ≤ 2 ppm	Beef jerky, ham in a can, sausage, lunch meat, bacon, hot dogs
Carrageenan	Lead ≤ 5 ppm Arsenic ≤ 3 ppm Cadmium ≤ 2 ppm Mercury ≤ 1 ppm	Pudding mix, cottage cheese, sour cream, ice cream, canned evaporated milk, organic soy milk, almond milk
Citric acid	Lead ≤ 0.5 ppm	Energy drink, powdered spice mix, barbeque sauce, organic strawberry preserves, organic tomato sauce
Monosodium L-Glutamate, sodium glutamate, MSG	Lead ≤ 1 ppm	Hot dogs, sausage

Activity Break: Survey your refrigerator, freezer, and cupboards. Do you see any food products that list any of the preservatives in the above table on the ingredients label? These products may contribute to your child's overall lead exposure. How often do you and your family eat these food products (e.g. daily, several times a week)?

There are many other chemicals used as preservatives in the food supply. Most are derived from sodium or sodium salt compounds. Whether or not these sodium compounds contain trace amounts of mercury or other heavy metal impurities as a result of their manufacturing process remains unknown. According to CDC and the Institute of Medicine, the excessive dietary intake of these sodium compounds is the leading cause of hypertension, kidney, and heart disease [50, 51]. These science based organizations recommend that you reduce their sodium chemical intake [50, 51] and I do too!

In this chapter, we learned that certain vegetable oils, food colors, and preservatives may contribute to the development of disease by depositing heavy metals into our bodies. Mercury and other heavy metals are able to displace zinc from the metal carrier protein metallothionein (MT) and this can lead to zinc losses from the body which adversely impacts health by creating inflammation and stress [2]. Low zinc status is associated with autism, ADHD, hyperactivity, pica, type-2 diabetes, insulin resistance, and heart disease conditions [28, 29, 52, 53, 54 and 55]. Zinc is needed by the body to build the MT proteins which maintain the body's immune system and health [27].

No matter what your child's condition, he will learn better in school if you eliminate *all of the food ingredients* from his diet that may contain allowable levels of the heavy metal impurities. If he is daydreaming or wiggling, he will not be able to focus on his teacher's instructions or the lessons being given in the classroom. Family members suffering from, or at risk of, type-2 diabetes, insulin resistance, or heart disease will also benefit from the same dietary changes.

Recommended Videos

Dufault, R. (2014, April). The medicine of food. In J. Barreiro (Chair), *Patterns of health and wellbeing*. Symposium conducted at the Smithsonian Institute National Museum of the American Indian. Retrieved from https://www.youtube.com/watch?v=IwapwKitM0k

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Chapter 4

What we know about corn sweeteners

In the previous chapter we took a look at the processed food ingredients in the following categories: vegetable oils, food colors, and preservatives. We examined how the use of these food ingredients contributes to heavy metal exposure and the development of various disease conditions including type-2 diabetes, heart disease, hyperactivity, autism and ADHD. In this chapter we will learn how corn sweeteners may impact health and contribute to the development of disease but first we will look at how corn sweeteners are manufactured from corn starch.

Corn sweeteners are made from corn starch, the same material manufactured over 150 years ago for the laundry business [1]. Corn starch is made from corn using the wet milling manufacturing process which separates the corn kernel into starch, gluten, germ and fiber [1]. The gluten, germ and fiber are further processed into feed for animals while the starch is washed and refined into corn sweeteners and ethanol [1]. As part of the washing process, the starch is softened as it is cleaned or steeped in sulfur dioxide or a slightly acidic sulfurous acid solution [2]. Next mercuric chloride, a mercury compound, is added to the mix to inhibit naturally occurring starch degrading enzymes produced by bacteria [2]. The resulting steep liquor is discarded as the corn starch mixture is strained over and over again with water to remove any remaining fiber, germ, or gluten [2]. Finally the starch is dried and this is the material from which corn sweeteners are made.

There are several different corn sweeteners made from corn starch with the most refined product being high fructose corn syrup (HFCS). For this reason, HFCS is viewed as the end product of the corn wet-milling process. During the corn sweetener refining process, several chemicals are added to the mix to include caustic soda, hydrogen chloride, alpha-amylase, gluco-amylase, isomerase, filter aid, powdered carbon, calcium chloride, and magnesium sulfate [3]. As was mentioned in Chapter 3, mercury cell sodium hydroxide (aka "caustic soda") and hydrogen chloride are used routinely to regulate the acidity or pH of food products during manufacturing processes. These same chemicals may be used in the corn sweetener refining process. Because current international food standards allow one microgram (µg) of mercury in each gram (g) of caustic soda [4, 5], there is a chance mercury exposure may occur from the consumption of corn sweeteners due to their manufacturing processes. Studies have in fact been published that report the amount of mercury residue found in HFCS or food products containing HFCS or corn syrup [6, 7, and 8]. It is unclear whether the mercury residue was from the use of the mercury cell chemicals or the mercuric choride that was added purposely to the starch at the beginning of the refinery process.

The following table lists the most common corn sweeteners found in the western diet:

Corn Sweeteners at Risk of Mercury Contamination and Some Food Products Potentially Impacted	
Corn Sweetener	**Common Uses in Food Products**
Corn syrup	Ketchup, Japanese style noodle soup, tv dinners, lunch meat, candy, caramel topping, chocolate syrup
Modified corn starch	Cake mix, pancake mix, tv dinners
Dextrose	Assorted cookies and crackers, candy, toaster pastries, pancake mix, cereal, tv dinners, hot dogs, sausage
Maltodextrin	Assorted chips, Japanese style noodle soup, stuffing mix, crackers
High fructose corn syrup	Ketchup, canned spaghetti and soups, pork and beans, soft drinks, caramel topping, chocolate syrup, salad dressings, teriyaki marinade, pancake syrup, toaster pastries

It is probably safe to assume that if you feed your child any products containing the corn sweeteners listed in the table, there is an excellent chance s/he will be exposed to mercury. My collaborators and I conducted a study at a community college in which students were asked to eliminate corn sweeteners from their diet. We collected blood samples at the end of the intervention and the one student who was unable to eliminate corn sweeteners from her diet had the highest inorganic mercury levels of all [9]. One of the problems with this potential mercury exposure is the impact on the metal carrier protein, metallothionein (MT). Mercury may displace zinc in the metallothionein (MT) molecule and such displacement can lead to zinc losses [10]. Over time, these losses may impair your child's ability to excrete heavy metals as s/he becomes zinc deficient [10].

In Chapter 1, we learned that zinc is needed to build the MT protein molecules which transport and excrete heavy metals from your child's body. Since there is now plenty of evidence that symptoms of autism can be created by disabling the MT gene [11, 12, 13, 14, and 15], you will want to avoid feeding your child any substance that may disable functioning of this important gene. The MT gene will not be able to carry out the instructions for building the MT protein molecules if there is not enough zinc available in your child's body. Substances like HFCS or food colors that contain mercury or other heavy metals may create conditions of zinc loss. Children with autism and ADHD are already struggling with zinc deficiency [16, 17, and 18] and the bioaccumulation of heavy metals [19, 20]. There is no reason to add fuel to the fire by feeding your learning disabled child corn sweeteners which may lead to zinc loss and/or the accumulation of heavy metals.

Activity Break: Survey your refrigerator, freezer, and cupboards. Look at the food ingredient labels of the processed foods. Do you see any of the corn sweeteners listed in the table on the previous page? How often do you and your family eat these food products (e.g. daily, several times a week)?

By now you may be wondering whether or not scientists have actually determined if consumption of corn sweeteners leads to zinc loss in humans. The answer is yes, indeed. Two American scientists, Ivaturi and Kies, determined in a 1990 study that consumption of fructose and HFCS by humans may lead to certain mineral imbalances to include zinc loss and copper gain [21]. In Chapter 3, we already discussed how consumption of yellow food colors leads to zinc loss in hyperactive children. So certain corn sweeteners, just like the yellow food colors, have the potential to create conditions of zinc loss that may disrupt or impair MT gene function. If your child's body does not have sufficient zinc because s/he is consuming too many soft drinks containing high fructose corn syrup, MT gene dysfunction may occur.

The gene may not be able to carry out its instructions for building the MT proteins needed to excrete the heavy metals inorganic mercury and lead from your child's body. This is one way the bioaccumulation of these heavy metals may occur.

There is strong evidence to suggest the bioaccumulation of inorganic mercury is already occurring in the American population and creating health problems. A researcher by the name of Dan Laks analyzed blood results data collected by the Centers for Disease Control (CDC) from 6,174 American women of child bearing age [22]. The data was collected by CDC during the 1999-2006 time period and the women ranged in age from 18 to 49. Laks found that within this population, detectable inorganic blood mercury levels rose sharply from 2% of the women in 1999-2000 to 30% of the women in 2005-2006 [22]. Laks also found that the *average* detectable inorganic blood mercury levels rose significantly over the same period of time [22]. What this means is inorganic mercury accumulates over time in the body with increasing age [22] as women continue to eat the toxic western diet. The older a women gets, the more inorganic mercury there will be in her body if she does not change her diet. No one has done the same kind of study to determine if average inorganic mercury levels also rise in men as they age. Studies have been conducted, however, on both rats and humans to determine how higher blood mercury levels impact health by increasing the risk of heart disease and type-2 diabetes [23, 24, 25, 26, 27, and 28]. Many of these same studies indicate that it isn't just the heavy metal mercury causing these health problems; exposure to, and the bioaccumulation of lead and arsenic also contributes to the development of these western disease conditions.

By now it should be clear to you that heavy metal exposure and bioaccumulation may occur from the consumption of highly processed foods. In Chapter 3, you learned about all of the food ingredients for which there are allowable and/or expected levels of inorganic mercury, arsenic and lead. Highly processed foods containing food colors, sodium chemicals, preservatives, bleached flour, vegetable oils, and corn sweeteners are all potential sources of heavy metal exposure, especially inorganic mercury. With respect to the development of type-2 diabetes, *inorganic mercury exposure from the consumption of* *processed food is directly related to fasting glucose or blood sugar levels* [29]. How do we know this?

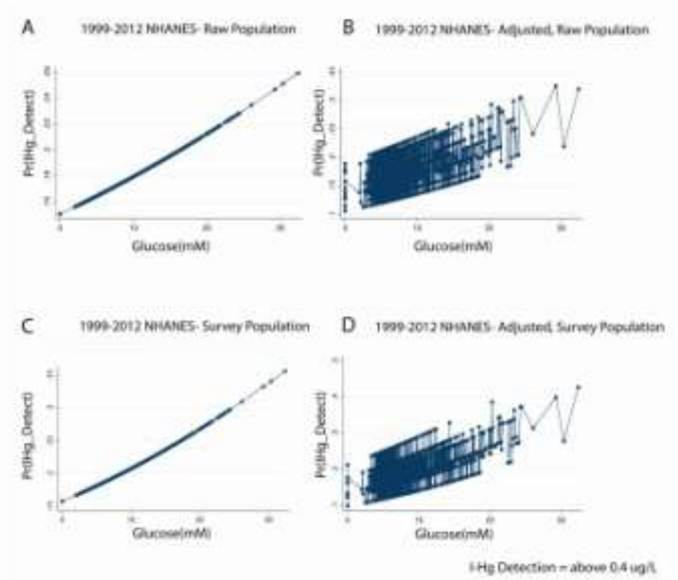
When my collaborators and I conducted the small study at the community college, we found that when students significantly reduced their consumption of processed foods while increasing their intake of whole, unrefined foods, they had lower inorganic blood mercury and fasting glucose levels than students who only eliminated corn sweeteners from their diet [29]. Our findings indicated blood mercury and fasting glucose levels could be influenced by dietary intake of processed foods [29]. The more processed foods the students eliminated from their diet, the lower their inorganic blood mercury and fasting glucose levels. To confirm the relationship between inorganic mercury in blood and fasting glucose levels we partnered with the University of California Los Angeles (UCLA) researcher Dan Laks to analyze the CDC's National Health and Nutrition Examination Survey (NHANES) data set [30].

The NHANES data set is used by researchers all over the world to study the role of diet and lifestyle in the development of disease [30]. CDC collects the data from thousands of Americans who answer survey questions about their diet and lifestyle and donate blood and urine samples for analysis [30]. The blood and urine samples are analyzed by CDC to determine a wide range of biomarker levels [30]. Biomarkers are measureable compounds or elements found in human body tissues and fluids.

Examples of Biomarkers Doctors Measure to Diagnose Disease or Determine Risk of Disease

Biomarker	Disease State
Fasting blood glucose level	Diabetes
Blood lead level	Developmental delay, behavior abnormalities, lead poisoning, ADHD, autism
Protein in urine	Kidney disease
Hemoglobin, hematocrit levels (blood)	Anemia

In our collaboration with Dan Laks, we analyzed the blood mercury and glucose measurements taken from 16,232 Americans from 1999-2012 [29]. The following figure shows the results of our analysis - inorganic mercury (I-Hg) detection is directly associated with fasting glucose in the NHANES 1999-2012 dataset [29]. The slope of each line tells the same story.



Our results indicate that as inorganic mercury accumulates in the blood of Americans, their fasting glucose or blood sugar level rises [29]. This trend was observed in both men and women and across races in a sample size of 16,232 Americans. The results of our study also indicate the more processed foods your family members eat, the higher their inorganic blood mercury and fasting glucose levels [29]. It goes without saying, as your fasting glucose or blood sugar level rises, so does the risk of being diagnosed with type-2 diabetes. To avoid the diagnosis of type-2 diabetes in family members, it is important to reduce their intake of processed food ingredients known or allowed to contain trace amounts of inorganic mercury. Study the tables provided in Chapter 3 again to determine which processed food ingredients may contain mercury and avoid their consumption along with corn sweeteners.

Our small study at the community college showed that it isn't enough to just eliminate corn sweeteners from the diet. To improve fasting sugar levels, one must also reduce intake of the other processed food ingredients that may contain inorganic mercury while increasing intake of whole, unrefined foods. This means your family members need to eat more whole foods and less refined foods to reduce their inorganic mercury levels and subsequent risk of type-2 diabetes.

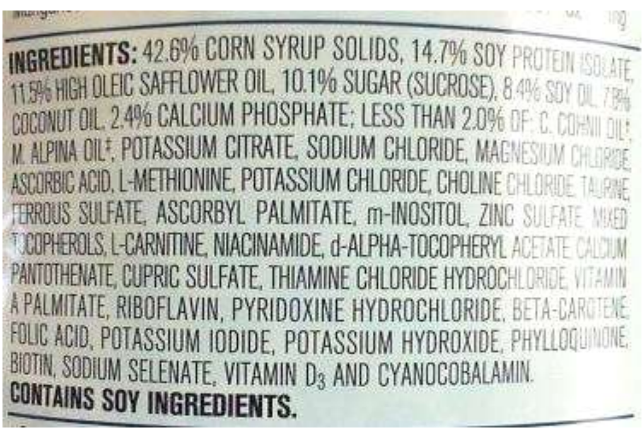
Activity Break: Survey your refrigerator, freezer, and cupboards. How many whole, un-refined foods do you see? Look for un-processed meats, fish, eggs, vegetables, fruits, beans, and rice. These whole foods do not have food ingredient labels. How often do you and your family eat these whole foods (e.g. every meal, daily, several times a week)?

In addition to contributing to overall inorganic mercury exposure and increasing risk of type-2 diabetes, over consumption of corn sweeteners may also lead to obesity in humans of all ages including infants. The obesity problem begins in our children before they are even born. As the expectant mother consumes high fructose corn syrup during her pregnancy, she is affecting and determining the lifelong function and metabolic systems of her baby [31]. High fructose corn syrup is considered an obesogen, a foreign compound that disrupts normal function and development of metabolic systems leading to increased risk of obesity [31]. In Chapter 2, we learned the average American was consuming 36.1 pounds of corn sweetener, including HFCS, per year in 2012. If the expectant mother is consuming this amount of HFCS, she may be putting her baby at risk of becoming obese. If she then chooses to feed her newborn baby "formula" instead of breast milk, she may further increase her baby's risk of obesity [32, 33]. Why?

Scientists do not know the reason(s) why and have provided little explanation. They have only reported in recent medical journal articles that babies consuming formula are at higher risk of becoming obese [32, 33]. Apparently babies fed only formula or fed a combination of breast milk and formula are more likely to become obese compared to babies who are only breastfed [32]. The age at which breast-feeding stops and formula is introduced also appears to be a key determinant of obesity risk throughout childhood, adolescence, and even young adulthood [33]. Scientists are therefore recommending to new mothers that they breast feed exclusively for at least six months to protect their infants from becoming obese [33].

Infant obesity is a problem in America and other countries that eat the toxic western diet. In the U.S., infant obesity is out of control and considered to be an epidemic by the government [34]. Recent estimates indicate that 8.1% of American infants and toddlers are obese [34]. Scientists at a 2013 National Institutes of Health Workshop admit that epigenetic processes such as methylation can modulate gene function and play a role in child development [34]. These same scientists also think infants might need more physical exercise [34]. I think there must be something in baby formula that makes infants obese. Infants do not become obese because they are not getting enough exercise; they can't even walk yet! Infants become obese when they are fed formula that contains corn sweeteners and other sugars [35].

You must be holding your head with both hands by now as the voice in your brain is screaming "What? Corn sweeteners in baby formula?" Yes! Many baby formulas contain corn sweetener in the form of corn syrup or corn syrup solids. Some formulas contain more corn sweetener than any other ingredient! Below is an example of a food ingredient label for baby formula.



I found a baby formula product in my local grocery store with a food ingredient label that claimed 54% of the product was made up of corn syrup solids and 26% of the product consisted of assorted vegetable oils. Of the ingredients at risk of heavy metal contamination that we've discussed in this book already, the table below displays those that may be found in baby or infant formula:

Common Ingredients Found in Infant Formula and Potential Heavy Metal Contaminants

Ingredient	Heavy Metal Contaminant
Corn syrup or corn syrup solids	Mercury (Hg)
Sunflower Oil	Mercury (Hg)
Soybean Oil	Mercury (Hg)
Coconut Oil	Mercury (Hg)
Palm Oil	Mercury (Hg)
Vegetable Oil	Mercury (Hg)
Beta carotene	Lead (Pb), Arsenic (As)
Potassium chloride	Lead (Pb)

This table of baby formula ingredients is not all inclusive. There could be other risky ingredients. I studied the food ingredient labels of only six different formula products. There are many more producers out there making baby formula. Are you now wondering if scientists have determined the levels of heavy metals in infant or baby formula?

The answer to your question is yes. Numerous studies have been conducted by scientists all over the world to determine the level of heavy metal contaminants in baby formula. Some very recent studies have identified higher than the allowable levels of mercury in baby formula [36, 37, and 38]. In one study, two of three formula samples contained mercury in concentrations above the allowable limits [36]. The researchers based in the Philippines warned of the possible direct or cumulative effects of these mercury exposures on infant health [36]. In another study, two of three infant formulas were again found to contain mercury in concentrations above the allowable weekly intake [37]. These researchers were based in Libya and they published their results in 2015 [37]. In a third recent study published in 2012, researchers in the European Union obtained formula samples from 24 different formula makers and found that while lead (Pb) levels were within the "safety limits," mercury levels were not [38]. These scientists, based in Germany, warned the mercury accumulation occurring in some formula fed infants would be higher than the established weekly tolerable intake [38]. Canadian researchers also investigated mercury levels in baby formula and found clear cases of mercury contamination in powdered formula [39]. The Canadian researchers discovered one brand of concentrated liquid infant formula had significantly higher mercury levels than other liquid brands [39]. In Portugal, researchers determined statistically significant differences for mercury content between processed organic and conventional baby cereal products [40]. Apparently organic baby food contained less mercury than conventional baby food [40]. No surprise finding there. The take home lesson here is if you know any new mothers who are feeding their babies formula, then please advise them to buy and use an organic brand to minimize their babies' heavy metal exposure.

The heavy metal arsenic (As) was reported to be more of a problem in baby foods containing rice based ingredients [41]. The only study published in the U.S. on heavy metal contamination of baby food or infant formula was conducted by FDA researchers and they only looked at arsenic contamination in products made from rice [42]. It is not surprising to me that FDA has not published any information on the amount of inorganic mercury in baby formula since the agency ordered me to stop my investigation of mercury in HFCS in 2005. In the preface section of this book, I shared the story of this key investigation.

Inorganic mercury residue in food products is an inconvenient truth some policymakers think is best left hidden. If the American public understood the extent of the problem of inorganic mercury and other heavy metals in the food supply, there would have to be changes in food manufacturing processes. Some of the changes might increase manufacturing costs and worse yet, reduce profits! It does not seem to matter to food manufacturers or policymakers that heavy metal exposures from the consumption of processed foods is occurring and creating conditions for the development of western diseases such as type-2 diabetes and assorted learning disabilities. There is a contamination problem in the food supply that impacts almost every processed food product found in the western diet, including baby formula.

With respect to learning disabilities and baby formula, two recent studies have been published that should be of interest to you. Researchers have found that both autism and ADHD are associated with early weaning and formula feeding [43, 44]. These findings make perfect sense, since formula feeding is associated with childhood exposure to inorganic mercury and lead, the heavy metals found to contribute to the development of ADHD and autism. Baby formula is a highly processed food often containing corn syrup solids, corn syrup, assorted vegetable oils, and the associated heavy metals.

Remember in the previous chapters we talked about the role of heavy metal exposure from processed food ingredients in creating conditions of ADHD and autism that impair child learning? This role is unfortunate and not going to go away until the food supply is cleaned up. It may be inconvenient and harder to breast feed or to eliminate processed foods from the diet but it is your child's only hope. A group of scientists just recently reported in 2014 that higher blood lead and/or mercury levels are correlated with the severity of social and cognitive impairment in children with autism [19]. Meanwhile, another group of scientists also recently confirmed dietary heavy metal intake correlates significantly with heavy metal levels in the blood of children and adults [45]. If what a child eats is contaminated with mercury or lead, then the mercury and lead levels will rise in the child's blood, especially when important micronutrients such as zinc or calcium are lacking in the family diet. These are important findings for parents of children with learning disabilities caused by heavy metal exposures.

To put it a different way, the more processed food your child eats, the higher their blood lead and/or mercury levels are going to be. These higher levels increase your child’s risk of experiencing the symptoms associated with social and cognitive impairment. You as a parent have the power to reduce these levels of heavy metals in your child’s blood and the severity of the symptoms associated with ADHD and autism that interfere with your child’s ability to learn. What you feed your child will influence whether or not he will reach his developmental capacity. To improve your child’s ability to learn, you can choose to eliminate processed foods from the family diet that are known to contain lead, arsenic, and/or mercury - corn sweeteners, food colors, vegetable oils, and preservatives. You can choose to serve your child a diet rich in whole foods containing the calcium, zinc, and other micronutrients needed by the body to maintain health and improve his brain function and development. I know you can do it!

In this chapter, we’ve discussed how corn sweetener consumption can increase your family’s risk of obesity; contribute to their overall blood mercury levels and development of type-2 diabetes. We’ve reviewed and cited the evidence showing that consumption of HFCS or yellow food colors may interfere with the availability of zinc in the body [16, 17, and 21]. We’ve discussed how zinc losses over time may disrupt MT gene function especially in children with autism [10]. This disruption in MT gene behavior may then impair your child’s capacity to transport and eliminate heavy metals from his body. We know that children with ADHD and autism tend to bioaccumulate lead and/or mercury and should therefore avoid eating food ingredients known to contain heavy metals or lead to disruptions in gene behavior.

With respect to gene behavior, remember in Chapter 1, we discussed how dietary calcium is needed by the body to support BDNF gene function. BDNF is the protein or the “glue” that allows your child’s memories to stay intact from one day to the next. Like BDNF, calcium is also needed for the proper functioning of the important PON1 gene. This very important calcium dependent gene expresses the enzyme paraoxonase. Your child’s body needs this enzyme to break down the organophosphate pesticides residues routinely found in grain end products and produce. Because U.S. Department of Agriculture (USDA) scientists have warned that over consumption of HFCS can lead to lower calcium levels in humans [46], it is important to recognize that HFCS consumption may disrupt PON1 gene function in humans. The ramifications of this warning will become crystal clear in the next chapter where we will discuss what we know about pesticides. For now, just know that children with autism and individuals with type-2 diabetes and heart disease all share two biomarkers in common - higher inorganic mercury levels and low PON1 gene activity.

Recommended Videos

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Chapter 5

What we know about pesticides

In the previous chapter, we reviewed how corn sweetener consumption may impact the way certain genes function by creating conditions of mineral loss that disrupt the body's ability to produce important proteins and enzymes. The inability to adequately produce certain proteins or enzymes may lead to disease conditions such as type-2 diabetes, the bioaccumulation of heavy metals, or neurodevelopmental disorders caused by pesticide exposures. Autism and ADHD are examples of neurodevelopmental disorders on the rise in response to dietary deficiencies and exposures to heavy metals and pesticides [1, 2, 3, 4, and 5]. Before we begin discussing the role of pesticide exposure in creating these debilitating disease conditions, first let's talk about what pesticides do.

Pesticides kill pests. They are chemical compounds designed to kill specific pests. Each pesticide contains an active ingredient that enables the compound to kill the target organism. In the United States, the Environmental Protection Agency (EPA) regulates who gets to use the different pesticides and for what purpose. For example, chlorine compounds are regulated by the EPA for use as a disinfectant to kill bacteria and viruses and a fungicide to kill mold and other fungi [6]. EPA allows your local water district to use chlorine to treat the drinking water supply and the waste water discharged from the sewage treatment plant. You may use chlorine bleach in your washing machine to help keep white clothes white.

Food manufactures are authorized by the EPA to use chlorine as a "food rinse" [7]. Chlorine dioxide and sodium chlorite may be used on food or feed contact surfaces and on agricultural commodities [7]. These chlorine compounds are also routinely used at animal and poultry premises including hatcheries [7]. They may be applied on eggs and fresh fruits and vegetables post harvest [7]. EPA admits there are chronic exposures occurring in the population from the consumption of chlorinated pesticide residues found on food [7]. Interestingly, chlorine is one of the few pesticides allowed for use in organic food production and handling [8].

The use of chlorine compounds in organic food production and handling is regulated by the U.S. Department of Agriculture (USDA) which provides specific guidance to farmers [8]. The guidance basically states that “water used directly on crops or foods is permitted to contain chlorine at levels approved by the Food and Drug Administration or the Environmental Protection Agency for such purpose [8].” Remember, the chlorine compounds that farmers can add to water are considered pesticides. After the organic farmer uses the chlorinated solution on crops or foods, he must then triple rinse the food with potable tap water [8]. The final rinse water may not contain more than the allowable levels of chlorine in drinking water [8]. The chlorine residue in drinking water is, of course, regulated by EPA. Because organic products are not allowed to contain pesticide residues, the rinsing process described here is the reason you will see the words “triple rinsed” on packaging that contains organic produce.

The problem with using all this chlorine as a pesticide is that we now know it may be a contributing factor in the development of some of the resistant organisms that do not respond to antibiotics [9, 10, and 11]. You may have already heard of these antibiotic resistant bacteria or super bacteria. To reduce your family’s risk of infection from these kind of bacteria, it is important to reduce their dietary exposure to chlorine compounds, including bleach. This can be done by rinsing all fruits and vegetables with tap water that you have de-chlorinated using carbon filtration or reverse osmosis. An inexpensive Brita filter can also be used as it will filter out most chlorine in tap water. It goes without saying that it is important to also avoid consumption of bleached flour and the end products made from bleached flour.

In addition to the allowable mercury levels in bleached flour [12] that we talked about in Chapter 3, flour may contain pesticide residues [13, 14]. According to the USDA Pesticide Data Program (PDP), the most common pesticide residues found in wheat and wheat flour are the organophosphate (OP) pesticides known by the following names chlorpyrifos, chlorpyrifos methyl, and malathion [14, 15, 16, 17]. These same pesticides are also commonly found in corn [18, 19]. What I mean by "commonly found" is that of the hundreds of wheat and corn samples collected for analysis by the PDP in any given year, up to 66.9 percent of the samples may contain malathion residues and up to 23.1% of the samples may contain residues of a chloripyifos compound. In some cases, a sample may contain residues of two or more OP pesticide compounds. Below is a table of the available PDP data for the most common OP pesticide compounds found in grain samples [14, 15, 16, 17, 18, and 19]:

Common Pesticide Residues Found in Grains Sampled by USDA Pesticide Data Program (PDP)

Grain Commodity - Analysis Year	% of Samples with Chlorpyrifos - Number of Samples Collected	% of Samples with Chlorpyrifos methyl - Number of Samples Collected	% of Samples with Malathion - Number of Samples Collected
Bleached wheat flour - 2004	?	20.8% of 151 samples collected	49.4% of 725 samples collected
Wheat - 2005	0.6% of 4 samples collected	23.1% of 156 samples collected	66.9% of 451 samples collected
Wheat - 2006	0.6% of 4 samples collected	16.7% of 115 samples collected	63% of 433 samples collected
Wheat - 2012	?	?	?
Corn - 2007	30% of 195 samples collected	?	37.9% of 659 samples collected
Corn - 2008	17.8% of 116 samples collected	?	33.7% of 219 samples collected

As you can see in the table, there are question marks where data is missing. The USDA PDP did not collect any wheat or corn samples in 2009, 2010, or 2011. In 2012, the USDA collected wheat samples but did not analyze them for the most commonly used pesticide compounds. Each year the PDP conducts over 2 million analyses on different fruit, vegetable, and grain crops but not all commodities are sampled and analyzed every year. Corn samples may be collected one year, and wheat or soybeans the next. Many different fruits and vegetables are collected and analyzed every year for various pesticide residues but grain samples are not collected and analyzed by the PDP with any regularity. It is interesting to note that in 2012, when the wheat samples were collected by USDA but not analyzed for the most commonly used OP pesticide residues, a major paper was published on the role of OP pesticide residues in creating conditions for autism [3].

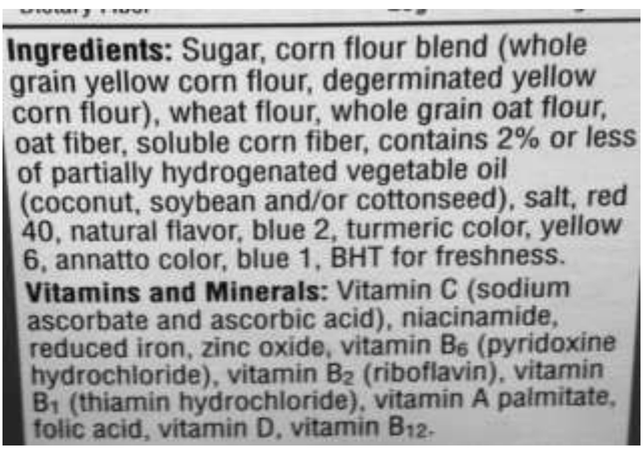
Activity Break: Survey your refrigerator, freezer, and cupboards. Do you see any food products that list wheat, bleached flour, or corn on the ingredients label that may contribute to your child's overall pesticide exposure? How often do you and your family at these food products e.g. daily, several times a week)?

By now you might be wondering just how much grain contaminated with pesticide residues is being consumed by the average American? It turns out Americans eat far more grain and cereal than fruit or vegetables combined. USDA keeps track of how much of each commodity Americans eat each year through the food availability per capita data system [20]. While American corn product consumption was 34 pounds per person, wheat product consumption was nearly 135 pounds per person in 2012 [20]. Corn products refer to hominy, grits, corn starch, and any food product made from corn flour or meal [20]. Wheat end products, on the other hand, generally include cereal, pasta and anything made from wheat flour [20].

The problem with all of this wheat consumption is that the organophosphate (OP) pesticide residue in the flour [14] used to make the bread, cereal, and pasta ends up in our bodies after we eat these processed food products [21, 22]. One group of scientists found that that the flour milling process did not significantly reduce the OP chlorpyrifos pesticides in the wheat but instead resulted in the distribution of residues in various processed end products [21]. Another group of scientists determined that while losses of pesticide residue do occur during food processing, baking and boiling, there are still often readily detectable levels of OP pesticide residues in the end products, especially in whole meal or bran-rich breads [22].

I can hear you thinking now. “So, aren’t pesticide exposures safe at low levels?” Maybe in some cases, but in the case of the chlorpyrifos compounds, the U.S. Public Health Service published a report stating there are concerns about the dietary *co-exposure* to chloryrifos and lead and mercury occurring in pregnant women, infants and children each and every day [23]. The concerns are related to the neurological impact on child development from co-exposures to these particular substances that are toxic in and of themselves and potentially far more toxic when they interact with one another in the body.

What does dietary co-exposure mean? When your family members consume the processed foods in the western diet, they are being exposed to chlorpyrifos and other OP pesticide compounds and heavy metals all at the same time. In Chapter 3, we discussed all of the heavy metals allowed in food colors, preservatives, and vegetable oils. As your child is eating a bowl of cereal containing flours made from wheat and corn and the food colors yellow #5, red #40, annatto, blue #1, and blue #2, s/he is potentially being exposed to the heavy metals lead, mercury and arsenic at the same time as s/he is being exposed to OP pesticide residues.



We do not yet know if these co-exposures are contributing to the increasing prevalence in the number of children with learning disabilities or adults suffering from chronic western diseases. There are no animal or humans studies or data available that examine the toxicity of the chlorpyrifos, lead, and mercury interactions that are definitely occurring in the human population [23]. Furthermore, no official risk assessment process has yet been developed to address how these interactions may impact gene regulation. Scientists are only now beginning the discussion on how to incorporate gene-environment interactions into the risk assessment process for toxic heavy metal exposure [24].

Activity Break: Survey your refrigerator, freezer, and cupboards. Did you see any food products that list two or more ingredients that may expose your child to two different toxic substances? How many products did you find that may be a co-exposure hazard to your child? How often do you and your family eat these food products (e.g. daily, several times a week)?

In previous chapters, we discussed at length the evidence that shows toxic metal exposures from processed food consumption contributes both to the development of learning disabilities and western disease. By now you are probably wondering if there is any evidence to suggest that pesticide exposures also contribute to the development of autism, ADHD, and pervasive developmental delay (PDD). Indeed, numerous studies have now been published that show that organophosphate (OP) pesticide exposure both before and after the birth of a child is associated with the development of autism, ADHD and PDD [25, 26, 27, 28, 29, 30, 31, and 32]. Intuitively, you must know the pesticide residues most frequently found in the foods we eat the most of are likely the very ones responsible for the rising prevalence of neurodevelopmental disorders. We will now review a couple of the studies that show your intuition is correct.

A Canadian scientist by the name of Bouchard led a fairly recent study to determine which OP pesticide is more closely related to the development of the neurodevelopmental disorder known as ADHD [25]. She and her team analyzed the U.S. Centers for Disease Control (CDC) data collected from the National Health and Nutrition Examination Survey (NHANES) during the four years for which ADHD was assessed in American children 8-15 years of age [25]. Bouchard et al. assumed the 1,482 children under study in the general population were getting their OP pesticide exposure primarily from fruit and vegetables [25]. It really doesn't matter where the children got their pesticide exposure from however. When Bouchard et al. analyzed the urinary metabolite output data for the 1,481 children; they found the metabolite levels for malathion exposure were much higher in the children diagnosed with ADHD compared to the levels in the children in the general population who were not diagnosed with ADHD [25].

Bouchard's study shed light on the impacts of OP pesticide exposure on learning *after* a child is born. Exposure to malathion when a child eats conventionally grown wheat, corn, fruit and vegetables is a factor in ADHD. Symptoms of ADHD include fidgeting, tapping one's hand or feet, running around inappropriately, leaving a seat in the classroom when sitting is the expected behavior, inability to pay attention or follow directions, and demonstrating a lack of patience when waiting for one's turn. All of these symptoms may impact a child's ability to learn in the classroom setting. These symptoms may be reduced when a child's exposure to malathion is eliminated or significantly reduced when the family adopts an organic, pesticide free diet. Researchers have in fact found that children with ADHD have shown significant improvement in many areas by switching to an organic diet [33, 34]. Centers for Disease Control and Prevention (CDC) scientists have confirmed that if you feed your child organic foods you will significantly lower his dietary exposure to OP pesticides [35]. If your child has been diagnosed with ADHD, you can help him learn better by switching to an organic diet.

Prenatal pesticide exposures occurring in the womb appear to be more closely linked to the development of autism and developmental delay (DD) [26] in children after they are born. In a new study conducted by researchers in California led by Janie Shelton, prenatal exposures to pesticides were determined by the mothers' residential proximity to agricultural operations and fields prior to and throughout the pregnancy period [26]. Geographical pesticide application data was obtained from the California Pesticide Use Report [26]. Shelton and her team compared the state pesticide application data to the residential proximity data provided by parents of 486 children with autism, 168 children with DD, and 316 typical or "normal" children [26]. Basically where a mother lives - her address - is a factor in determining her overall exposure to pesticides and risk of giving birth to a child with autism or DD. Exposure to the OP pesticide chlorpyrifos during the second trimester and nonspecified organophosphate pesticides during the third trimester was closely linked to the development of autism [26]. Meanwhile, exposures to carbamate pesticides were more closely associated with DD [26]. The take home message here is that proximity to OP pesticides at some point during pregnancy increases risk of autism by at least 60% [26].

The closer a pregnant woman lives to an agricultural operation that applies pesticides on their crops, the more likely it is she will be exposed to harmful pesticides. It is important to note that Shelton et al. did not consider *dietary* pesticide exposures in their study [26]. Exposures were presumably via inhalation (air contaminants) and possibly via ingestion (dust). Once again, however, it really doesn't matter where the pesticide exposure comes from. The important point is that when pesticide exposure occurs, it is significantly associated with the development of the neurodevelopmental disorders that are increasing in prevalence. What you can do if you are an expectant mother is adopt an organic diet and reduce your child's overall exposure to pesticides in the womb. The science based evidence tells us that we must eliminate or significantly reduce the expectant mothers' pesticide exposures to have the best possible birth and child development outcomes.

In the case of OP and carbamate pesticide exposures, whether the exposure is via food or inhalation or before or after birth, when the child is born his body must have the ability to metabolize and eliminate the pesticides via urinary output. Good health outcomes are related to having the ability to excrete toxic substances from the body via urinary output [35]. The most important player in the game of toxic substance elimination, especially in the case of organophosphate (OP) pesticide metabolite excretion is the PON1 gene [36]. This gene is calcium dependent and responsible for carrying the instructions for producing the enzyme paraoxonase (PON) which the body must have to break down and eliminate organophosphate pesticide residues. It is so important for the family diet to contain enough calcium!

The paraoxonase (PON1) enzyme is made by the body in the liver and secreted in blood where it is incorporated into high density lipoproteins (HDL). Overconsumption of any substance impacting liver function such as alcohol or high fructose will suppress PON 1 gene activity leading to disease conditions [36]. PON1 activity is lower in individuals with type-2 diabetes, heart disease and Alzheimer's [36]. The availability and activity of PON1 are also impaired in many children with autism and ADHD making them more susceptible to the toxic effects of OP pesticide residues which we have learned are most frequently found in wheat and corn [37, 38, 39].

PON1 gene activity has been extensively studied in humans and so, in addition to alcohol and high fructose, we know a number of other factors that modulate or alter its expression [36, 40]. The most important factors, in my opinion, are inorganic mercury and lead exposures, gender and age [36, 40]. From previous chapters, we now understand that inorganic mercury and lead exposures occur daily through our consumption of highly processed foods. These particular heavy metal exposures may suppress PON1 gene activity [36, 40]. In the case of inorganic mercury, we know that as we get older and continue to eat the toxic western diet, our inorganic blood mercury levels will rise [41] and our PON1 gene activity will fall. I believe the loss of PON1 gene function is one reason why older people are more prone to developing the western diseases such as Alzheimer's, type-2 diabetes, cancer, and heart disease.

What about our children? PON1 activity plays an important role in the body's developing immune system. Age is the most important factor of all, as PON1 activity is very low before birth and gradually increases during the first few years of life in humans [40]. In one study, scientists at UC Berkeley found the PON1 levels in many children may remain lower than those of their mothers for several years [42]. The scientists concluded that these children may be more susceptible to OP pesticides throughout their childhood and more vulnerable to developing autism [42]. Gender matters too. Baby boys are born with lower PON1 activity compared to baby girls [36, 40]. The lower PON1 activity in boys certainly explains why they are at far greater risk of developing autism than girls! They have less capacity to produce the paraoxonase enzyme and are more susceptible to the adverse effects associated with OP pesticide exposure.

In a different study, scientists at UC Berkeley found that two year-old children were less likely to display symptoms of developmental delay when their mothers had higher paraoxonase levels during their pregnancy [43]. Proper function and adequate expression of the PON1 gene is essential both for prenatal development and child health because exposure to OP pesticides is a common occurrence in the U.S. It is therefore important for the family diet to be free of contaminants that may suppress PON1 gene activity such as inorganic mercury [36, 40], lead [44, 45], and high fructose corn syrup [36]!

Activity Break: Survey your refrigerator, freezer, and cupboards. Do you see any food products that may contain ingredients with allowable heavy metal residues (e.g. food colors, preservatives, vegetable oils), or high fructose corn syrup? These ingredients may suppress PON1 gene activity and impair your child's ability to metabolize and excrete OP pesticide residues.

If a child with low PON1 gene activity eats food such as wheat end products laced with OP pesticide residues, s/he is going to have a reaction and feel symptoms similar to those experienced by someone with a low or underactive thyroid. Both low and high levels of exposure to OP pesticides impact thyroid function in adults with low PON1 gene activity [46]. We can certainly expect the same or greater impact on thyroid function in children with low PON1 gene activity when they are exposed to OP pesticide residues and cannot break down the pesticide residues in their food supply. The result is OP pesticide poisoning which is often misdiagnosed by pediatricians as respiratory infection, viral syndrome, gastroenteritis, atopic dermatitis, or drug-related encephalopathy [47]. Children with low PON1 gene activity, especially those diagnosed with autism or ADHD, may exhibit any of a number of symptoms associated with low thyroid and/or OP pesticide poisoning [47, 48]. These symptoms are presented in the following table:

Symptoms of Thyroid Dysfunction or OP Pesticide Poisoning
Cold intolerance
Constipation
Dry skin, dermatitis
Cognitive dysfunction (anxiety, memory deficits, depression)
Growth retardation
Drowsiness, lethargy, fatigue
Headache
Slow speech or speech impairment
Weight gain or difficulty in gaining weight
Increased infections
Gastroenteritis, intestinal abnormalities
Seizures or rigidity

By now I hope you have a whole new view of pesticide use and exposure from the consumption of conventionally grown grain, fruits, and vegetables. The problem with pesticide use is that when we use these compounds, we will become exposed to them, especially when we eat conventionally grown crops or live near agricultural operations. Pesticide use isn't just the practice of spraying fields and crops with EPA regulated neurotoxins. Chlorine solutions are also used post harvest on fruits, vegetables, eggs, and meat. The OP pesticide malathion is applied directly on grain in the storage silos several times a year to kill grasshopper larvae [49]. These and other pesticide applications ensure there will be pesticide exposures occurring every day in the U.S. depending on where we live, what we eat, and what we do for a living.

The CDC tracks exposure to OP pesticides or their metabolites through the National Biomonitoring Program (NBP) [50]. Exposure data are reported for the U.S. population as a whole and for subgroups. While most American groups are exposed to OP pesticides, children ages 6-11 have significantly higher exposures than adults and appear to be at greatest risk from OP neurotoxicity [51]. To address the continuous and very old pesticide exposure issue, in 1993, the prestigious National Research Council published a book titled, "*Pesticides in the diets of infants and children* [52]." Many scientists today join the scientists who wrote the book then [52] to express their deep concern that infants and children are often being exposed to multiple pesticide residues in single food commodities and these exposures along with co-exposures to lead or inorganic mercury can further threaten child development [3].

What you can do as a parent to deal with the ongoing problem of pesticide exposures is feed your child a healthy diet rich in the micronutrients required to support proper PON1 gene function. Your child's body needs calcium to build the PON1 enzyme paraoxonase for breaking down the OP pesticide residues. The family diet must therefore be calcium rich and include all of the foods listed in the calcium table in Chapter 1. The family diet also must contain adequate zinc to build the metallothionein proteins to metabolize and excrete the heavy metals such as inorganic mercury and lead that make it into the food supply. You can eliminate food ingredients from the family diet that suppress PON1 gene activity such as high fructose corn syrup or those ingredients that are allowed to contain heavy metals such as those we discussed in Chapter 3. You can reduce your family's exposure to pesticides by switching to organic produce and food products. You can feed them less processed food and more whole, organic foods. You have the power to reduce your family's exposure to pesticides and improve your child's learning, health, and developmental outcomes. You can exercise that power. I know you can do it!

Recommended Videos

Institute for Agriculture and Trade Policy (2012). *The autism revolution: thinking* *about environment and food*. Retrieved from https://www.youtube.com/watch?v=mgAsDXgo5ao

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Chapter 6

How we can create a safe food environment

In the previous chapters we identified the kinds of foods we need to include in the family diet and the food ingredients we need to eliminate from the family diet to ensure proper gene function. We learned that methyl donating nutrients play an important role in turning genes on and off. We determined the importance of essential micronutrients found lacking in the western diet. We learned that many food ingredients are sources of heavy metal and/or pesticide exposures. By now we hopefully have a better understanding of the role western diet plays in creating conditions for the development of common western diseases to include autism, ADHD, type-2 diabetes and heart disease. In this last chapter, we will cover some topics that often come up when parents are trying to make the best choices for their child's diet to create a safe food environment. We will briefly discuss food labeling requirements and practices, the "gluten free" diet, food allergies, factors impacting gut function, and concerns about supplements. We will look at food labeling requirements and practices first.

Food labeling is regulated in the U.S. by the Food and Drug Administration (FDA). Food manufacturers are required to follow the package labeling guidelines provided by the FDA [1]. FDA does not pre-approve food labels but provides guidance to manufacturers on what they need to include on packaging [1]. With respect to the food ingredients in a food product, FDA requires the manufacturer to list each ingredient in descending order of predominance by weight [2]. What this means is the ingredient that weighs the most is listed first, and the ingredient that weighs the least is listed last [2]. Whether or not exposure to an ingredient becomes toxic over time is beside the point. For example, trace or incidental amounts of mercury, lead, arsenic, or pesticides are not required to be listed on the food ingredient label. Food allergens are the exception to the rule on “trace amounts.”

The only time a trace amount of an ingredient must be listed on the food package label is when it is considered a “major food allergen” [2]. Of the more than 160 food allergens known to cause reactions in sensitive individuals, FDA recognizes eight of them [2]. If any of the following eight “major food allergens” may be present in the food product, then FDA requires manufacturers to either list them in the ingredient list or in a “contains” statement [2]:

1. milk, including whey
2. egg
3. fish
4. Crustacean shellfish
5. tree nuts
6. wheat
7. peanuts
8. soybeans

The table below illustrates the two ways trace amounts of the “major food allergens” can be listed on the food label:

Label 1	Label 2
INGREDIENTS: Whole wheat flour, Water, High fructose corn syrup, Egg, Soybean oil, Whey, Yeast, Sugar, Soy flour Contains: Milk, Soy, Egg, Wheat	**INGREDIENTS:** Whole wheat flour, Water, High fructose corn syrup, Egg, Soybean oil, Whey (Milk), Yeast, Sugar, Soy flour

In addition to a listing of the food ingredients, manufacturers must provide other information on the food package label such as nutrition facts and manufacturer contact information [1]. Manufacturers may also indicate whether their product meets the criteria for the "organic" designation and they may make FDA approved health claims [1]. To the average parent, the food package label appears straight forward. However, the reality of the situation in our industrialized society is far different than you might imagine. While food labels do provide some good information about the product found inside the package, they are also used as marketing tools for manufacturers.

The marketing of food is the same today as it was two hundred years ago. We live in a society where manufacturers often make health claims that may not help parents distinguish healthy food choices from less healthy food choices. Many claims made by manufacturers on food packaging are indeed false or misleading [3]. One recent FDA Commissioner wrote an open letter to manufacturers stating the following problem: "misleading "healthy" claims continue to appear on foods that do not meet the long- and well-established definition for use of that term" [3]. To understand the snake oil mentality that prevails today, one must look at the history of food and drug regulation in the U.S.

The FDA came into being with the passage of the 1906 Pure Food and Drugs Act by Congress [4]. The 1906 Act was passed in response to the public's outrage at the filthy conditions of the Chicago stockyards described by Upton Sinclair in his book "The Jungle" [4]. Prior to 1906, there was no U.S. government food or drug safety regulatory agency. The private U.S. Pharmacopeial Convention (USP) began setting standards for drug quality in 1820 [5]. In those days, drugs included the therapeutics of the time - tonics, extracts, honeys, infusions, liniments, mixtures, ointments, pills, syrups, vinegars, extracts, powders, wines and so on [5].

Today the USP is a scientific nonprofit, trade organization made up of volunteers and individuals working in the various regulated industries. The organization sets standards for the identity, strength, quality, and purity of medicines**,** food ingredients, and dietary supplements manufactured, distributed and consumed worldwide [6]. USP only recently took over the food ingredient safety standards from the Institute of Medicine [6]. As a parent, it is important to understand that FDA has always adopted the food and drug safety standards set forth by trade organizations such as the USP or other likeminded organizations. The U.S. Congress gives FDA the authority to codify and enforce these standards to protect public health. Many parents do not realize that FDA is only an enforcement agency; it does not determine whether or not a food ingredient is safe. Manufacturers are required to determine if a food ingredient is safe. Does this mean that the safety of food ingredients on the market today has already been determined through evidence or science based research? No it does not.

For many years FDA never required food manufacturers to show that their food ingredients are safe [7]. Prior to the 1950's, there were few food ingredient safety standards or laws in the U.S. [7]. In 1949, FDA Commissioner Paul B. Dunbar initiated a Congressional investigation of some of the chemicals used in food [7]. For two years, the investigation went on and recommendations were made to change the existing food and drug laws to impact the use of certain food additives and colors [7]. Most of the changes to the food laws were outlined in the Food Additives Amendment enacted by Congress in 1958 [8]. For the first time, no substance could legally be introduced into the U.S. food supply unless there had been a prior determination of its safety by the manufacturer [7]. Congress had essentially assigned the task of determining the safety of food ingredients to the food manufacturers [7]. In passing the 1958 Food Additives Amendment, Congress gave FDA the authority to determine which of the hundreds of food ingredients already on the market could be considered "Generally Recognized as Safe" or "GRAS" and exempt from further review by FDA [8].

FDA published the first "list" of food ingredients meeting the GRAS criteria in 1958 [8]. The ingredients that achieved GRAS status and made it onto the GRAS list could be used *without restriction* in food products. They were considered safe not because they had undergone any formal evaluation or study to determine their toxicity on human health but because they had a long history of use in food [8]. The substances on the first GRAS list were essentially grandfathered in to the new system of determining food ingredient safety. Additional food ingredients were placed on the GRAS list only after the manufacturer submitted a petition to the FDA. In many cases, food ingredients had been on the market for many years without a safety determination but had not made it onto the first GRAS list. We will now look at high fructose corn syrup (HFCS) as a case study to see how a food ingredient may be placed on the GRAS list through the petition process which continues to this day.

In 1983, after high fructose corn syrup (HFCS) had already been on the market for several years, the corn refining industry submitted a petition to FDA to consider HFCS a safe substance because it was made from enzyme preparations for which FDA had already recognized as GRAS and it was thought to be the same as honey with minor components found at levels similar to those in corn syrup and corn sugar, both substances already on the GRAS list [9]. FDA approved the petition submitted by the corn refining industry not because the substance had been studied to determine any adverse impact on human health but because the substance was similar in makeup to other substances already considered safe [9]. With respect to the potential harm to sensitive subpopulations, FDA reviewers wrote that the requirement to list “high fructose corn syrup” on the ingredient label was warning enough to sensitive consumers [9]. In 1996, despite objections from a diabetes research center, FDA reaffirmed its decision to consider HFCS a GRAS substance [9]. Of course, today there is ample evidence to show the harm of HFCS consumption to human health both in terms of contributing to obesity and the development of type-2 diabetes. Yet, HFCS remains on the GRAS substance list and can be used as a food ingredient without restriction or warning to consumers of its potential adverse health effects. It is so important for you, as a parent and the guardian of your child, to read and understand food ingredient labels!!

In Chapter 3, we discussed the GRAS status of the mercury cell caustic soda and hydrogen chloride used routinely to regulate the acidity or pH of food products during the manufacturing process. Remember, these substances contain trace amounts of inorganic mercury that may bleed into the food supply creating an exposure hazard to consumers who eat highly processed foods. In Chapter 4, we established the fact that the more processed food your family eats, the higher their blood inorganic mercury levels may be. We learned that higher blood mercury levels increase your family's risk of heart disease, diabetes, and autism. Hopefully, by now you will agree with me that substances with allowable trace mercury or other heavy metal levels should definitely no longer have GRAS status.

FDA provides a database of some of the hundreds of GRAS substances [10]. Of the food ingredients we've talked about in this book that are detrimental to your family's health, several are considered to be generally recognized as safe (GRAS) by the FDA. They are listed in the table below along with their allowable impurity levels or their known risk of heavy metal contamination.

GRAS Ingredients with Allowable Heavy Metal Impurities or Likely to Contain Heavy Metal Contaminants

Ingredient	Allowable Heavy Metal Impurities	Likely to Contain Heavy Metal
Caramel	Arsenic ≤ 3 ppm Lead ≤ 10 ppm Mercury ≤ 0.1 ppm	
Calcium chloride	Lead ≤ 2 ppm	
Potassium chloride	Lead ≤ 2 ppm	
Sodium benzoate	Lead ≤ 2 ppm Mercury ≤ 1 ppm	
Sodium diacetate	Lead ≤ 2 ppm	
Citric acid	Lead ≤ 0.5 ppm	
Corn syrup		Mercury (Hg)
Potassium chloride		Lead (Pb)
Dextrose (corn sugar)		Mercury (Hg)
High fructose corn syrup		Mercury (Hg)

Activity Break: Survey your refrigerator, freezer, and cupboards. Did you see any food products that list the GRAS ingredients shown in the table on the previous page? These ingredients may contribute to your child's overall heavy metal exposure. How often do you and your family eat these food products (e.g. daily, several times a week)?

The industrialized society that we live in today allows food manufacturers to lace our foods with toxic substances. Trace amounts of toxic heavy metals and pesticide residues kill single celled bacteria and fungi (mold) and this ensures the food product will stay edible for long periods of time. When you buy bleached flour, you can keep it on your cupboard shelf for many months without mold growth or insect infestation. Organic flour, on the other hand, must be kept in the refrigerator in a sealed plastic bag to prevent mold and insect eggs from hatching. As a parent you must be vigilant in reading food ingredient labels to determine which food products are safe to buy so you can reduce your family's exposure to toxic substances. To improve family health outcomes, not only must you stay away from harmful food ingredients, but you must be wary of unsubstantiated health claims.

Many food and supplement manufactures use labels to claim their products are healthy when they are not. Manufacturers also use labels for marketing purposes to mislead and prompt consumers to buy products they may not even need. "Gluten free" labels on products may be considered one example of misleading marketing practices used by food manufacturers. Before we examine this misleading practice, we need to know more about gluten and why it is a problem for some people.

Gluten is a protein found in wheat, barley and rye [11]. Individuals with the inherited chronic inflammatory auto-immune disorder known as celiac disease have difficulty metabolizing gluten. Their body thinks it is a dangerous foreign substance and their immune system declares war. Symptoms of an irritable bowel may ensue upon exposure to wheat. The stricken individuals may feel cramping, abdominal pain, bloating, gas, or experience diarrhea or constipation. In Chapter 5, we learned that some of these same symptoms may also be experienced when a child or adult has low PON1 activity and is exposed to organophosphate pesticide residues in wheat [12, 13, and 14]. PON1 gene dysfunction as a result of poor diet is probably far more common than celiac disease which is considered rare impacting only 1% of the population. While low PON1 gene activity is common in children with autism and ADHD, a true celiac disease diagnosis is not.

A properly trained gastroenterologist can easily diagnose whether or not a child truly has celiac disease. If you have a child with autism, I encourage you to bring him to an appropriately trained physician and have him tested for celiac disease before you succumb to the marketing pressures of putting him on a gluten free diet. There are risks associated with adopting a gluten free diet which we will discuss later. For now, just know that the proliferation of “gluten free” labeled products on the market has been allowed by FDA for one reason and one reason only - to protect the 3 million Americans with celiac disease.

FDA allows food manufacturers to voluntarily label any product “gluten free” as long as the product contains less than 20 parts per million (ppm) gluten [15]. This means any, and I mean any, product meeting the less than 20 ppm gluten criteria can be labeled “gluten free.” Foods that are by nature gluten free such as bottled water may be labeled “gluten free” [15]. This is where the manufacturers are using the gluten free labels in a misleading way. A consumer sees “gluten free” on the label of a product not likely to naturally contain gluten and buys the product at a higher price than the same product being sold by a different manufacturer without the “gluten free” words on the label. The consumer may be led to believe a certain kind of product or food must have a risk of gluten otherwise why would one manufacturer apply the “gluten free” label on the package while another does not?

Just last week at the grocery store, I saw with my own eyes a “gluten free” label on coconut syrup selling at a much higher price than a competitor’s product with the very same ingredient. Coconut obviously is not a grain likely to contain gluten. The manufacturer was trying to add value to its product by placing the words “gluten free” on the label. When a food such as wheat truly contains gluten and has been processed to remove the gluten, it makes sense for the manufacturer to voluntarily place the “gluten free” words on the product label.

It is important to understand that the more processing that occurs, the more likely a food will be contaminated with something unhealthy. For example, additional processing to remove gluten from grain may introduce inorganic mercury to the product if the *chemical method* is used to remove the gluten. Why? Because the chemical method may utilize caustic soda, including mercury cell, to maintain the pH during the gluten extraction process [16]. In using mercury cell caustic soda during the chemical method, trace amounts of mercury residue could end up in the final gluten free product. With or without mercury residue, the extra step in processing will make the gluten free product more expensive and justify the higher price. In the following table, please see the difference in pricing for the comparable wheat noodle products! Which product would you buy for your family?

Comparable Noodle Products: Name, Weight, List of Ingredients, and Pricing			
100% Organic Fusilli (16 oz.) **INGREDIENTS:** organic durum wheat semolina, water **CONTAINS: Wheat**	**Gluten Free Rotini (16 oz.)** **INGREDIENTS:** 100% wholegrain brown rice flour	**Organic Gluten Free Fusilli (16 oz.)** **INGREDIENTS:** organic brown rice, organic quinoa, organic amaranth, organic corn	**Rotini (16 oz.)** **INGREDIENTS:** semolina (wheat), durum wheat flour, niacin, iron (ferrous sulfate), thiamine mononitrate, riboflavin, folic acid **CONTAINS WHEAT INGREDIENTS**
$3.69	$3.39	$10.98	$2.89

If your child has not been diagnosed with celiac disease, or wheat allergy, by a qualified physician, I hope you chose the organic product selling for $3.69.

The selling of a gluten free product for which consumers will pay a higher price is attractive to food manufacturers who want to make as much money as possible. Gluten free food manufacturers are raking in the bucks [17, 18] as they target their marketing practices at parents of children with autism [19] despite the fact that there is no evidence to suggest a gluten free diet will cure or alleviate symptoms of autism. How do I know gluten free food manufacturers are targeting parents of children with autism? I visited the "Gluten Free & Allergy Friendly Expo" website sponsored by gluten free food manufacturers and read the following sentence in their mission statement: "The Gluten Free & Allergen Friendly Expo is dedicated to meeting the needs of the celiac community, those with gluten and food sensitivities, auto-immune/inflammatory diseases, and *autism*" [19]. I also visited the website of one of the most well known organizations that provides information to parents of children with autism and found several gluten free manufacturers listed as sponsors of the organization [20].

By law these gluten free manufacturers cannot make the health claim on food packaging that gluten free products will cure or be of beneficial use in treating children with autism without FDA approval which they do not have [1]. So what some of the gluten free manufacturers are doing is targeting parents of children with autism through their websites by offering the parents free donations or assistance in fundraising events to support the autism cause [21, 22, and 23]. If you are a parent of a child with autism, you need to be wary of the marketing practices some gluten free manufacturers engage in to sell you their products. I want you to be wary because there is no scientific evidence to support the hypothesis that feeding your child gluten will increase or cause the gastrointestinal symptoms associated with autism. On the contrary, the scientific evidence suggests the GFCF diet might actually be detrimental to child health.

Due to marketing practices or misguided advice, many parents have put their children on a gluten free or gluten free - casein free (GFCF) diet only to be disappointed when their children did not respond positively to the dietary changes. Child behavior or health outcomes will not change in response to dietary changes if the hypothesis is wrong. Gluten sensitivity or allergy is clearly not the problem in autism unless the child is actually allergic to wheat or has celiac disease. Scientists recently conducted a study and found that when they fed one group of children with autism gluten [and casein] there was no significant difference in gastrointestinal symptoms compared to another group of children with autism who did not eat the gluten and casein [24]. I am concerned the GFCF diet might cause more harm than good. Several studies now indicate that feeding your autistic child a gluten free or GFCF diet may very well result in lower protein, folate, calcium, and/or vitamin D intakes potentially risking his overall health and development [25, 26, 27, and 28]. There simply is not sufficient evidence to support the gluten free or GFCF diet as a treatment for autism [29, 30]. The take home lesson here is that if you have a child with autism, it is important to consult with a healthcare provider before placing your child on gluten free or GFCF diet.

Most legitimate health care providers will recommend the gluten free or GFCF diet only after a diagnosis of intolerance or allergy to gluten and/or casein has been determined [30]. Such a diagnosis may involve blood serum testing, skin-prick testing, food diary analysis, or placing the child on an elimination diet [31]. A physician specializing in diagnosing and identifying allergies is an allergist or immunologist. If you suspect your child has an allergy, please consult an appropriately trained specialist who can rule out suspected foods and accurately identify the substance responsible for your child's allergic response.

In addition to wheat, dairy, and the proteins found in wheat and dairy, there are other foods and substances, or "allergens," found in foods that can provoke an allergic response in your child. In Chapter 3 we discussed the role of food colors in creating hyperactivity in children. Hyperactivity is just one symptom of food intolerance or allergy. There are many more symptoms that can and do occur if a child has a sensitivity or allergy to a food or chemical food ingredient. The following table provides a list of symptoms that may be present in a child with a food or food ingredient allergy and/ or chemical sensitivity [32].

Symptoms of Food - Food Ingredient Allergy and/or Chemical Sensitivity
Difficulty reading (dyslexia) and writing (dysgraphia)
Depression or lethargy, moodiness, crying, emotional sensitivity
Mental confusion
Finger tapping, ticks, tremors
Nervousness or inability to look others in the eye
Hypersensitivity to odors, light, cold, pain, touch, sound
Extreme silliness, unrestrained behavior
Hyperactivity, extreme talkativeness
Impulsivity
Aggression
Tiredness, drowsiness, lack of energy
Inattention, difficulty concentrating, forgetfulness

In reading the list of symptoms, were you surprised to find that food allergies or sensitivity to food ingredients and other chemicals can impact child behavior and learning? If you eliminate harmful food ingredients and pesticide exposures from your family's diet, I think you will find that your child's health and behavior will improve. Your child's ability to learn will most certainly improve over time, especially as heavy metals decrease in your child's bloodstream. This is what the science based evidence that has been presented in this book tells us. What your child eats determines how his genes behave and whether or not his body can metabolize and excrete neurotoxins that would otherwise impact his overall health and brain development.

We've talked at length about neurotoxins in this book to include the heavy metals inorganic mercury and lead and organophosphate pesticides. We've learned that co-exposures to these harmful substances can lead to adverse health outcomes. People have genetic variations that make them more susceptible to the adverse health outcomes. Some people have a genetic variation that makes them hypersensitive to mercury [33]. People with a certain PON1 gene variation are genetically programmed to be hypersensitive to organophosphate pesticides. Children with autism, allergies, developmental delay and ADHD have lower PON1 activity levels so they have to stay away from toxic substances that further suppress their PON1 gene activity. Otherwise healthy people can also develop disease when they eat an unhealthy diet that is deficient in key micronutrients and includes the high intake of high fructose corn syrup and heavy metals. Genes may turn on and off in response to poor diet wreaking havoc on the immune system. Proper PON1 gene expression and activity is required for the immune system to operate properly.

One aspect of the immune system is the helpful bacteria found in your gut. There are good and bad bacteria in your gut. The paraoxonase enzyme produced by the PON1 gene plays an important role in keeping the bad bacteria in check [34]. This enzyme protects against harmful bacteria overgrowth or biofilm formation in the gut [34]. Scientists have determined that high fructose fed rats and humans have a significant increase in the number of bad bacteria residing in their gut [35, 36]. Scientists have found these same bacteria growing out of control in the feces of children with autism indicating their elevated presence in the gut environment [37]. These findings make perfect sense since we now know children with autism have significantly lower PON1 gene activity. Due to their low PON1 gene activity, they have little paraoxonase available to prevent those bad bacteria from overgrowing or becoming out of control. Of course, when these children are fed high fructose corn syrup and foods contaminated with heavy metals, the bad bacteria are going to take over and wreak havoc causing their little guts to become inflamed!

What can you as a parent do if your child is suffering with an inflamed gut? Cut out the high fructose corn syrup and the other toxic substances that make their way into the western food supply. Eliminate the food ingredients known or allowed to contain trace amounts of heavy metals that may suppress PON1 gene activity - inorganic mercury and lead. Feed your child a diet rich in calcium to support the PON1 gene function. Remember in Chapter 1, you were provided with a table of foods containing high concentrations of calcium? In addition to increasing your child's calcium intake, you can boost the growth of good gut bacteria by feeding him a natural probiotic - not a supplement. Natural probiotics contain good bacteria and are found in many cultured food products to include those listed in the following table:

Probiotic or Cultured Foods with Good Bacteria
Sour pickles (organic)
Sauerkraut (organic)
Buttermilk
Sour cream
Yogurt , organic (frozen or refrigerated – fruit optional, no added sugars except REAL maple syrup or organic cane sugar)
Kefir (yogurt like drink)
Cheese (uncooked white cheddar, feta, swiss, blue)
Acidophilus milk (organic)
Cottage cheese – can sweeten with organic cane sugar or maple syrup

Recent clinical trial data suggests a diet that includes probiotic foods reduces conditions of irritable bowel or allergic gastroenteritis and alleviates the symptoms of abdominal pain and discomfort, gas, gut inflammation, and constipation [38, 39, and 40].

Activity Break: Survey your refrigerator, freezer, and cupboards. Do you see any cultured food products listed in the chart that can alleviate gut inflammation? How often do you and your family eat these food products (e.g. daily, several times a week)? How can you incorporate these products into your child's diet without using a supplement?

The beneficial effect of using individual dietary supplements (e.g. pills) remains unknown in most cases. What we do know is over consumption of herbal and dietary supplements leads to liver injury [41]. This is not surprising given the fact that supplements are highly processed and often contain trace amounts of heavy metals [42]. We also know that calcium supplementation does not prevent osteoporosis and can increase the risk of heart attack in women by 20-40% [43]. Remember the society we live in today allows manufacturers to sell almost anything to anyone with limited oversight and little regulation over health claims.

Dietary supplement manufacturers and distributors are not required to obtain approval from FDA [44]. FDA does not determine the safety of supplements [44]. Before a manufacturer markets a supplement, it is only responsible for ensuring the product is "safe [44]." There is no FDA oversight to ensure the manufacturer has actually conducted a safety review or study to determine any adverse effects associated with consumption of the supplement. Consequently, there continues to be numerous supplement products on the market that confer little benefit except in specific cases. I do not recommend the use of supplements in place of whole, organic food.

In the case of children with Autism and/or ADHD, there are only two supplements that might be beneficial: 100% cod liver oil, or if vegetarian, algal oil. Both cod liver oil and algae are rich sources of the omega-3 fatty acids which everyone needs to stay healthy [45]. A better option for incorporating these important fatty acids in your family's diet, however, is whole food.

To boost your child's omega-3 fatty acid intake without supplementation, you can increase your family's intake of the foods in the following table:

Whole Foods High in Most Important Omega-3 Fatty Acids - docosahexaenoic acid (DHA)
Salmon, fresh or canned in water
Dried Algae (minimal processing)
100% Cod liver oil (oil not pill)
Trout (caught from a clean stream)
Crab, fresh or canned in water
Shrimp
Catfish (caught from a clean stream)
Clam, fresh or canned in water
Oysters (fresh or canned)
Anchovies (fresh canned)
Eggs (with DHA)

Notice that larger fish, such as albacore tuna or swordfish, are not listed in the table. I have not listed these foods because they are known to contain *organic* mercury at levels unacceptable to the developing child, fetus, and pregnant woman [46].

Activity Break: Survey your refrigerator, freezer, and cupboards. Do you see any of the whole foods listed in the chart that are high in omega-3 fatty acids? How often do you and your family eat these food products (e.g. daily, several times a week)? How can you incorporate these foods into your child's diet?

There is a significant difference between the mercury species - inorganic and organic - and how they impact human health through gene-environment interactions. We are only just beginning to understand a few of these interactions [47, 48, and 49]. Epigenetics, the study of gene-environment interactions, is a new field of study in biology and in the infant stage of development. The bottom line is the risk to child health from exposure to the miniscule levels of organic mercury that may be found in the foods listed in the chart above appears to be extremely low unless, of course, the child is hypersensitive to this mercury species. Otherwise the child's crucial need for omega-3 docosahexaenoic acid (DHA) outweighs the extremely low risk associated with the consumption of these foods. Dietary DHA from appropriate fish, shellfish, and algae consumption is essential for proper brain development and can make a positive difference in the learning capacity of children with autism and/or ADHD [50, 51, and 52].

How will you know if your child is hypersensitive to the mercury species found in fish and shellfish? Once you've eliminated all of the harmful food ingredients and pesticides we've talked about in this book from your child's diet and increased his intake of methyl donating nutrients and zinc and calcium rich foods, you should see improvement in his behavior. As time goes on, with the dietary changes, the heavy metals in his blood stream will decrease and the symptoms of ADHD and/or autism may be alleviated or, in some cases, even disappear altogether. Now is the time to add the fish and shellfish to his diet if you have not already done so. Wild, fresh or frozen salmon cooked on your barbeque or in your oven is your best bet. If you see any negative reaction in your child within 24 hours of ingestion, then you will know he is sensitive to the mercury species found in fish. If there is no reaction, then you are home free! You are now maximizing your child's development potential because you have eliminated most of the toxic substances from his diet and incorporated the essential micronutrients he needs for healthy brain development.

In my view, and that of other scientists, the adverse impact of co-exposures to toxic substances that occur from consuming the processed foods in the western diet is of far greater concern than trace amounts of organic mercury in small fish and shellfish. In previous chapters, we learned that in 2012, the average American ate 36.1 pounds per year of corn sweeteners and 36 pounds per year of vegetable oil. These two substances are found in processed foods and also used extensively in the fast food and chain restaurants. Their consumption may result in the bioaccumulation of *inorganic* mercury, especially when dietary intake of vegetables and fruit is low [49]. Let us get some perspective on the organic mercury exposure issue from fish consumption. How much fish and shell fish do you think the average American eats?

In 2012, the average Americana ate 8.6 pounds per year of fish and shellfish [53]. The table below shows how per capita processed food ingredient and fish consumption has changed in the U.S. over the years:

Historic Fish and Fast Processed Food Ingredient Consumption in the United States by the Average American

Commodity	1970 per capita consumption (lbs/year)	2012 per capita consumption (lbs/year)	Percent Increase or decrease (rounded)
Fish and Shellfish	7.5	8.6	**+15%**
Canned tuna	1.9	1.8	**decrease**
Canned salmon	0.3	0.1	**decrease**
Corn Sweeteners (corn syrup, modified corn starch, dextrose, maltodextrin, high fructose corn syrup)	9.3	36.1	**+288%**
Wheat flour	78	94.6	**+21%**
Salad & cooking oil (vegetable including soybean, cottonseed, sunflower seed, canola, peanut)	10.3	36.0	**+ 250%**

The USDA is constantly revising the data it presents in its food availability data system [53] and I can only report what is being reported by USDA at the moment. So the table above includes the figures currently being reported by the USDA [53]. Too bad there are no figures for food color or preservative consumption. Corn sweeteners, wheat flour, and vegetable oils may contain trace amounts of inorganic mercury and exposures occur simultaneously in many processed foods. While total fish and shellfish consumption has increased by 15% since 1970, tuna and canned salmon consumption has declined or essentially stayed the same. Canned tuna is the most common fish eaten by children. Do you think the organic mercury found in tuna fish is associated with the increase in autism and ADHD? Not likely.

Activity Break: Survey your refrigerator, freezer, and cupboards. Do you see any processed foods listing one or more corn sweeteners, vegetable oils and wheat on the label? How often do you and your family now eat these food products (e.g. daily, several times a week)? I hope your cupboard is now bare when it comes to keeping these kinds of food products on hand!!

One last concept to understand is the fact that if you boost your child's intake of omega-3 DHA and he is zinc deficient, you are not likely to see any improvement in his behavior or learning capacity. Zinc is needed by the body to utilize the omega-3 fatty acid that brain cells need to survive [54]. Diets deficient in zinc and omega-3 fatty acids contribute to the development of both autism and ADHD in children [48]. Thus it is important for your child to eat a diet that is both zinc and omega-3 rich. The two elements work hand in hand to keep brain cells healthy. In Chapter 1, you were provided with a table of zinc rich foods. Be sure to keep it handy as a reference in your kitchen along with the tables showing the foods rich in calcium and high in methyl donating nutrients.

This book was written for use during the online nutrition tutorial project for parents of learning disabled children. As a participating parent, you will have completed the six modules of instruction. By the sixth week, I hope you and your family have quit eating fast food outside of the home. I hope you have eliminated from your family's diet the highly processed foods that list the food ingredients allowed to contain heavy metals. I hope you now understand how harmful these ingredients are to your child's health and development. I hope you have adopted an organic diet to decrease your family's pesticide exposure. I hope you are able to increase your family members' dietary intake of foods rich in calcium, zinc and methyl donating nutrients to enhance proper gene function and sustain their immune systems. I hope "fast food" now means food you've prepared yourself from scratch ingredients over the weekend and put in the freezer for a quick warm up later. I hope you have realized that you and your child cannot easily eat food prepared outside of your home without risking family health. Be wary of the marketing practices used by the food manufacturers and supplement distributors who are only seeking ways to maximize their profits. Please keep educating yourself on proper diet, and trust your instincts!

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Screening Questionnaire for Participation in Nutritional Epigenetics Tutorial

Parent Name: ______________________E-mail: ___________________Child Birthdate:___/___/___

The following questions will help us determine your eligibility to participate in our online nutrition tutorial for parents of learning disabled children.

Is your child between the ages of 34 months and 8 years?	yes [ ] no [ ]
Do you have a home computer with daily access to the Internet?	yes [ ] no [ ]
Are you or any members of your family on a special diet (e.g. gluten free, casein free, organic, Atkins, weight watchers, etc.)?	yes [ ] no [ ]
Is your child on any medication?	yes [ ] no [ ]
Do you have a high school diploma, GED, or higher education?	yes [ ] no [ ]
Can you provide documentation of your child's learning disability (e.g. copy of Individualized Education Plan or IEP, behavior support plan, doctor's note, family service plan)?	yes [ ] no [ ]
Does your child …….? (Check all that apply)	
often fidget, tap hands/feet, run, or climb about when it is not appropriate to do so?	yes [ ] no [ ]
become extremely upset by changes in routine or unmet expectations (e.g. tantrum or meltdown ensues)?	yes [ ] no [ ]
often leave his/her seat in situations where remaining seated is expected?	yes [ ] no [ ]
hurt him/herself or others (e.g. head banging, hit playmates)?	yes [ ] no [ ]
become upset when touched on skin (by people or clothing)?	yes [ ] no [ ]
often blurt out an answer before a question has been completed?	yes [ ] no [ ]
often have trouble waiting his or her turn?	yes [ ] no [ ]
often interrupt or intrude on others?	yes [ ] no [ ]
lack empathy?	yes [ ] no [ ]
act unaware of social rules or codes of conduct?	yes [ ] no [ ]
make inappropriate or offensive comments?	yes [ ] no [ ]
run away when given an alternative he/she finds unacceptable?	yes [ ] no [ ]
frequently chew on objects (show signs of pica)?	yes [ ] no [ ]

Module 4

Ingredients That Add Heavy Metals to Your Body

During this module of instruction, you will identify the most common food ingredients that contain allowable heavy metal residues. Scientists have determined that the concentration of heavy metals in food stuffs eaten by humans correlates directly with the heavy metals found in their bloodstream. We now know such exposures increase your risk of developing certain diseases such as Type-2 diabetes. Recent clinical trial data gathered throughout the world confirms children with autism have higher levels of mercury and lead in their blood and children with ADHD have higher levels of lead in their blood compared to healthy children without these disorders.

LEARNING OBJECTIVES

1. Recognize the food ingredients that contain allowable heavy metals (e.g., lead, inorganic mercury, cadmium, arsenic).

2. Describe how heavy metals may be introduced to food ingredients (e.g. vegetable oils, corn sweeteners, food colors.)

3. Explain how exposures to certain heavy metals may lead to changes in zinc status.

4. Become familiar with recipes for preparing zinc rich meals.

5. Review U.S. Congressional reports on heavy metals in the baby food supply.

ACTIVITIES

1. As you read Chapter 4 of your textbook, complete the Chapter 4 Reading Guide provided in this study guide on pages 23-26.

2. Using the list of foods high in zinc that you created during Module 2 (on page 8 of this workbook), do a keyword search on the internet to find a recipe that incorporates three or more foods on your high zinc food list. Shop for the ingredients, follow the recipe and prepare and eat the meal.

3. Visit Dr. Dufault's website http://www.reneedufault.com/ and scroll down to the blog titled *Congress Found Heavy Metals in the Food Supply*. Read the blog. Click on the picture or visit the references at the bottom of the page to access and read at least one of the two US Congressional reports published in 2021.

   What did you learn from reading one of these reports?

   ____

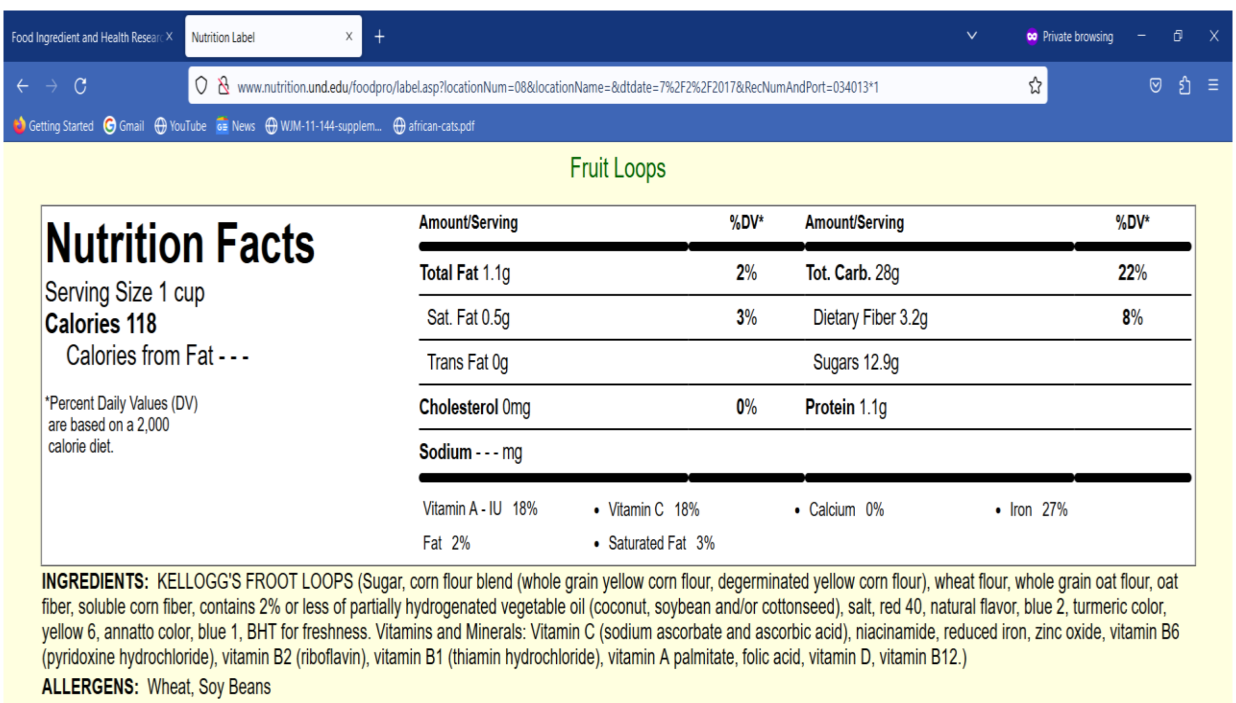
   ____

   ____

4. Using the tables provided in Chapter 4 of your textbook, survey your kitchen cupboards and refrigerator to find and list all the food products that may contain ingredients with at least one heavy metal impurity (use the chart on the next page to record your results). You will need to read the ingredient labels. For example, the food ingredient label below contains two ingredients with allowable or known heavy metal residues:

   INGREDIENTS: Premium brewed green tea, high fructose corn syrup, honey, citric acid, natural flavors, ginseng extract, vitamin C.

   Below is a label for Froot Loops:



Fruit Loops

Nutrition Facts
Serving Size 1 cup
Calories 118
Calories from Fat - - -

*Percent Daily Values (DV) are based on a 2,000 calorie diet.

Amount/Serving	%DV*	Amount/Serving	%DV*
Total Fat 1.1g	2%	**Tot. Carb.** 28g	22%
Sat. Fat 0.5g	3%	Dietary Fiber 3.2g	8%
Trans Fat 0g		Sugars 12.9g	
Cholesterol 0mg	0%	**Protein** 1.1g	
Sodium - - - mg			

Vitamin A - IU 18% • Vitamin C 18% • Calcium 0% • Iron 27%
Fat 2% • Saturated Fat 3%

INGREDIENTS: KELLOGG'S FROOT LOOPS (Sugar, corn flour blend (whole grain yellow corn flour, degerminated yellow corn flour), wheat flour, whole grain oat flour, oat fiber, soluble corn fiber, contains 2% or less of partially hydrogenated vegetable oil (coconut, soybean and/or cottonseed), salt, red 40, natural flavor, blue 2, turmeric color, yellow 6, annatto color, blue 1, BHT for freshness. Vitamins and Minerals: Vitamin C (sodium ascorbate and ascorbic acid), niacinamide, reduced iron, zinc oxide, vitamin B6 (pyridoxine hydrochloride), vitamin B2 (riboflavin), vitamin B1 (thiamin hydrochloride), vitamin A palmitate, folic acid, vitamin D, vitamin B12.)
ALLERGENS: Wheat, Soy Beans

FOODS IN MY CUPBOARD WITH HEAVY METAL RESIDUES

Name of product	**Food ingredient(s) with allowable or reported heavy metal residues**
e.g., Fruit Loops	Vegetable (soybean) oil, red 40, blue 2, yellow 6, annatto, blue 1

STUDY GROUP DISCUSSION QUESTIONS

- What evidence is there to suggest that consumption of highly processed food contributes to your heavy metal exposure? Provide a reference to support your response.

  ____

  ____

- How does heavy metal exposure impact MT gene function and your body's zinc status? From your survey findings which food ingredients can you eliminate you're your diet to improve your zinc status?

  ____

  ____

- Share with a friend or family member the recipe you followed to prepare your zinc rich meal. Which ingredients were high in zinc? How did the meal turn out?

  ____

  ____

  ____

  ____

Need to find a healthy high zinc recipe? Try this one - Oat Bran Banana Bread

Ingredients: 2 eggs, ½ cup maple syrup, ½ cup organic plain (or honey flavored) Greek yogurt, 2-3 mashed bananas, 1 ¼ cup organic flour, 1 cup organic oat bran, 1 tsp. baking soda, ½ tsp salt, 1 tsp. cinnamon, 1 cup walnuts (or pecans)

Instructions: Preheat oven to 350 degrees, grease a loaf pan. In a large bowl or blender, mix eggs, maple syrup, yogurt, and banana. In a separate bowl, mix flour, oat bran, baking soda, salt and cinnamon. Add blended wet ingredients to flour mixture. Stir well. Blend in nuts. Pour into greased loaf pan and place in oven. Bake for 1 hour or until a knife can be inserted and pulled out clean.

Reading Guide for Chapter 4, Module 4

Directions: Please answer the following questions as you are reading Chapter 4 of your textbook.

Ingredients That Add Heavy Metals to Your Body

1. The most common heavy metals found as residues in the food supply include which of the following:
   a. lead
   b. inorganic mercury
   c. cadmium
   d. arsenic
   e. all the above

2. The levels of heavy metals in foods eaten by adults and children match the heavy metal levels found in their blood. True or False

3. Explain why increasing heavy metal levels in blood can become a problem as you age.
   ____
   ____

Vegetable Oils

4. The average American consumes 16 pounds of vegetable oil each year. True or False

5. What is FEDIOL and what report did they publish?
   ____
   ____

6. Inorganic mercury can get into refined vegetable oils when a mercury cell chlor-alkali chemical is used in the manufacturing process to improve the taste of the oils. True or False

7. How has the amount of cooking oil eaten by Americans changed since 1970 compared to 2010 (Hint: see Table 4.2 to see pounds per person (capita) per year)?
   ____
   ____

8. In 2010 the average American ate 49.4 pounds of combined vegetable oil and fats. True or False

9. Vegetable oils are found in many products; examples of such products include
   a. salad dressings
   b. cookies
   c. mayonnaise
   d. all the above

10. Eating too much vegetable oil promotes the development of ___________ disease and ________________.

Corn Sweeteners

11. What compound is deliberately added to corn starch to prevent the production of enzymes by bacteria? __________________

12. The corn sweetener manufacturing process involves the use of a mercury compound called *mercuric chloride*. True or False

13. Which of the following are corn sweeteners that may contain mercury residue?

    a. corn syrup
    b. dextrose
    c. high fructose corn syrup
    d. maltodextrin
    e. modified corn starch
    f. all the above

Inorganic Mercury Exposure from Eating Corn Sweeteners

14. What evidence shows that eating a lot of food products with a corn sweetener in them may lead to elevated inorganic mercury levels in your blood?
    ____
    ____
    ____

15. Which corn sweetener have you eaten the most of so far in your life?
    ____

16. How has the *type* of sugar consumed by Americans changed since 1970 (Hint: see Table 4.4)?

____

____

17. Eating many products containing HFCS may lead to changes in the way some of your genes function. True or False

Food Colors and Heavy Metals

18. What must the package warning label on foods with yellow #5, red #40 and/or yellow #6 in them say In the European Union and United Kingdom?

____

____

19. Certified food colors in the U.S. and elsewhere may have allowable levels of lead, mercury, and arsenic in them.   True   or   False

European and US Food Color Research

20. Eating food products that contain certain food colors and/or sodium benzoate causes hyperactivity in children. True or False

21. Which of the following food colors have allowable mercury *or* lead residues? (Hint: Tables 4.5 and 4.6)

    a. Yellow 5
    b. Yellow 6
    c. Red 40
    d. Annatto
    e. Caramel
    f. all the above

22. The US has conducted all kinds of food color research. True   or   False

Internet Research and Lead Exposures

23. Google: Do a keyword search on "ADHD and lead exposure." What did you find?

____

____

24. Certified food colors (Table 4.5) along with the less common food colors annatto, beta carotene, caramel, and titanium dioxide (Table 4.6) are all allowed to contain _______ppm lead.

25. List some preservatives that have allowable lead levels. _____________, ______________, _____________, MSG, ____________ and _______________.

26. Sodium benzoate is a ___________________ with allowable impurities of ________________ and ________________.

27. Google. Do a keyword search on "autism and lead and mercury." What did you find?

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28. Review: What is metallothionein and which gene is responsible for its production? What does it do for your body? What nutrient must you eat enough of to produce this important protein? (page 69 under US Food Color Research)

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29. Click on each reference for the US Congressional Reports at the following links: US Congressional Report February 2021 and US Congressional Report September 2021. As you read them, ask yourself ***what is missing from these reports*** based on what you learned in Chapter 4 of your textbook. What is not talked about in these reports? Write what you think here.

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NOTE: Another way to access the Congressional reports below (if you are reading an e-book) is to simply click on the pictures and the link will open to the website.