The Plastic Pandemic

Submitted to:

Mr. Kevin Guest
Chief Marketing Officer
USANA Health Sciences

Submitted by:

Lyle MacWilliam, MSc, FP
MacWilliam Communications Inc.
7594 Klinger Road
Vernon, British Columbia
CANADA V1H 1H4

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Introduction

You will find it between latitudes 135°-155° W and longitudes 35°-42° N, 1,000 nautical miles off the California coast and within the North Pacific Subtropical Gyre — a slowly spiralling vortex of currents created by a constant high-pressure system.[1] Called the Eastern Pacific Garbage Patch, it is an oceanic desert with little marine life, yet teaming with plankton-like nurdles of plastic. Estimated to be twice the size of the state of Texas, the eastern patch is located between California and Hawaii, connected by a 6,000-mile oceanic corridor to the western patch, located off the coast of Japan. Together, the size of these oceanic garbage dumps exceeds that of the continental United States, forming a floating continent of human debris that is the world's collective landfill. Because most of the plastic particulates are suspended throughout the upper water column, the patches are not visible from the air or by satellite; however, it is estimated that they contain over 100 million metric tonnes of debris.[2]

Plastic constitutes 90% of all human refuse found in our oceans. It is estimated that every square mile of our ocean waters harbours 46,000 pieces of plastic that, in some areas, outweighs the biomass of plankton by a factor of seven — a chilling testimony to the extent of humankind's environmental impact.[2] Of the more than 100 billion kilograms of plastic the world produces each year, 10% ends up in our oceans.[3] While much of it sinks, leaching toxins into the sea floor, the rest accumulates on the surface, where photo-degradation and wave action fragment the debris into confetti-like flecks that accumulate oils and toxins in concentrations magnitudes higher than that found in the surrounding waters. These plankton-like fragments of plastic are frequently consumed by marine life, where the ingested solids release hormone-altering chemicals and other toxins into the marine food chain. Plastic has acutely affected the Pacific Albatross, which roams a wide swath of the Pacific Ocean. On Midway Island, researchers have found extremely high death rates of young chicks asphyxiated and poisoned from consuming plastic fed to them by their parents, who mistake it for food.

In fact, throughout their lifecycle — from manufacture to disposal — products made from plastics are exerting a silent yet profoundly harmful effect on our personal health and the health of our planet.

What is Plastic?

Plastic is a common term for an immense range of synthetic and semi-synthetic solids that consist of repeating units of simple organic compounds (monomers) linked together (polymerized) to form a hydrocarbon backbone. Composed principally of carbon, hydrogen, oxygen, nitrogen, chlorine and sulphur, polymer chains have characteristic elastic properties and can be shaped and pressed into an endless variety of forms. Most plastic polymers, unless modified with stabilizers, will begin to decompose when heated much beyond the boiling point of water.

Parkesine, a semi-synthetic polymer of plant cellulose synthesized in 1855, was the first plastic used commercially as a replacement for ivory. In 1909, Bakelite became the first fully synthetic plastic, created from the polymerization reaction of phenol and formaldehyde. Strong, cheap and durable, Bakelite found its use in countless products, including radios, clocks, electrical insulators and billiard balls. Technological advances from World War I soon led to the development of polystyrene (Styrofoam) and polyvinyl chloride (PVC), products that are still in wide use today. Nylon, introduced by Du Pont Chemicals in 1939, went into production for parachutes during World War II and later created a consumer craze as a replacement for expensive silk stockings. Nylon remains an important plastic today, employed in a wide variety of commercial and industrial applications from ropes and fabrics to ball bearings and bushings. Since the introduction of nylon, the plastics industry has exploded with an endless variety of goods conceived for every imaginable purpose.

Today, plastics are ubiquitous in our homes, in our businesses, and in our environment. The linoleum on your kitchen floor, the underlay and fabric of your living room carpet, your kitchen appliances, cooking utensils, draperies, computers, television sets, children's toys, household wiring, plumbing, — even the paints used on your bedroom walls and the bristles in your toothbrush — are testimony to the fact that we live in an increasingly 'plastic' world.

The question arises: is this world of petroleum-based synthetics and disposable consumer gadgets as benign as we are led to believe, or is there a crisis lurking in our ever-increasing reliance on man-made — rather than natural — materials?

Safety and Toxicity

Due to their chemical inertness and insolubility in water, plastics generally have a very low toxicity, passing through the digestive tract with no ill effect other than possible obstruction. Rather, it is the monomers, themselves, that can be quite problematic. For example, vinyl chloride, the building block for polyvinyl chloride (PVC), is a well-recognized carcinogen that causes angiosarcoma, a rare form of liver cancer. Even short exposure to

vinyl chloride vapour at doses as low as 500 parts per million is acutely toxic to the liver.[4] Styrene (vinyl benzene), the building block for polystyrene, while less toxic than other monomers, is described by the U.S. EPA as a suspected carcinogen and a suspected toxin to the gastrointestinal, kidney, and respiratory systems.[5] The phthalate monomer, Bisphenol A (BPA), a heat stabilizer found in PVC plastics, is also used in the manufacture of polycarbonate plastics for water and baby bottles, epoxy resins for dental sealants, beverage and food cans, and as a fire retardant for household furniture. It is a potent endocrine disrupting chemical (EDC) known to mimic the female hormone β-estradiol (estrogen). BPA has been shown to increase insulin resistance, chronic inflammation and heart disease.[6, 7] It has recently been associated with aneuploidy,[8-14] a chromosomal abnormality now found in more than 5% of pregnancies and which is responsible for several birth defects and developmental abnormalities.[7] Sensitivity to BPA appears to be enhanced during late (perinatal) gestation.[15] Acting on evidence that BPA residues can rapidly leach from polycarbonate plastic bottles into the surrounding fluids, Health Canada recently banned BPA from use in plastic baby bottles.

Polymerization supposedly binds monomers, such as BPA, styrene and vinyl chloride, together into inert forms; however, no polymerization process is 100% complete. Finished products will *always* have a small amount of the monomer loosely bound within the plastic matrix and free to leach out under the right conditions. These include heating and microwaving of the plastic, repeated washing with harsh detergents, scratching, cracking or abrasion of the surface, general photo-degradation, and prolonged contact with fatty foods and oils.

In addition to the monomers, the chemical additives mixed into the finished polymer can also be problematic. The European Union recently banned one of the most common plasticizing agents, DEHP (di-ethylhexyl phthalate), because of its potent effects as an endocrine disrupting chemical (EDC). Other additives include UV-filtering chemicals, anti-static and anti-mould agents, flame retardants, colorants, plasticizers, and heavy metals such as cadmium, antimony, mercury, lead and arsenic.[7] When added to the plastic, they can modify its texture and increase its pliability, color, and resistance to heat, fire, mould and photo-degradation. Because they are not part of the polymer itself, these additives will also leach out of the plastic under conditions of heating, abrasion and general degradation, or contact with fatty foods. However, it is at the end of the product's life cycle when the release of toxins through oxidative degradation and incineration in our landfills can inflict a long-lasting and harmful environmental impact.

Current U.S. Food and Drug Administration regulations, mandated in 1958, accept that all plastics will leak toxins into our foods. These regulations assume "it is the *dose* that makes

the poison." In other words, if the amount of toxic leachate falls below a prescribed limit of exposure, it is assumed that the product has no harmful effect. The regulations are blind to recent evidence showing that certain endocrine disrupting plasticizers express adverse effects that are far more pronounced at extremely low doses (in the parts per trillion) than at significantly higher doses (parts per million).

The regulations also fail to address the conundrum that combinations of endocrine disrupting additives can act *synergistically*, with a combined effect much greater than the effects of the individual toxins. Neither do the regulations address the fact that the *timing* of exposure to many plastic leachates may be more relevant than the dose. There is considerable new evidence suggesting that during periods of rapid growth (such as during late pregnancy) a fetus can become exquisitely sensitive to very low levels of endocrine disrupting toxins that leach from plastics and are unintentionally ingested by the mother.[7]

Plastics by Number

Plastics are categorized based on polymer type and recyclability. The internationally accepted numerical code shown in the middle of the recycling logo designates the type of plastic that is contained in the product or packaging.

Polyethylene terephthalate (PET) is used in the manufacture of high-impact packaging, water and soft drink bottles, cereal box liners, cooking oil containers, microwave food trays and various fabrics. It is considered safe to use under normal conditions, where leaching of additives into the liquid is negligible. PET plastics do not contain phthalate plasticizers found in other plastics.

High-density polyethylene (PE-HD or HDPE), an opaque or cloudy plastic used in the manufacture of containers for shampoos, detergents, milk jugs, cosmetics, motor oil, sturdy shopping bags, and vitamins, is the more durable form of PET. Both PET and HDPE leach additives when exposed to strong sunlight or heat. Over time, these plastics will degrade. Never put hot liquids into or re-use the bottles for other consumables, as leaching will occur over time.

Polyvinyl chloride, found in shower curtains, meat and cheese wrappers, 3-ring binders, some bottles, shrink-wrap, construction and plumbing materials, children's and adult's toys, electronic equipment, clothing and furniture, vinyl flooring and siding, mattress covers, and ceiling tiles, contains harmful phthalate plasticizers as softeners. While PVC, itself, is largely inert, phthalates and fire retardants can leach out with harmful, toxic effects. Moreover, incineration of PVC materials in landfills releases dioxins, a carcinogenic environmental pollutant. Some retail stores, including Wal-Mart, Target, Sears and Kmart have moved to phase out PVC goods.

Low-density polyethylene (PE-LD or LDPE), used in shopping bags, DVD/CD cases, computers, some bottles, and product packaging, is rarely found in products for human consumption. Toxic chemicals used in the manufacture of LDPE plastics include butane, benzene

and butyl acetate. While generally considered safe, the plastic stubbornly resists biodegradation and is not considered eco-friendly. The use of re-usable cloth shopping bags for groceries and biodegradable containers for kitchen wastes will help reduce the wasteful consumption of this polluting plastic.

Polypropylene, found in bottle caps, pails, diapers, kitchenware, yogurt, cottage cheese and candy containers, and electronic product packaging, is a heat resistant plastic considered highly safe for human use. Stable under hot water and through repeated use, it has been approved for food and beverage storage. PP is considered the safest of all the plastics; however, it oxidizes rapidly when exposed to strong UV radiation. Degradation fragments in the ocean can concentrate toxic PCBs and other poisons at levels up to one million times stronger than in the surrounding waters.

Polystyrene, one of the earliest forms of plastic, is used in drinking cups, take-out food containers, egg cartons, disposable trays and building materials (including caulking and insulation). It is composed of polymers of styrene, a possible human carcinogen. While the polymer is considered safe, foamed polystyrene containers are known to degrade in the presence of heat and oil. DO NOT use foamed polystyrene cups to consume or store hot liquids, as leaching of styrene residues can occur. As most recycling programs will not accept polystyrene, its disposal creates a significant landfill and pollution problem.

All other plastics not listed above are found here, including polyurethane, acrylic, acrylonitrile, butadiene styrene, fiberglass, nylon, polycarbonate, and polylactic acid. While most are considered safe, polycarbonate drinking and baby bottles have recently been fingered for leaching of Bisphenol A, a phthalate residue known to be a potent endocrine disruptor. Not all group 7 plastics contain BPA and some even contain natural organic material, making these hybrid plastics more environmentally friendly than most other forms.

In summary, plastics denoted with the number 5 (PP) are the safest plastics to use as they have generally low toxicity and can be re-used several times. Plastics denoted by the numbers 1 (PET), 2 (PE-HD) and 4 (PE-LD) are acceptable but have limited shelf life and issues concerning toxicity. If possible, avoid products labelled 3 (PVC), 6 (PS) and 7 (O), which have been shown to be harmful to both personal and environmental health.[16, 17]

A complete discussion of each of the six categories of plastics is beyond the scope of this article; instead, we will focus on the relative safety of three types of plastic, one of which is relatively safe to use (PET) and two of which are not (PS and PVC). Lastly, we will provide some commonsense advice on how to reduce our dependence on *all* plastics and help minimize the harmful environmental impact of these products.

Polyethylene Terephthalate (PET)

Polyethylene terephthalate (PET) is a polyester of therephthalic acid and ethylene glycol. A creamy white material, PET demonstrates high heat resistance and chemical stability. The product is biologically inert if injected, dermally safe, and is not hazardous if inhaled. Short and long-term toxicity studies using animal models show no evidence of toxicity, nor do other studies demonstrate any evidence of mutagenic or carcinogenic effects.[18-22] One recent

study investigating the genotoxicity of PET water storage containers found no evidence of toxic compounds migrating from PET regardless of time or conditions of storage.[23] While there is some evidence of a weak estrogenic effect and the leaching of phthalate contaminants from some PET products, the observed levels were far below established EPA safety standards.[24, 25]

Recent concern has been raised about the migration of antimony upon storage of bottled water in PET plastics. A heavy metal with acute toxicity, antimony is used as a catalyst during the polymerization process and remains loosely bound in the matrix of the finished plastic. Recent tests on bottled water from 28 countries revealed that the antimony in the stored samples *quadrupled* within 6 months, providing clear evidence of significant leaching from the PET containers. In two studies, researchers found an abundance of antimony in 15 Canadian brands and 48 European brands of bottled water. The Canadian bottled-water samples showed antimony concentrations up to 71 times higher than levels found in pristine Ontario ground water samples.[26, 27] While the levels were well below Canada Health Standards, the question arises as to the *cumulative* effect of consuming water contaminated with this lipid-soluble heavy-metal toxin.

Antioxidants, including butylated hydroxytoluene (BHT) and Irganox® are commonly added to PET products to reduce oxidative damage. There is limited migration of these additives under normal storage conditions;[28, 29] neither do these antioxidants demonstrate any estrogenic effects.[30] Migration of intermediate reaction products, ethylene terephthalate monomers and high-temperature volatiles is generally limited.[31, 32, 33] Migration of ethylene glycol from the plastic matrix into acetic solutions has, however, been noted during long-term storage.[34] Investigation of the re-use of PET containers has found that the products can be safely re-used, although inspections for abrasion and damage should be periodically done.[35]

In summary, the prevailing evidence suggests that PET products are safe when used prudently; however, confirmation of leaching from the product should encourage consumers to minimize storage of consumables — fatty foods and acidic liquids in particular — in these containers. Consider using domestic water filtered through reverse osmosis filtration and stored in glass or stainless steel containers as a more sensible option to bottled water.

Polystyrene (PS)

Made from the aromatic monomer, styrene, polystyrene is a colorless, hard, glassy substance that flows when heated. Depending on the additives, it can be transparent or colored; because of its extrusion properties, PS can be molded into a huge range of products,

including disposable cutlery and razors, plastic models, DVD cases, drinking cups and lids, and common laboratory materials. When injected with blowing agents, polystyrene forms a porous foam-like material (commonly referred to as Styrofoam®, a registered trademark of Dow Chemical) that is 30 times lighter than the parent substance. Foamed polystyrene is commonly used for floatation and buoyancy devices, packaging materials, and insulated drinking cups. Its thermal resistivity makes it excellent for construction materials, including insulated panelling and concrete forms. Because it is not biodegradable, Styrofoam is often used in bridge and highway construction.[36]

Yet this popular and ubiquitous plastic has a dark side. Trace amounts of production chemicals imbedded in the plastic matrix are not so benign as the finished polymer. Benzene, a highly reactive derivative of Coal Tar, is used in the production of styrene and is a well known carcinogen.[37, 38] Chronic exposure to benzene damages the bone marrow and can lead to anemia, hemorrhage and immune depression. Benzene causes leukemia and is associated with other blood cancers and pre-cancers of the blood.[39] In addition to the presence of benzene, the finished polymer also contains unpolymerized monomers of styrene. Studies show that styrene has both acute and chronic effects in humans. In animal studies, the chemical is toxic to both the liver and the lungs, causing lung tumors.[40-42] While there is little evidence of reproductive effects,[43] human studies show that styrene exposure has both genotoxic[44-47] and neurologic effects.[48, 49]

Several studies confirm the migration of styrene residues, UV stabilizers, anti-static agents, and other additives from styrene and foamed-styrene containers into foods and liquids.[50-56] In some cases, very high migration rates of specific additives were noted.[50, 54, 56] One study, showed that migration of styrene from foamed polystyrene cups into beverages was found to be *strongly* dependent on both fat content and storage temperature, and was observed to be as high as 0.025% (based on weight) for a single use.[53, 57] Unfortunately, there is a paucity of human data on whether the numerous additives and contaminants within the polystyrene matrix can leach out at levels high enough to induce chronic adverse health effects.[58-60]

What *is* known is that if you fill a foamed polystyrene cup (Dow Chemical does not make Styrofoam® cups) with hot lemon tea or warm vegetable oil, it will begin to degrade and upon doing so will release toxic constituents into the liquid. As well, volatile styrene residues have been detected in eggs stored in polystyrene containers. A study conducted by Louisiana State University showed that styrene monomers and ethylbenzene increased in shell eggs stored in polystyrene containers for two weeks. Eggs from these containers contained up to seven times more ethylbenzene and styrene than farm fresh eggs.[61] Benzene

from laminated bags made of polystyrene has also been found to leach into meat, poultry, cheese and other packaged foods.[62]

Do these toxic residues get into our bodies? The fact that 100% of the U.S. population has measurable levels of styrene in their fatty tissues should quickly put the question to rest. The industry's trade group, the Polystyrene Packaging Council, even admits that styrene contaminants migrate into our foods, yet cavalierly states that there is "no cause for concern." However, the State of California doesn't buy their argument. In February 2009, State Assemblyman, Jerry Hill, introduced legislation to prohibit the use of polystyrene in *all* food packaging. Several local jurisdictions within California have already banned polystyrene packaging for both health and environmental reasons; other states and jurisdictions are considering similar actions.

Despite its many talents, there is widespread evidence that chronic exposure to polystyrene residues may have an adverse effect on human health. Moreover, disposal of polystyrene at the end of its lifecycle has become an intractable problem; it overflows community landfills, litters the landscape, and has become a persistent environmental pollutant in inland waters and oceans.

Polyvinyl Chloride (PVC)

PVC polymer is a hard, tough, resinous material with little practical application unless suffused with plasticizers, UV and heat stabilizers, flame retardants and lubricants. Once stabilized, PVCs are the most resilient and fire resistant of all plastics. PVC products are ubiquitous in today's home environments — the 'plastic of choice' for an immense variety of household uses. Unfortunately, PVC plastics are widely considered the most toxic and environmentally unfriendly of all the plastics in use today. As is the case for other plastics, it is not the PVC polymer itself, but the other chemicals added to the mix, that is problematic.

Phthalate Plasticizers

Esters of phthalic acid (phthalates) are the main additives to PVC, supplemented to increase its pliability (plasticity). Phthalates are easily released into the environment because there is no chemical bonding between the phthalates and PVC plastic in which they are mixed. As PVC plastics age and break down, the release of phthalates increases. Once free, these powerful endocrine disruptors are easily ingested through liquids, foods and circulating house dust. Although rapidly metabolized, phthalates are quickly gaining notoriety for their widespread adverse health effects. Unfortunately, because the use of vinyl products is so widespread, it is almost impossible to avoid exposure.

For example, phthalate plasticizers, associated with asthma, reproductive anomalies, neurological disorders, and cancer, make up 30% by weight of a typical baby mattress and expose newborns to exceptionally high levels of toxic off-gassing. While the FDA and the Consumer Safety Commission have issued consumer warnings regarding the use of phthalates, mattress manufacturers continue to use these toxins in their vinyl products.[63]

Until recently, polyvinyl toys, made for children and adults, also contained high levels of these plasticizers. In 2006, the European Union placed a ban on six types of phthalate esters commonly used as softeners in children's toys. In 2008, the U.S. Congress took similar action, passing the Consumer Product Safety Improvement Act, which includes a federal ban on phthalates in toys and children's products. However, imported toys can still contain high levels of these recognized toxins.

Phthalates are commonly found in household dust and indoor air in modern homes, and are present in human urine and breast milk. Concentrations are highest in young children and women.[64] In one study of girls aged 6-9, phthalates were detected in 100% of those tested.[65] Phthalates have been linked to observed increases in childhood learning and behavioural disorders.[66] Infants are exposed primarily through breast milk consumption[67] and through aspiration of phthalates in the dust from vinyl floors and carpets.[68] One study, investigating the link between phthalate exposure and Autism Spectrum Disorders (ASD), found PVC flooring to be an important indoor source of airborne phthalates. The study concluded that asthma and allergy prevalence are associated with phthalate concentrations in the settled dust of children's bedrooms.[69] The off-gassing of diethylhexyl phthalate (DEHP) from vinyl flooring can result in exposures as high as 0.086 mg per kg of body weight per day.[70] Human biomonitoring data reveal that the tolerable intake of phthalate plasticizers for children in the home environment is frequently exceeded, in some instances up to 20-fold.[71]

As well, extremely high neo-natal exposures in hospital settings can occur due to medical equipment, such as intravenous tubing and bags, which contain up to 50% DEHP by weight.[72-75] Infants born prematurely are subject to high levels of exposure due to various medical interventions. For example, neonatal blood transfusions can subject a tiny infant to levels of DEHP that exceed an astounding 3 mg/kg body weight/day. Data reveal that in clinically relevant concentrations, DEHP — the most widely prevalent plasticizer and a known human carcinogen — can leach from medical equipment at levels sufficient to impair the electrical and mechanical behaviour of the heart.[76]

Other vinyl products, such as found in the interiors of new cars, initially off-gas harmful levels of phthalate esters into the surrounding air — the reason for that 'new car' smell. Health concerns relating to exposure to these vapours has recently prompted three major

Japanese car manufacturers to eliminate PVC products from their vehicles. Vinyl shower curtains are another major source of toxic exposure to phthalates. One study showed that vinyl shower curtains released up to 100 chemicals, including DEHP, and other reproductive toxins and known carcinogens, into the surrounding air.[77] The study, conducted by the U.S. Center for Health, Environment and Justice, puts numbers to the fact that the unpleasant smell of new vinyl products is not safe for you — if you can smell it, take it back.

Phthalates are recognized as carcinogens and powerful endocrine disrupting chemicals (EDCs) capable of causing reproductive toxicity and fetal death in laboratory animals.[78] Recent studies confirm that pregnant women are exposed to phthalates through personal care products (such as lipstick, deodorant, hand cream, and nail polish) and through both their occupational and home environments. The studies provide evidence that such exposures can have harmful effects on the development of the fetus and infant. [79-81] Impairments include pulmonary and thryroid dysfunction, precocious (early) puberty, reproductive impairment, and congenital abnormalities.[82-89] One of the most consistent reports, however, concerns the anti-androgenic (feminizing) effects of phthalates in males.[90,91] While human studies are limited, there is strong indication that fetal exposure to these EDCs can deplete male steroid hormone levels and lead to undescended testes, decreased male fertility, sperm count and semen quality, and increased risk of testicular cancer. All these reproductive anomalies are common to testicular dysgenisis syndrome, an increasingly prevalent male developmental disorder noted in young boys.[92-98]

There is also evidence that exposure to phthalates from plastics is partly responsible for the alarming increase in obesity and insulin resistance observed throughout the developed world. It is believed that phthalate exposure interferes with leptin, a key metabolic hormone that plays a vital role in regulating energy intake and expenditure, leading to increased fat storage and metabolic dysfunction.[99-101] In a recently completed cross-sectional study of U.S. men, concentrations of phthalates and urinary phthalate metabolites were associated with increased waste circumference and insulin resistance in U.S. males.[102]

The evidence that phthalates can have such wide-ranging harmful effects at such low levels of exposure has prompted some researchers to call for the evaluation of overall health risks from everyday, simultaneous exposures to several phthalates commonly used in consumer products.[103]

Lifecycle of PVCs

As harmful as PVC products are proving to be during their manufacture and use, at the *end* of their lifecycle they also inflict widespread environmental damage. Upon incineration as medical wastes or in domestic and industrial landfills, PVCs release hydrochloric acid and

dioxins, a class of organo-chlorine combustion products that are extremely persistent environmental toxins. Studies of the burning of household wastes show that landfill incineration of PVCs is a major source of dioxin release. High environmental levels of these pollutants are evident in areas proximal to waste incineration, and their disbursement through prevailing winds is widespread. In February 2007, the technical and Scientific Advisory Committee of the US Green Building Council identified PVC products as consistently among the *worst* materials for human health. The international environmental coalition, Greenpeace, is advocating a phase-out of all PVC compounds because of the adverse health and environmental impacts of PVCs throughout their lifecycle.

Safety Tips and Alternatives

1) Take the sniff test: if there's a hint of plastic in your food or beverage don't consume it.

2) Return any plastic products that continue to off-gas unpleasant odors — and tell the retailer *why* you are doing so.

3) Get rid of polycarbonate water bottles: Bisphenol A, a powerful endocrine disruptor is the main constituent of polycarbonate and easily leaches from the plastic.

4) DO NOT put plastics in your dishwasher: most plastics degrade when exposed to heat and strong detergents, in so doing they release toxic additives.

5) If you use plastic containers for food storage, keep them out of strong sunlight or high temperatures to avoid degradation of the plastic.

6) DO NOT consume hot liquids from polystyrene, foamed polystyrene or polycarbonate cups and avoid eating with plastic utensils.

7) Unless they are the safer PP and PET plastics, avoid using plastic bags or wrap for food storage, particularly if the food is fatty or oily.

8) DO NOT microwave food *on* or *in* plastic — even if it is supposedly 'microwave safe.'

9) If you eat on plastic dishes, get rid of them (by recycling, of course) and use ceramic dishware instead.

10) As much as possible, avoid canned foods — particularly those acidic in nature; they will be contaminated with Bisphenol A, which leaches from the can's plastic lining.

11) If you use plastic water bottles and food containers, discard them when they become scratched or worn.

12) For long-term storage of items, such as lotions, beauty products and mouthwash, consider transferring them to glass or ceramic dispensers.

13) If building a new home, avoid the use of vinyl flooring, siding, carpeting, wall coverings and counter tops: if the budget allows, use tile, hardwood and other natural products instead.

14) Avoid the use of plastic water-storage carboys and use copper rather than PVC water lines for your domestic water supply; alternatively, filter your domestic water with reverse osmosis filters.

15) Remove vinyl mattresses covers (there are safer waterproofing alternatives), and keep vinyl products out of children's rooms and play areas.

16) Consider installing a high-efficiency HEPA filtration system in your home to minimize airborne vinyl and polystyrene residues.

17) Refuse to accept plastic bags at the grocery store, even if they are recyclable; ask for paper or supply your own environmentally friendly cloth bags instead.

18) Recycle all your plastics, where possible, and use biodegradable garbage bags instead of plastic bags to help reduce the environmental impact of plastics in our landfills.

19) Wherever possible, switch to glass, stainless steel, ceramic and natural alternatives to plastic dishware and utensils.

20) Become part of the solution, rather than part of the problem, by encouraging local 'Green' alternatives in your community and support state and federal initiatives to reduce our dependence on plastics.

Conclusions

We cannot entirely avoid the use of plastics in today's world; however, we can do much to minimize exposure to its toxic effects. It starts with awareness of the fact that — benign as they appear to be — plastics are synthetic poisons for which we are poorly equipped to deal. By seeking out alternatives to the use of plastics, we do ourselves — and our global environment — an immense favor.

Reference List

(1) Scientists Find 'Great Pacific Ocean Garbage Patch'. *National Science Foundation* 2009 August 28;Available at: URL: www.sciencedaily.com/releases/2009/08/090827180747.htm. Accessed December 10, 2009.

(2) Great Pacific Garbage Patch. *Wikipedia* 2009;Available at: URL: http://en.wikipedia.org/wiki/Great_Pacific_Garbage_Patch. Accessed December 10, 2009.

(3) Silverman J. Why is the world's biggest landfill in the Pacific Ocean? *Howstuffworks com* 2009;Available at: URL: http://science.howstuffworks.com/great-pacific-garbage-patch.htm. Accessed December 10, 2009.

(4) Vinyl Chloride. *Wikipedia* 2009;Available at: URL: http://en.wikipedia.org/wiki/Vinyl_chloride. Accessed December 10, 2009.

(5) Styrene. *Wikipedia* 2009;Available at: URL: http://en.wikipedia.org/wiki/Styrene. Accessed December 10, 2009.

(6) Alonso-Magdalena P, Morimoto S, Ripoll C, Fuentes E, Nadal A. The estrogenic effect of bisphenol A disrupts pancreatic beta-cell function in vivo and induces insulin resistance. *Environ Health Perspect* 2006 January;114(1):106-12.

(7) Goettlich P. Get Plastic out of Your Diet. *Mindfully org* 2003 November 16;Available at: URL: http://www.mindfully.org/Plastic/Plasticizers/Out-Of-Diet-PG5nov03.htm. Accessed December 10, 2009.

(8) Hunt PA, Koehler KE, Susiarjo M et al. Bisphenol a exposure causes meiotic aneuploidy in the female mouse. *Curr Biol* 2003 April 1;13(7):546-53.

(9) Johnson GE, Parry EM. Mechanistic investigations of low dose exposures to the genotoxic compounds bisphenol-A and rotenone. *Mutat Res* 2008 March 12;651(1-2):56-63.

(10) Pacchierotti F, Ranaldi R. Mechanisms and risk of chemically induced aneuploidy in mammalian germ cells. *Curr Pharm Des* 2006;12(12):1489-504.

(11) Parry EM, Parry JM, Corso C et al. Detection and characterization of mechanisms of action of aneugenic chemicals. *Mutagenesis* 2002 November;17(6):509-21.

(12) Quick EL, Parry EM, Parry JM. Do oestrogens induce chromosome specific aneuploidy in vitro, similar to the pattern of aneuploidy seen in breast cancer? *Mutat Res* 2008 March 12;651(1-2):46-55.

(13) Tsutsui T, Tamura Y, Suzuki A et al. Mammalian cell transformation and aneuploidy induced by five bisphenols. *Int J Cancer* 2000 April 15;86(2):151-4.

(14) Hassold T, Hunt P. To err (meiotically) is human: the genesis of human aneuploidy. *Nat Rev Genet* 2001 April;2(4):280-91.

(15) Rubin BS, Murray MK, Damassa DA, King JC, Soto AM. Perinatal exposure to low doses of bisphenol A affects body weight, patterns of estrous cyclicity, and plasma LH levels. *Environ Health Perspect* 2001 July;109(7):675-80.

(16) Plastic by the Numbers. *CNet News* 2009 October 12;Available at: URL: http://news.cnet.com/2300-13838_3-6237932-2.html?tag=mncol. Accessed December 10, 2009.

(17) Toxic Water and Baby Bottles - A Health Concern Explained. *Squidoo com* 2009;Available at: URL: http://www.squidoo.com/dangerous_plastics. Accessed December 10, 2009.

(18) Monarca S, De FR, Biscardi D et al. Studies of migration of potentially genotoxic compounds into water stored in pet bottles. *Food Chem Toxicol* 1994 September;32(9):783-8.

(19) Blagoeva P, Stoichev I, Balanski R, Purvanova L, Mircheva TS, Smilov A. [The testing for carcinogenicity of a polyethylene terephthalate vascular prosthesis]. *Khirurgiia (Sofiia)* 1990;43(6):98-105.

(20) Final report on the safety assessment of polyethylene. *Int J Toxicol* 2007;26 Suppl 1:115-27.

(21) Merski JA, Johnson WD, Muzzio M, Lyang NL, Gaworski CL. Oral toxicity and bacterial mutagenicity studies with a spunbond polyethylene and polyethylene terephthalate polymer fabric. *Int J Toxicol* 2008 September;27(5):387-95.

(22) Ergene S, Celik A, Cavas T, Koleli N, Aymak C. The evaluation of toxicity and mutagenicity of various drinking waters in the human blood lymphocytes (HULYs) in vitro. *Food Chem Toxicol* 2008 July;46(7):2472-5.

(23) Ceretti E, Zani C, Zerbini I et al. Comparative assessment of genotoxicity of mineral water packed in polyethylene terephthalate (PET) and glass bottles. *Water Res* 2009 October 31.

(24) Pinto B, Reali D. Screening of estrogen-like activity of mineral water stored in PET bottles. *Int J Hyg Environ Health* 2009 March;212(2):228-32.

(25) Montuori P, Jover E, Morgantini M, Bayona JM, Triassi M. Assessing human exposure to phthalic acid and phthalate esters from mineral water stored in polyethylene terephthalate and glass bottles. *Food Addit Contam Part A Chem Anal Control Expo Risk Assess* 2008 April;25(4):511-8.

(26) Shotyk W, Krachler M, Chen B. Contamination of Canadian and European bottled waters with antimony from PET containers. *J Environ Monit* 2006 February;8(2):288-92.

(27) Shotyk W, Krachler M. Contamination of bottled waters with antimony leaching from polyethylene terephthalate (PET) increases upon storage. *Environ Sci Technol* 2007 March 1;41(5):1560-3.

(28) Schwope AD, Till DE, Ehntholt DJ et al. Migration of BHT and Irganox 1010 from low-density polyethylene (LDPE) to foods and food-simulating liquids. *Food Chem Toxicol* 1987 April;25(4):317-26.

(29) Marcato B, Guerra S, Vianello M, Scalia S. Migration of antioxidant additives from various polyolefinic plastics into oleaginous vehicles. *Int J Pharm* 2003 May 12;257(1-2):217-25.

(30) Soto AM, Sonnenschein C, Chung KL, Fernandez MF, Olea N, Serrano FO. The E-SCREEN assay as a tool to identify estrogens: an update on estrogenic environmental pollutants. *Environ Health Perspect* 1995 October;103 Suppl 7:113-22.

(31) Kim H, Gilbert SG, Johnson JB. Determination of potential migrants from commercial amber polyethylene terephthalate bottle wall. *Pharm Res* 1990 February;7(2):176-9.

(32) Freire MT, Castle L, Reyes FG, Damant AP. Thermal stability of polyethylene terephthalate food contact materials: formation of volatiles from retain samples and implications for recycling. *Food Addit Contam* 1998 May;15(4):473-80.

(33) Park HJ, Lee YJ, Kim MR, Kim KM. Safety of polyethylene terephthalate food containers evaluated by HPLC, migration test, and estimated daily intake. *J Food Sci* 2008 August;73(6):T83-T89.

(34) Kashtock M, Breder CV. Migration of ethylene glycol from polyethylene terephthalate bottles into 3% acetic acid. *J Assoc Off Anal Chem* 1980 March;63(2):168-72.

(35) Feron VJ, Jetten J, de KN, van den BF. Polyethylene terephthalate bottles (PRBs): a health and safety assessment. *Food Addit Contam* 1994 September;11(5):571-94.

(36) Polystyrene. *Wikipedia* 2009;Available at: URL: http://en.wikipedia.org/wiki/Polystyrene. Accessed December 10, 2009.

(37) Huff J. Benzene-induced cancers: abridged history and occupational health impact. *Int J Occup Environ Health* 2007 April;13(2):213-21.

(38) Rana SV, Verma Y. Biochemical toxicity of benzene. *J Environ Biol* 2005 April;26(2):157-68.

(39) Benzene. *Wikipedia* 2009;Available at: URL: http://en.wikipedia.org/wiki/Benzene. Accessed December 10, 2009.

(40) Harvilchuck JA, Zurbrugg RJ, Carlson GP. CC10 mRNA and protein expression in Clara cells of CD-1 mice following exposure to styrene or its metabolites styrene oxide or 4-vinylphenol. *Toxicol Lett* 2008 December 15;183(1-3):28-35.

(41) Harvilchuck JA, Carlson GP. Effect of multiple doses of styrene and R-styrene oxide on CC10, bax, and bcl-2 expression in isolated Clara cells of CD-1 mice. *Toxicology* 2009 May 17;259(3):149-52.

(42) Meszka-Jordan A, Mahlapuu R, Soomets U, Carlson GP. Oxidative stress due to (R)-styrene oxide exposure and the role of antioxidants in non-Swiss albino (NSA) mice. *J Toxicol Environ Health A* 2009;72(10):642-50.

(43) NTP-CERHR monograph on the potential human reproductive and developmental effects of styrene. *NTP CERHR MON* 2006 February;(17):vii-5, I1.

(44) Cemeli E, Mirkova E, Chiuchiarelli G, Alexandrova E, Anderson D. Investigation on the mechanisms of genotoxicity of butadiene, styrene and their combination in human lymphocytes using the Comet assay. *Mutat Res* 2009 May 12;664(1-2):69-76.

(45) Cirla PE, Castoldi MR, Marchese E et al. [Plastic industry and exposure to carcinogenic chemical agents: an Italian Multicentric Study in Lombardy]. *G Ital Med Lav Ergon* 2007 July;29(3 Suppl):319-21.

(46) Mino C, Lopez-Cortes A, Arevalo M, Sanchez ME. Monitoring of DNA damage in individuals exposed to petroleum hydrocarbons in Ecuador. *Ann N Y Acad Sci* 2008 October;1140:121-8.

(47) Rueff J, Teixeira JP, Santos LS, Gaspar JF. Genetic effects and biotoxicity monitoring of occupational styrene exposure. *Clin Chim Acta* 2009 January;399(1-2):8-23.

(48) Guillemin MP, Berode M. Biological monitoring of styrene: a review. *Am Ind Hyg Assoc J* 1988 October;49(10):497-505.

(49) Welp E, Kogevinas M, Andersen A et al. Exposure to styrene and mortality from nervous system diseases and mental disorders. *Am J Epidemiol* 1996 October 1;144(7):623-33.

(50) Castle L, Kelly M, Gilbert J. Migration of mineral hydrocarbons into foods. 2. Polystyrene, ABS, and waxed paperboard containers for dairy products. *Food Addit Contam* 1993 March;10(2):167-74.

(51) Kempf M, Ramm S, Feuerbach T, Schreier P. Occurrence of 2,2,4-trimethyl-1,3-pentanediol monoisobutyrate (Texanol) in foods packed in polystyrene and polypropylene cups. *Food Addit Contam Part A Chem Anal Control Expo Risk Assess* 2009 April;26(4):563-7.

(52) Murphy PG, MacDonald DA, Lickly TD. Styrene migration from general-purpose and high-impact polystyrene into food-simulating solvents. *Food Chem Toxicol* 1992 March;30(3):225-32.

(53) Tawfik MS, Huyghebaert A. Polystyrene cups and containers: styrene migration. *Food Addit Contam* 1998 July;15(5):592-9.

(54) Uhde WJ, Woggon H. [New results on migration behavior of benzophenone-based UV absorbents from polyolefins in foods]. *Nahrung* 1976;20(2):185-94.

(55) Vitrac O, Challe B, Leblanc JC, Feigenbaum A. Contamination of packaged food by substances migrating from a direct-contact plastic layer: Assessment using a generic quantitative household scale methodology. *Food Addit Contam* 2007 January;24(1):75-94.

(56) Woggon H, Uhde WJ. [Antistatic finishing of plastics from food hygiene and toxicological viewpoints]. *Nahrung* 1977;21(3):235-45.

(57) Couds in Your Coffee? Try Less Styro, More Foam. *Grinning Planet* 2009;Available at: URL: http://www.grinningplanet.com/2008/04-08/foam-cups-polystyrene-cups-article.htm. Accessed December 15, 2009.

(58) Fishbein L. Toxicity of the components of poly(vinylchloride) polymers additives. *Prog Clin Biol Res* 1984;141:113-36.

(59) Fishbein L. Toxicity of the components of styrene polymers: polystyrene, acrylonitrile-butadiene-styrene (ABS) and styrene-butadiene-rubber (SBR). Reactants and additives. *Prog Clin Biol Res* 1984;141:239-62.

(60) Fishbein L. Additives in synthetic polymers: an overview. *Prog Clin Biol Res* 1984;141:19-42.

(61) Matiella JE, Hsieh TC. Volatile Compounds in Scrambled Eggs. *Journal of Food Science* 2006 August 25;56(2):387-90.

(62) Hunter BT. Dangers of packaging materials getting into food. *Mindfully org* 1993;Available at: URL: http://www.mindfully.org/Plastic/Packaging-Chemicals-Food-Dec93.htm. Accessed December 10, 2009.

(63) Five Problems with Baby Mattresses (Toxic Chemicals). *Healthy Child* 2009;Available at: URL: http://www.healthychild.com/toxic-sleep/five-problems-with-baby-mattresses-toxic-chemicals/. Accessed December 14, 2009.

(64) Our Health and PVC: What's the Connection? *Center for Health, Environment and Justice* 2009;Available at: URL: http://www.chej.org/BESAFE/pvc/documents/2009/Fact-Sheets/110909%20Our%20Health%20and%20PVC.pdf. Accessed December 12, 2009.

(65) Wolff MS, Teitelbaum SL, Windham G et al. Pilot study of urinary biomarkers of phytoestrogens, phthalates, and phenols in girls. *Environ Health Perspect* 2007 January;115(1):116-21.

(66) Our Health and PVC: What's the Connection? *Center for Health, Environment and Justice* 2009;Available at: URL: http://www.chej.org/BESAFE/pvc/documents/2009/Fact-Sheets/110909%20Our%20Health%20and%20PVC.pdf. Accessed December 12, 2009.

(67) Main KM, Mortensen GK, Kaleva MM et al. Human breast milk contamination with phthalates and alterations of endogenous reproductive hormones in infants three months of age. *Environ Health Perspect* 2006 February;114(2):270-6.

(68) Kolarik B, Naydenov K, Larsson M, Bornehag CG, Sundell J. The association between phthalates in dust and allergic diseases among Bulgarian children. *Environ Health Perspect* 2008 January;116(1):98-103.

(69) Larsson M, Weiss B, Janson S, Sundell J, Bornehag CG. Associations between indoor environmental factors and parental-reported autistic spectrum disorders in children 6-8 years of age. *Neurotoxicology* 2009 September;30(5):822-31.

(70) Rossi M. Neonatal Epxosure to DEHP (di-2-ethylexyl phthalate) and Opportunities for Prevention. *Healthcare without Harm* 2009 November;Available at: URL: http://www.noharm.org/us_canada/issues/toxins/pvc_phthalates/phthalates.php.

(71) Heudorf U, Mersch-Sundermann V, Angerer J. Phthalates: toxicology and exposure. *Int J Hyg Environ Health* 2007 October;210(5):623-34.

(72) Heudorf U, Mersch-Sundermann V, Angerer J. Phthalates: toxicology and exposure. *Int J Hyg Environ Health* 2007 October;210(5):623-34.

(73) NTP-CERHR Monograph on the Potential Human Reproductive and Developmental Effects of Di (Ethylhexyl) Phthalate (DEHP). *NTP CERHR MON* 2006 November;(18):i-III76.

(74) Oehlmann J, Schulte-Oehlmann U, Kloas W et al. A critical analysis of the biological impacts of plasticizers on wildlife. *Philos Trans R Soc Lond B Biol Sci* 2009 July 27;364(1526):2047-62.

(75) Phthalates and DEHP. *Healthcare without Harm* 2009;Available at: URL: http://www.noharm.org/seasia/issues/toxins/pvc_phthalates/phthalates.php. Accessed December 8, 2009.

(76) Gillum N, Karabekian Z, Swift LM, Brown RP, Kay MW, Sarvazyan N. Clinically relevant concentrations of di (2-ethylhexyl) phthalate (DEHP) uncouple cardiac syncytium. *Toxicol Appl Pharmacol* 2009 April 1;236(1):25-38.

(77) CanWest News Srvice. Vinyl shower curtains contains a 'volatile hazard' study says. *CanWest News* 2009 June 12.

(78) Shea KM. Pediatric exposure and potential toxicity of phthalate plasticizers. *Pediatrics* 2003 June;111(6 Pt 1):1467-74.

(79) Berman T, Hochner-Celnikier D, Calafat AM et al. Phthalate exposure among pregnant women in Jerusalem, Israel: results of a pilot study. *Environ Int* 2009 February;35(2):353-7.

(80) Cesario SK, Hughes LA. Precocious puberty: a comprehensive review of literature. *J Obstet Gynecol Neonatal Nurs* 2007 May;36(3):263-74.

(81) Ormond G, Nieuwenhuijsen MJ, Nelson P et al. Endocrine disruptors in the workplace, hair spray, folate supplementation, and risk of hypospadias: case-control study. *Environ Health Perspect* 2009 February;117(2):303-7.

(82) Boas M, Main KM, Feldt-Rasmussen U. Environmental chemicals and thyroid function: an update. *Curr Opin Endocrinol Diabetes Obes* 2009 October;16(5):385-91.

(83) Cesario SK, Hughes LA. Precocious puberty: a comprehensive review of literature. *J Obstet Gynecol Neonatal Nurs* 2007 May;36(3):263-74.

(84) Ge RS, Chen GR, Tanrikut C, Hardy MP. Phthalate ester toxicity in Leydig cells: developmental timing and dosage considerations. *Reprod Toxicol* 2007 April;23(3):366-73.

(85) Hong D, Li XW, Lian QQ et al. Mono-(2-ethylhexyl) phthalate (MEHP) regulates glucocorticoid metabolism through 11beta-hydroxysteroid dehydrogenase 2 in murine gonadotrope cells. *Biochem Biophys Res Commun* 2009 November 13;389(2):305-9.

(86) Huang PC, Kuo PL, Guo YL, Liao PC, Lee CC. Associations between urinary phthalate monoesters and thyroid hormones in pregnant women. *Hum Reprod* 2007 October;22(10):2715-22.

(87) Latini G, Scoditti E, Verrotti A, De FC, Massaro M. Peroxisome proliferator-activated receptors as mediators of phthalate-induced effects in the male and female reproductive tract: epidemiological and experimental evidence. *PPAR Res* 2008;2008:359267.

(88) Ormond G, Nieuwenhuijsen MJ, Nelson P et al. Endocrine disruptors in the workplace, hair spray, folate supplementation, and risk of hypospadias: case-control study. *Environ Health Perspect* 2009 February;117(2):303-7.

(89) Rouiller-Fabre V, Lambrot R, Muczynski V et al. [Development and regulations of testicular functions in the human foetus]. *Gynecol Obstet Fertil* 2008 September;36(9):898-907.

(90) Swan SH. Environmental phthalate exposure in relation to reproductive outcomes and other health endpoints in humans. *Environ Res* 2008 October;108(2):177-84.

(91) Talsness CE, Andrade AJ, Kuriyama SN, Taylor JA, vom Saal FS. Components of plastic: experimental studies in animals and relevance for human health. *Philos Trans R Soc Lond B Biol Sci* 2009 July 27;364(1526):2079-96.

(92) Latini G, Scoditti E, Verrotti A, De FC, Massaro M. Peroxisome proliferator-activated receptors as mediators of phthalate-induced effects in the male and female reproductive tract: epidemiological and experimental evidence. *PPAR Res* 2008;2008:359267.

(93) Meeker JD, Calafat AM, Hauser R. Urinary metabolites of di(2-ethylhexyl) phthalate are associated with decreased steroid hormone levels in adult men. *J Androl* 2009 May;30(3):287-97.

(94) Meeker JD, Sathyanarayana S, Swan SH. Phthalates and other additives in plastics: human exposure and associated health outcomes. *Philos Trans R Soc Lond B Biol Sci* 2009 July 27;364(1526):2097-113.

(95) Pant N, Shukla M, Kumar PD et al. Correlation of phthalate exposures with semen quality. *Toxicol Appl Pharmacol* 2008 August 15;231(1):112-6.

(96) Phillips KP, Tanphaichitr N. Human exposure to endocrine disrupters and semen quality. *J Toxicol Environ Health B Crit Rev* 2008 March;11(3-4):188-220.

(97) Virtanen HE, Rajpert-De ME, Main KM, Skakkebaek NE, Toppari J. Testicular dysgenesis syndrome and the development and occurrence of male reproductive disorders. *Toxicol Appl Pharmacol* 2005 September 1;207(2 Suppl):501-5.

(98) Wirth JJ, Rossano MG, Potter R et al. A pilot study associating urinary concentrations of phthalate metabolites and semen quality. *Syst Biol Reprod Med* 2008 May;54(3):143-54.

(99) Boberg J, Metzdorff S, Wortziger R et al. Impact of diisobutyl phthalate and other PPAR agonists on steroidogenesis and plasma insulin and leptin levels in fetal rats. *Toxicology* 2008 September 4;250(2-3):75-81.

(100) Casals-Casas C, Feige JN, Desvergne B. Interference of pollutants with PPARs: endocrine disruption meets metabolism. *Int J Obes (Lond)* 2008 December;32 Suppl 6:S53-S61.

(101) Hatch EE, Nelson JW, Qureshi MM et al. Association of urinary phthalate metabolite concentrations with body mass index and waist circumference: a cross-sectional study of NHANES data, 1999-2002. *Environ Health* 2008;7:27.

(102) Stahlhut RW, van WE, Dye TD, Cook S, Swan SH. Concentrations of urinary phthalate metabolites are associated with increased waist circumference and insulin resistance in adult U.S. males. *Environ Health Perspect* 2007 June;115(6):876-82.

(103) Wittassek M, Angerer J. Phthalates: metabolism and exposure. *Int J Androl* 2008 April;31(2):131-8.