THE PLASTICS PROBLEM

Overview

Nearly 100 billion pounds of plastic are produced in the United States each year. Plastics are now heavily used in food and beverage packaging, building products, electrical wiring, vehicles, furniture, toys, and medical devices. Plastics now comprise nearly 70% of the synthetic chemical industry in the nation. Two plastic ingredients, *bisphenol A* (BPA) and *Di(2-ethylhexyl) phthalate* (DEHP), are the subject of this report because of increasing evidence that they disrupt normal growth and development in many different species of animals due to their hormonal activity.

The production of BPA has increased steadily since the 1990s, from about 16 million pounds per year in the early 1990s to nearly 2.3 billion pounds in 2007. It is used in the manufacture of clear, hard polycarbonate plastics and epoxy resins. More than 200 million pounds of DEHP are produced annually, most of which is added to polyvinyl chloride plastics (PVC). Both chemicals are used to package food and contain beverages, and they are found in surface and ground water, the oceans, fish, food, and many consumer products.

BPA and DEHP have been detected in the blood and urine of nearly everyone who has been tested. Each compound is commonly found in human breast milk, and both cross the placenta and the blood-brain barrier. The youngest children tested in the U.S. carry the highest concentrations of these molecules or their metabolites in their tissues.

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Both chemicals are hormonally active in test animals: BPA mimics estrogen, and DEHP blocks testosterone. Studies in humans are limited, but several have found effects also detected in animal experiments. The study of their environmental influence on human health is exceptionally difficult due to confounding exposures, the lag time between exposure and changes in health, and the need to reconstruct histories of exposure that occurred long ago. A growing number of government-sponsored scientists believe that effects found in animals may plausibly occur in humans, while manufacturers' scientists vigorously defend their claims of chemical safety. These government-sponsored studies have found that BPA is biologically active at exceptionally small doses in some animals, altering normal patterns of growth and development of a variety of organ systems and functions.

Although the U.S. government has authority under several federal statutes to regulate or prohibit the production, use, sale, and disposal of both chemicals, BPA remains virtually unregulated, while DEHP is ineffectively regulated. This is well demonstrated by the chemicals' presence in human tissues.

Prior to intense industrial production, use, and environmental release, neither chemical was tested to understand its behavior in the environment or its risk to human health. At present, no legal mechanism is in place at any level of government to assure warning or protection against exposure to these molecules. This report presents a summary of potential health risks associated with BPA and DEHP, patterns of exposure among women, children and others, and policy recommendations designed to reduce or prevent exposure among susceptible populations.

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Endocrine Disrupting Chemicals

During the last half of the twentieth century, scientists found that numerous synthetic chemicals can interfere with normal function of human hormones. Colborn and Colwell in 1992 termed these substances to be "*endocrine disrupting contaminants*" (EDCs) and in 1999 the U.S. National Academy of Science (NAS) called them "*hormonally active agents*" (HAAs).[1] The human endocrine system is composed of a complex network of glands that release hormones into the blood to signal and govern normal growth, development, metabolism and reproduction. Human hormones include estrogen, progesterone, testosterone, thyroid hormones, and melatonin, among others, and these can be biologically active at exceptionally small doses.

Evidence that synthetic estrogens could induce responses similar to human hormones developed early in the twentieth century. The drug diethyl-stilbestrol (DES)[2] was first marketed as a synthetic estrogen to prevent miscarriages, preterm birth, and other pregnancy problems. By 1953 published studies demonstrated that the drug neither prevented miscarriages nor preterm births; however, many physicians continued to prescribe it until 1971, when it was reported to cause clear cell adenocarcinoma, a rare form of vaginal cancer, among girls and young women who had been exposed to DES while in their mothers' wombs.[3] Daughters of women who took DES had other problems, including reduced fertility, premature births, miscarriages and an elevated risk of breast cancer. Sons of women who took the drug were more likely to experience undescended testicles and hypospadias (premature exit of the urethra before the end of the penis). Additional studies identified third-generation effects among DES exposed mice, suggesting possible risks to grandchildren of DES-exposed mothers that are not yet clear.[4] The DES history contains lessons and warnings about heightened human susceptibility to synthetic hormones during embryonic development, as well as the potential for multi-generational effects.[5]

The National Academy of Sciences considered the influence of hormonally active agents on wildlife and human health in 1999. They reported, *"Although it is clear that exposures to HAAs (hormonally active agents) at high concentrations can affect wildlife and human health, the extent of harm caused by exposure to these compounds in concentrations that are common in the environment is debated."* [6]

Manufacturers of commercially important HAAs vigorously support the safety of their chemicals, while government-sponsored scientists increasingly report effects in laboratory experiments at exceptionally low doses similar to those experienced by humans from environmental exposures.

Wildlife studies provided supporting evidence that some industrial chemicals and pollutants could also unintentionally behave like hormones.[7] The insecticide DDT, for example, was recognized to induce reproductive failure in many predatory birds, including eagles, ospreys, falcons and hawks, and some species of fish during the 1950s and 1960s. In later decades, other species yielded signs that they might be sentinels for human health. Fish swimming near paper mill sewage outfalls and exposed to dioxins in effluent exhibited estrogenic, androgenic, anti-androgenic and anti-thyroid effects. Alligators exposed to the insecticide dicofol developed reproductive abnormalities following a 1980 spill in Lake Apopka, Florida. Their egg survival rates declined and both males and females developed abnormal sexual organs. Alligators studied in nearby unpolluted lakes exhibited none of these conditions. Different species of birds suffered reproductive failures following exposures to DDT, PCBs and PAHs in the North American Great Lakes Region, as well as in the Puget Sound and the Baltic Sea in Northern Europe.[8]

Since 1971 scientists have reported that many other chemicals, including some pharmaceuticals, pesticides, plasticizers, solvents, metals, and flame retardants, have the potential to mimic or block endogenous human hormones. Some of these compounds mimic naturally occurring hormones like estrogens (the female sex hormones), androgens (the male sex hormones), and thyroid hormones. They can also bind to a receptor site within cells and thereby block endogenous hormones. Some of the best-known hormonally active contaminants other than synthetic hormones include dioxins, PCBs, organochlorine pesticides (including DDT), and BPA.[9]

Many scientists now believe that developing fetuses, infants, and children may be more vulnerable to harm than adults following exposures to hormonally active chemicals. This is because organ systems, hormone

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pathways, and metabolic systems are all still developing. In addition, young children breathe more air, consume more food and drink more water per pound of body weight than adults, and this increases their relative exposure to any chemicals present in their environment. The National Academy of Sciences in 1993 recognized the susceptibility of the very young to pesticides,[10] and in 1996 the *Food Quality Protection Act* was adopted by Congress and included the mandate that EPA develop an "*Endocrine Disruptor Screening Program*" to identify specific risks posed by hormonally active pesticides. A similar screening requirement was embedded into the Safe Drinking Water Act Amendments during the same year.[11] Both of these efforts have been under-funded and research has been stalled for more than a decade.

Support for policies that prevent childhood exposure to hazardous substances have deep roots in twentieth century environmental history. Many other substances once considered safe for everyone have been found to be harmful to fetuses, infants, and children during certain "critical windows" of development. Examples include lead, mercury, pesticides, tobacco, alcohol, pharmaceuticals, and vehicle emissions. Congress and EPA have responded to this more refined science by adopting laws and regulations that are more protective of the youngest in society. Importantly, the former absence of chemical testing had created the false impression of safety.

Many forms of human illness have increased in prevalence during the past several decades including infertility, miscarriage, breast cancer, prostate enlargement and cancer, obesity, and various neurological and neurobehavioral problems. Simultaneously, human reproductive and wildlife biologists have found an increase in developmental, reproductive and hormonal disorders in

wildlife associated with chemicals recognized to be hormonally active. More recently laboratory studies and *in vitro* experiments have noted health effects in laboratory animals similar to those found in wildlife studies.

Government-sponsored scientists now express concern that hormonally active chemicals may be a possible cause for the rising human incidence of adverse developmental and reproductive system effects such as breast, testicular, and prostate cancer.[12, 13, 14, 15] Other scientists report the importance of a human's age at time of exposure. Fetal and neonatal exposures shortly after birth may result in health effects that are difficult to detect until later in life.[16] Yet industry-sponsored scientists maintain that animal studies do not necessarily imply a similar level of hazard to humans, and that risks will vary with differences in species, age, gender, genetic traits, exposure and other factors. A prominent committee convened by the U.S. National Academy of Sciences to consider the nature of risk posed by hormonally active chemicals has agreed that the health effects seen in animals are important signals of human health risks, especially when well correlated with increasing trends in human illness.[17] Indeed, pesticide regulation and pesticide bans have relied almost exclusively on animal evidence as a surrogate for human data to estimate health risks since 1970, the year EPA was created.

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Growth of the Plastics Industry

The importance of the BPA and DEHP problem is tied closely to the enormity of their markets. A few statistics clarify the scale:[18]

- The U.S. plastics industry now accounts for $379 billion in sales, and employs nearly 850,000 people.[19]
- Plastics comprise nearly 70% of the synthetic chemical industry and include nearly 500 different chemical resins.[20]
- Plastic product manufacturing is the fourth largest manufacturing segment in the U.S. with over 21,000 companies manufacturing plastic products or plastics raw materials.[21]

Given the scale of this industry, it should not be a surprise that plastics in children's environments have steadily increased in recent years.

- Nearly 113 billion pounds of resins were produced in 2006, including more than 2.3 billion pounds of BPA, and nearly 240 million pounds of DEHP (2002) used to create 14.5 billion pounds of polyvinyl chloride (PVC).[22]

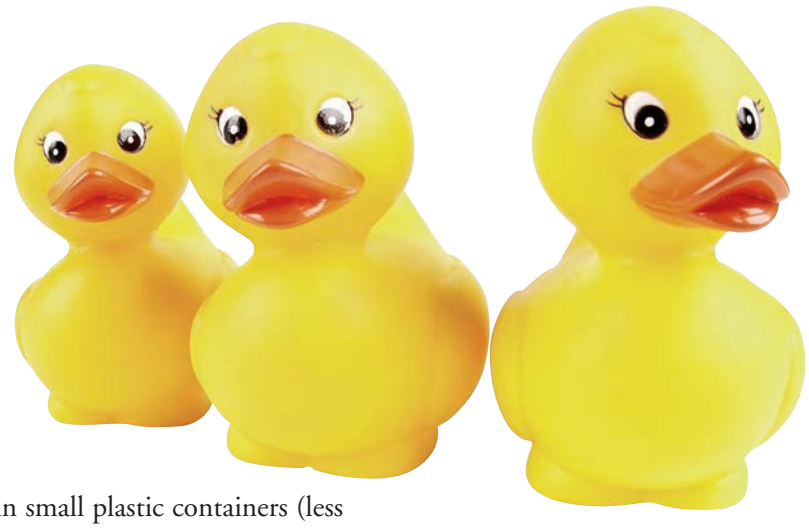
- By the late 1990s, packaging materials were the largest and fastest growing market for plastics, including bags, bottles, and food containers (consuming 26 percent of all plastics).[23] These often include DEHP and BPA.

- BASF estimated consumption of plastic in the U.S. at 223 pounds/person/year. It also estimated that consumption would increase to 300 pounds per year by 2010.[24]

Given the scale of this industry, it should not be a surprise that plastics in children's environments have steadily increased in recent years. Most homes built since 1985 are wrapped in plastic such as Tyvek™, first made by DuPont in 1959. Many homes are enclosed by PVC siding, serviced by PVC water lines, and wired with PVC-coated electrical lines. Walls are coated with plastic/epoxy paints, countertops are commonly plastic, wood floors are often coated with polyurethane finishes or covered with polypropylene rugs or vinyl tiles, and some homes have plastic insulation. Many infants, children, and adults sleep on PVC covered mattresses.

Most foods and beverages consumed by children are packaged in plastic, including soda and soups (can linings sometimes made with BPA epoxy) juice boxes (made of polyethylene),[25] frozen juice concentrates,[26] and single-serve plastic milk bottles (expected to replace the half-pint milk carton in school lunch programs).[27] Snack-sized food and beverage packages made of plastic are on the rise due to their convenience. As package size diminishes, use of plastic increases.[28]

The growth in bottled water consumption is an example of the dramatic increase in the use of plastic for food packaging that has occurred in the last decade. A decade ago, most children did not drink from plastic containers but today many arrive at school with plastic juice boxes, or purchase beverages in similar containers. Milk once sold only in glass is now sold almost exclusively in plastic containers or cardboard cartons



lined with plastic. Sales of bottled water in small plastic containers (less than one liter in size) increased more than seven-fold in the U.S. between 1997 and 2005, rising from four billion to nearly 30 billion bottles sold.[29]

Children's toys increasingly are made from plastic, and nearly 80% of the world's toys are made in China.[30] The European Council of Vinyl Manufacturers stated that almost all soft plastic toys are made with PVC, including dolls, bath ducks, inflatable toys, balls, and baby care items.[31] Children's video games, computers, MP3 players, cameras and cell phones collectively exceed billions in individual sales each year in the U.S. alone. Most of the components are plastic, and the devices' life-spans are rarely more than three years. Planned obsolescence guarantees extraordinary waste.

Children ride to and from school in cars, buses, and other vehicles that are increasingly made from plastic. New cars contain nearly 332 pounds of many different types of plastic. Some of these give off gases inside the passenger compartments, contributing to the "new car smell." Nearly 7.5 million new vehicles are sold in the U.S. each year, meaning that 2.5 billion pounds of plastic in vehicles has little hope of being recycled.

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Consumer Confusion

What chemicals are in the plastics just described? It's virtually impossible to know for all but the simplest products, such as polyethylene (PETE) beverage bottles. Why? Ingredients used to make plastics are not required to be labeled, and many manufacturers are unwilling to disclose the plastic ingredients or sources. Given the complexity of international plastics markets, it is not surprising that many manufacturers or distributors cannot identify ingredients or sources of plastics in their products.

Some plastics are labeled to facilitate recycling, not to identify chemicals used in their manufacture. The only clue a consumer has when identifying chemical ingredients in plastic products is the resin identification code on the plastic product, intended to facilitate recycling. The code was designed to indicate the type of resin used in the manufacturing process and to identify which products should or should not be recycled.[32] There is no federal law requiring this code, although many states have legislation mandating the use of the codes on some types of bottles.[33] There are no federal methods to ensure the proper use of the codes. Currently, the Federal Trade Commission only offers guidelines for environmental marketing claims designed to have an effect on labeling, but not requiring or enforcing it.[34]

Table 1. Recycling Symbols for Plastic Resins

Symbol	Type of Plastic	Products Packaged (Examples)
1 PETE	PET Polyethylene Terephthalate	Most convenience-size beverage bottles, mouthwash bottles, boil-in-bag pouches
2 HDPE	HDPE High Density Polyethylene	Milk jugs, trash bags, ice cube trays, storage containers
3 PVC	PVC Polyvinyl Chloride (DEHP)	Cooking oil bottles, packaging around meat, some baby bottle nipples, beverage pitchers
4 LDPE	LDPE Low Density Polyethylene	Produce bags, food wrap, bread bags, zip-lock bags, baby bottle liners
5 PP	PP Polypropylene	Yogurt containers, straws, margarine tubs, spice containers
6 PS	PS Polystyrene	Styrofoam cups and containers, take-home boxes, egg cartons, meat trays
7 OTHER	**Other (Bisphenol A)**	**Polycarbonate baby bottles, 5-gallon water cooler bottles, meat trays, toddler fruit cups**