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Special Report

Learning Hazards: Toxic Fire Retardants And How To Avoid Them In Consumer Products And Food

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EXECUTIVE SUMMARY

Introduction

As a general rule fire retardants help protect us, but not all fire retardants are made alike. Certain of these chemicals, known as polybrominated diphenyl ethers (PBDEs), raise safety concerns because they have been collecting in our bodies and may, at high exposures, cause nervous system damage in children. Americans are just beginning to learn about possible risks posed by PBDEs, which are being found in our blood, body fat and breastmilk at levels several times higher than in the citizens of any other country where they've been tested. In a few cases, these levels are comparable to those that have caused reproductive and nervous system damage in animals.

Luckily, consumers have a choice: There are safer alternative fire-retardants, and the Solutions section of this report lists consumer products that are PBDE-free, along with simple ways to minimize PBDE exposure in our homes and in our diets. The report also examines the literature on PBDEs to date, including new studies released in the spring of 2005.

PBDES: The "New PCBs"

PBDEs, widely used in polyurethane furniture foam and plastic TV and computer monitors, have been found to be collecting in the bodies and breast milk of human beings over the past 30 years. They also have been found in wildlife, house dust and our food. Children's PBDE levels, in particular, may receive occasional spikes from dust encountered while playing on the floor.

Current total PBDE levels in the blood of U.S. residents are the highest reported worldwide to date, ranging from 40 to 70 times higher than levels found in residents of Germany, Sweden and the Netherlands, where two types of PBDEs have been phased out since the mid-1990s. Sweden has seen a decrease in PBDE levels since 1998, suggesting that their phaseout has been effective. A European Union ban of most varieties of PBDEs went into effect in 2004 [26, 24, 27]. A 2005 study by Arnold Schechter, M.D., M.P.H., a professor of environmental sciences at the University of Texas School of Public Health, shows that, in some cases, blood levels of PBDEs in Americans have surpassed the levels of polychlorinated biphenyls (PCBs), which are known to harm the developing brain and nervous system in humans and have been banned in the U.S. since 1978 [39]. In animal studies, PBDEs have produced effects similar to the effects of PCBs, and the two chemicals are similar in structure as well.

Because PBDEs also cross the placenta, some scientists fear that, as has happened with PCBs, maternal levels of PBDEs may result in children's delayed development, including learning and behavioral problems [26]. For this reason, women may want to reduce their exposures so as not to pass these chemicals on to their children. "It's *in utero* exposures that are the biggest concern," says Linda Birnbaum, Ph.D., director of the Environmental Protection Agency's Experimental Toxicology Division, noting that it is from exposures during periods of rapid fetal development that rats show the worst effects of PBDEs.

It is important to emphasize that despite the presence of chemicals in breast milk, the American Academy of Pediatrics (AAP) recommends that women continue to breast-feed for at least the first year of their children's lives. Not only does breast-feeding protect against a host of health problems, from ear infections to allergies and learning difficulties, but it also may mitigate harm done from exposures in the womb, according to Alexander Cattaneo, Ph.D., of the Italian Institute of Child Health. "Babies who nurse do better than babies who don't nurse," Dr. Birnbaum says.

How PBDEs Enter the Environment and Our Bodies

PBDEs are persistent organic pollutants (POPs) that rapidly and widely disperse and persist in the environment. Many studies have indicated that because PBDEs are not bound to molecules of plastic or foam, they readily migrate out of crumbling foam furniture or plastic computer casings into house dust [15, 27]. Dust wiped from inside computers has shown PBDE levels from 77 to over 1,500 nanograms per 100 square centimeters (a nanogram is a billionth of a gram). Dr. Schechter this year has found PBDEs in household dust at 1,000 times greater levels than he has found in his studies of supermarket food [38]. The behavior of young children, who crawl on the floor and constantly put their hands and other items in their mouths, may place them at greater risk from PBDEs, says Philip J. Landrigan, M.D., director of the Center for Children's Health and the Environment at Mount Sinai School of Medicine.

Although the two most widespread varieties of PBDEs, penta- and octa-BDEs, are no longer being produced as of January 2005 by the Great Lakes Chemical Corporation, their sole U.S. manufacturer, their presence in long-lived consumer products, such as beds and sofas, ensures that exposures may continue for years. And until stocks of PBDE-treated foam run out, new furniture will still include it. On the legislative front, California is the only state that has passed legislation banning penta and octa PBDEs from products sold there (by 2006), and Maine and Hawaii have stated plans to do so. Currently and for at least the next year in California, there is no reason not to assume that new polyurethane furniture is PBDE-free.

New Studies Find PBDEs Approaching Unsafe Levels in U.S. Homes, Food and Blood

The following new findings are highlighted in this report.

*PBDEs are on the rise in the blood of Americans, in some cases surpassing levels of PCBs, which have been banned and are on the decline [17, 39].

*The highest PBDE levels measured in humans are now comparable to levels linked to lower sperm counts and damaged ovaries in animal tests, according to Tom McDonald, Ph.D., M.P.H., until recently staff toxicologist in the California Environmental Protection Agency's Office of Environmental Health Hazard Assessment, now senior toxicologist with the Arvesta Corporation, a producer of herbicides and insecticides.

*Farmed fish have the highest levels of PBDEs, on average, of all animal food groups tested by Dr. Schecter, a finding that confirms recent research by Ronald Hites, Ph.D, director of the Environmental Science Research Center at the University of Indiana School of Public and Environmental Affairs [16, 40]. "It's very similar to what we saw with dioxins, PCBs and other organic pollutants," Dr. Schecter says. "There's just a concentration of these [chemicals] in farmed catfish and other farm-grown fish. In general, wherever we looked we saw farmed fish had higher levels."

*PBDEs are present in house dust at levels up to 1,000 times or more higher than the levels found in food, suggesting that, unlike PCBs, which are mainly ingested in food, PBDEs are entering our bodies through both food and inhaling or ingesting dust [39,40]. Dr. Schecter found almost 70,000 parts per billion (ppb) of PBDEs in vacuum sweepings, compared with 3 ppb in farmed salmon. The dust studies highlight the likelihood of exposures while cleaning or to children playing on the floor and bringing their contaminated hands to their mouths.

*Daily exposures to PBDEs in food for adults in the U.S. average 2.342 nanograms per kilogram of body weight per day. For nursing infants, however, the daily PBDE intake is 126 ng/kg BW/day, or 54 times what adults take in. Still, doctors emphasize that, for their growth and development, babies continue to breast-feed. Mothers can, however, reduce PBDE exposures to both themselves and their infants.

Exposures to PBDEs from Food

Once they are released into the environment, PBDEs, like PCBs and dioxins, "bioaccumulate," or rise in the food chain, collecting in animal fats. While contamination of our food supply has not received as much attention as PBDEs in house dust, it is of concern for two reasons:

*Dr. Schecter, William Luksemburg, president of Alta Analytical Laboratory, and others have found higher levels of PBDEs in farmed salmon and catfish than in other fish and meats. Farmed fish also contain significantly higher levels of dioxins and PCBs [16, 40, 23]. These chemicals accumulate in our bodies. Therefore, the more contaminated food we consume, the higher our exposure—and our unborn children's—may be. As Dr. McDonald notes, it can take two to seven years or more to rid the body of just half its burden of PBDEs [26].

*The highest PCB exposures, those that have contributed to birth defects and lowered I.Q., have come from contaminated food, such as fish, and as the two chemicals are so similar, we should be concerned about a similar danger from PBDEs.

Reducing Our Exposures to PBDEs: Consumer Solutions

By taking the following simple actions, we can reduce our exposures to PBDEs as well as to PCBs, dioxins and other POPs. These solutions are discussed more fully, with specific product listings, starting on p. 20 of this report. As an overview:

* **Eat a heart-healthy diet.** Reducing your consumption of animal fats will also lower amounts of PCBs, PBDEs, dioxins and other POPs in your diet. "Eating less amounts of animal fats will result in lower PBDE levels [in our bodies] in the long run," Dr. Birnbaum says. She recommends a "heart healthy" diet, which will, in addition to helping protect cardiovascular disease, also reduce our exposure to bioaccumulating chemicals such as PBDEs, PCBs and dioxins.

* **Eat farmed fish less frequently (some researchers recommend no more than once per month)**, especially European and U.S. salmon, which have been shown to have high PBDE, PCB and dioxin levels [16]. Choose wild salmon “fresh, frozen or canned” instead. To find other safest fish, see p. 21.

* **Clean floors with a HEPA filter vacuum cleaner** that traps fine particles of dust, soot and pollen, and wet mop regularly. Keep your home well-ventilated. This will also help reduce concentrations of other forms of indoor air pollution, Dr. McDonald says.

* **Cover and seal rips in upholstery** that expose polyurethane foam, especially if the foam is loose and crumbling, a condition that may encourage the release of PBDEs into house dust and air [41].

When buying new furniture, explore your PBDE-free options as listed in the Solutions section of this report on p. 21.

* **Contact your mattress manufacturer** to see whether your mattress is made with polyurethane foam that contains PBDEs (see “What to ask,” p. 22). If it does, but you aren’t ready to replace your mattress, consider purchasing a tightly woven allergen-barrier mattress casing to block dust that may be laden with PBDEs. Replace the mattress as soon as it shows wear with one of the non-PBDE options listed in the Solutions section, p. 22.

***If you buy a new air conditioner, choose one with a HEPA filter** and clean it regularly to remove dust.

Learning Hazards: Toxic Fire Retardants And How To Avoid Them In Consumer Products And Food

A *Green Guide* Special Report

by P. W. McRandle

Introduction

For the past 30 years, a family of flame-retardant chemicals known as polybrominated diphenyl ethers (PBDEs), have been found to be collecting in the bodies and breast milk of human beings. These chemicals have been shown to cause learning deficits and reproductive problems in animals, and they may have similar effects in humans. Widely used in polyurethane furniture foam and plastic TV and computer monitors, PBDEs readily spread into the environment. They have been found in wildlife, house dust and the food we eat [17]. Food is a major source of the high PBDEs levels in our bodies, but a growing body of evidence strongly suggests that house dust plays a significant role. Children's levels, in particular, may receive occasional spikes from dust encountered while playing on the floor.

But there's no reason to panic. The good news is that simple daily lifestyle choices can have a comprehensive healthy effect, counteracting potential risks from the wide range of chemicals we are exposed to, including those that threaten children's development.

Threats to Fetuses, Infants and Children

Contaminated breast milk has provoked public and governmental concern, particularly in the European Union, where a ban of two kinds of PBDEs went into effect in 2004. Because PBDEs cross the placenta and have been found in umbilical-cord blood and breast milk, some scientists fear that, as with PCBs, maternal levels of PBDEs may result in children's delayed development, including learning and behavioral problems, according to Tom McDonald Ph.D., M.P.H., until recently staff toxicologist in the California Environmental Protection Agency's Office of Environmental Health Hazard Assessment, now senior toxicologist with the Arvesta Corporation, a producer of herbicides and insecticides [26]. Studies in the last three years have shown that the breast milk of U.S. women has 40 to 70 times more PBDEs than that of European and Japanese women. And research Arnold Schechter, M.D., M.P.H., a professor of environmental sciences at the University of Texas School of Public Health, presented at the 2005 Society of Toxicology meeting shows that children's daily intake through breast feeding is 54 times what adults take in (for their body weight) from food.

But exposures start even earlier than infancy. Fetuses absorb PBDEs in the womb from maternal blood. PBDE levels in the blood of human American fetuses range from 30 to 106 times greater than the levels found in Europe, according to a 2003 study published in *Environmental Health Perspectives* [25]. Most fetuses in their U.S. sample were being exposed to levels as great as those of workers in Sweden who were "considered to have had direct, work-related exposures," Anita Mazdai, Ph.D., of the Department of Obstetrics and Gynecology at the Indiana University School of Medicine and her coauthors found. "The

lowest levels we've seen in the U.S. are still pretty much higher than the highest levels we see in Europe," says Linda Birnbaum, Ph. D., director of the EPA's Experimental Toxicology Division.

Depending on their chemical structures, PBDEs may also vary in their toxicity, how long they stay in the body, and how prone they are to bioaccumulation. Different structures have resulted in several varieties, the commercial forms being known as penta-, octa-, and deca-BDEs (see Appendix One).

Alarming Rise in Human Levels

PBDE levels measured in people have risen rapidly over the last thirty years. In a review of PBDE studies, Ronald Hites, Ph.D, director of the Environmental Science Research Center at the University of Indiana School of Public and Environmental Affairs, reports that tests of Swedish breast milk from 1972 showed 0.07 parts per billion (ppb) PBDEs [17]. Twenty-five years later, tests of Swedish breast milk in 1997 revealed 3.69 ppb of PBDEs, almost 53 times the former amount. In the U.S., PBDE levels in blood drawn in 1973 were 0.7 ppb; thirty years later levels in blood samples had shot up to 62 ppb, an 89-fold increase.

But there is cause for hope: Over this same period, as PBDE levels in blood have been rising, levels of PCBs and dioxins have declined by over 80 percent, according to Dr. Schecter's research [39]. This gives hope that a similar ban of PBDEs will show a similar decline. Sweden, for example, has seen a reduction in PBDE levels in breast milk following a phaseout in the early 1990s [16, 7].

Among the U.S. population, levels of PBDEs vary greatly. Some people can have just a few parts per billion in their blood or breast milk, while others have several hundred. These disparities are probably due to differences in exposure to the chemicals and biological differences between people. A recent survey of studies conducted in 2003 and 2004 found that U.S. women had median level of 46 ppb in breast milk, 41 ppb in blood, and 46 ppb in their body fat. [26]

Most of us will never know our body burdens, but Florence Williams in a January 2005 *New York Times Magazine* article describes her effort to find out what she might be passing on to her nursing child by having her breast milk tested for contaminants. Williams learned she had PBDE levels of 36 ppb, the median-level in the U.S. A toxicology consultant assured her that her daughter is probably not receiving unsafe exposures. But according to research by Dr. McDonald, some U.S. breast milks PBDE levels are equivalent to those that have resulted in subtle damage to learning and memory as well as to reproductive systems in rats.

Benefits of Breast-feeding Outweigh Risks

Despite potential chemical exposures, health practitioners recommend that women continue to breast-feed for at least the first year of their child's life. Not only does breast-feeding protect against a host of health problems, as noted by the American Academy of Pediatrics, from urinary and respiratory-tract infections to asthma and learning difficulties, but it also can counter any harm done from chemical exposures in the womb. The AAP also says that breast-feeding can result in enhanced performance in cognitive testing, citing a study that showed 8-year-old breast-fed children doing better at verbal and performance IQ tests [1].

"Breast-feeding is still absolutely, unequivocally, the best source of nutrition for a human infant. It has factors that can't possibly be replicated by cow's milk or formula. But we have to reduce the use in American society of toxic chemicals that have the potential to accumulate in breast milk," according to Philip J. Landrigan, M.D., director of the Center for Children's Health and the Environment at Mount Sinai School of Medicine[33].

A Recent Test Case

In a test underwritten by the *Oakland Tribune*, Michelle Hammond, her husband Jeremiah Holland and their two children, 5-year-old Mikaela and 18-month-old Rowan, were tested for PBDEs and other contaminants in September 2004. The parents had volunteered with no reason to believe they suffered

from any significant exposures, as they eat only organic foods and avoid animal fats. To their surprise, Rowan had PBDE levels higher than all of them, 838 parts per billion, placing him in the top 5 percent of measured U.S. levels [13,17]. Most unexpectedly, Rowan had high levels (277 ppb) of PBDEs of the deca-variety, used in computers and televisions, and yet the family has no television. Michele Hammond, the boy's mother, says, "I grew up not watching TV and I don't have time to watch TV. But we've always had a computer in our house and it's a fairly old computer. With Rowan, my parents used to take care of him and they had several computers." A 2004 study by the Computer Takeback Campaign found that computers leach deca-BDEs onto surfaces around them, and a 2005 study by Dr. Schechter found high levels of deca- as well as other varieties of PBDEs in vacuum sweepings [27, 38].

How PBDEs Disperse In Our Environment

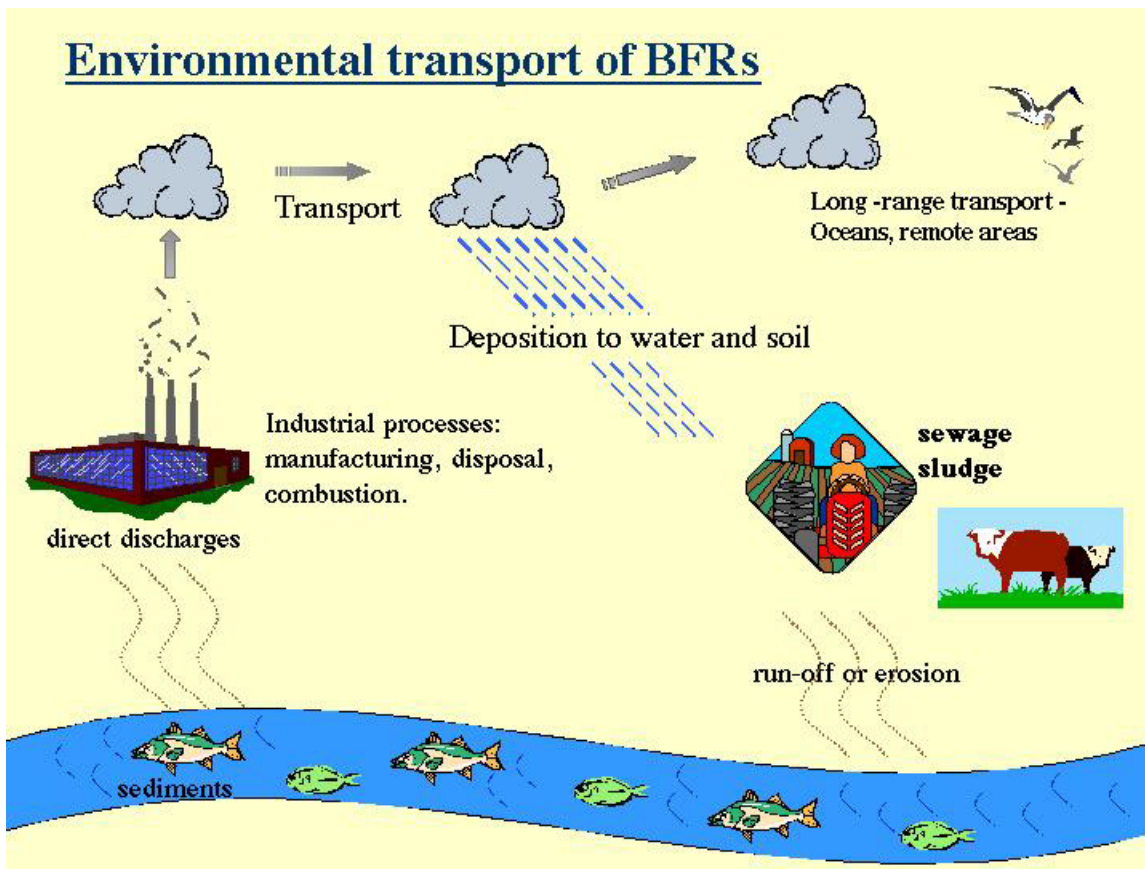


Image courtesy of Sarah Janssen, M.D., Ph. D. Occupational and Environmental Medicine Fellow at the University of California at San Francisco.

Approximately 67,390 metric tons of PBDEs (most of it deca) were produced worldwide in 2001 alone, and they don't stay in one place. Scientists hypothesize that PBDEs are emitted into the air from factories that produce them, cycling with rainfall back into rivers, contaminating fish and wildlife. Penta-BDE can be released into the atmosphere from municipal incinerators and from improper burning, as happens during England's annual early November Bonfire Night celebrations [12]. PBDE concentrations have been found in high levels in streams near industrial plants as well as in our air, sediments, sludge, soil, with much higher levels measured in Canada than in Europe [45, 17]. Having made their way into the environment, PBDEs bioaccumulate, meaning they collect in animal fats and concentrations magnify as they move up the food chain, being measured in birds and fish and mammals [38]. Like PCBs and dioxins, PBDEs are now found worldwide in species ranging from wild chinook salmon to harbor seals

in San Francisco, from Canadian arctic ringed seals to human breast milk in America, Canada, Japan, Sweden and elsewhere [17].

Indoors, PBDEs slowly off-gas from foam and plastic products into the air [48]. They may also be released as foam and plastics degrade or slough off particles, escaping from products because they are added to materials rather than chemically bound to them [57, 3, 42]. PBDEs are measured in indoor air, and are measured on surfaces (windows) and particles (dust).

Toxicity Of PBDEs: Risk Of Learning Lags And Reproductive Harm

The results of laboratory tests in animals clearly indicate the health concerns PBDEs may pose. Most disturbingly, some effects seen in animals, including a lowered sperm count, damage to ovaries and learning impairment, can arise at relatively low doses. Most of the studies have been conducted using penta-BDE.

Reproductive Health Hazards

European studies have shown sperm counts declining among men for the last 50 years, and a 2005 study by Sergio Kuriyama, Ph.D., Institute of Clinical Pharmacology and Toxicology, Department of Toxicology, Charité University Medical School Berlin, suggests that PBDEs, along with other environmental contaminants, may be playing a role in these reduced sperm counts [21]. Kuriyama and his colleagues gave female rats a dose of penta-PBDE that they say is equivalent to six times the average level in humans on day six of pregnancy. The pregnant rats gave birth to male offspring that suffered from a 30 percent decline in sperm production. These rats also became hyperactive.

As Dr. Kuriyama and his co-authors point out, while rats can be fertile with even a 90 percent reduction in sperm count, “relatively small changes in sperm

production in men may have severe consequences for human reproduction” [21]. There is also preliminary evidence from rat studies that similar low level exposures can damage cause microscopic changes to the ovaries [26].

Damage to Brain and Nervous-System Development

Low doses (0.6 mg/kg body weight) of penta-BDE, given during the critical period of brain development shortly after birth, have harmed learning and memory in mice [8]. And Henrik Viberg Ph.D. at the department of Environmental Toxicology, Uppsala University, Sweden, has now shown that exposure to all varieties of PBDEs can damage learning and memory [46]. Dr. Birnbaum notes that studies of cultured brain cells have shown that PBDEs impair neural signaling. Another possible mechanism by which PBDEs could cause damage to the developing brain is through disruption of thyroid hormone levels. In animal experiments, exposure to penta-BDE during pregnancy significantly reduced the levels of thyroid hormones in offspring. Women who suffer from reduced thyroid hormones are more likely to give birth to children with mental retardation and lowered IQs [24].

From animal studies such as these, it is possible to estimate the health risk that current human levels of PBDEs in blood, fat, breast milk are having on the reproductive and developmental health of offspring. Dr. McDonald converted the level of PBDEs that caused toxicity in animals to an equivalent level in humans. Based on this conversion, Dr. McDonald estimated that a level of about 304 ppb in human blood, milk and fat tissue was enough to damage the reproductive abilities of both male and female children. That is to say, a woman who has a level of greater than 304 ppb in her body fat could be at risk of giving unsafe levels of PBDEs to her children during pregnancy and while breastfeeding.

About five percent of women in the U.S. have PBDE levels in this range. “What my analysis has been showing,” says Dr. McDonald, “is that the levels of PBDEs in the animals from these

neurodevelopmental studies are at or near what we're seeing in the high end of these people." [26]. Dr. Birnbaum also notes that "people at the high end of the population [those with the highest PBDE levels] don't have a large margin of exposure between themselves and animals showing health effects."

The neurotoxic and reproductive effects produced by PBDEs are unfortunately similar to those of PCBs, DDT and dioxins, all of which also accumulate in the body along with many other contaminants [46]. We have to concern ourselves not just with one chemical but with the combined effects of various bioaccumulating chemicals gathering in our bodies.

Cancer

While we know that PCBs and dioxins are carcinogens, the results are mixed on PBDEs. Studies have linked deca-BDEs to cancer at very high exposures, but the International Agency for Research on Cancer states that deca-BDE is "not classifiable" in regards to its human carcinogenicity because of limited and inadequate studies [8, 19]. In 1986, The U.S. National Toxicology Program (NTP) conducted a two-year study in which deca-BDEs were fed to rats and found some evidence of carcinogenicity for both males and females [32]. Unfortunately, penta- and octa-BDEs have not been studied for carcinogenicity, though the NTP is scheduled to conduct cancer studies of penta-BDE starting approximately September 2006, according to John Bucher, senior toxicologist there.

PBDEs Are Rapidly Approaching Dangerous Levels In Americans

Like PCBs, dioxins and pesticides such as DDT, PBDEs are persistent organic pollutants (POPs). Stored in fat, PBDEs stay in the body for years before being even partially eliminated; this has resulted in their rising levels in the bodies of Americans, Canadians and Europeans. Studies have shown that it takes the body almost three years, on average, to eliminate half of the penta-BDEs,

the most toxic variety, absorbed through daily exposure from food [14]. Tests on human blood, fat tissue, breast milk and umbilical-cord blood show that PBDE levels on average are increasing in Americans' bodies at a rate that's been doubling every five years [17].

A 2005 study of American blood by Arnold Schecter indicates that, as of 2003, PBDEs were the most prevalent POP in the blood tested, showing up at levels more than twice those of PCBs [39]. While these results may not reflect the general population, owing to sample size, Dr. Schecter notes that "PCBs and dioxins are decreasing in U.S. blood and PBDEs are rapidly increasing."

As PBDEs rise, they pose a threat to growing children at every stage of development. In the womb, while the fetus is growing rapidly, it can be exposed through the placenta and umbilical-cord blood to levels as high as the mother's. Cord blood contains fat cells (or lipids) from the mother, and PBDEs concentrate in fat cells. "There is a dramatic mobilization of maternal fat stores during the third trimester of gestation, a period critical to brain development," notes Dr. Mazdai. Because this period of critical brain development is similar to that in which exposed rats have suffered damage to learning and memory, Dr. Birnbaum warns, "It's in-utero exposures that are the biggest concern."

After birth, breast-feeding can expose infants again to PBDEs.

"Couches, chairs and carpets will continue to release PBDEs into the environment for many years to come and possibly even after disposal. This would suggest, for at least the short term, that levels in people will continue to rise," says Dr. McDonald.

Although toxicologists are most concerned about human exposures to penta-BDEs, recent research has shown that deca-BDE is also present in our bodies, as Rowan's case makes clear [3, 17, 39]. Deca-BDE was thought to be less of a concern because it has a relatively short half-life in humans of about one to two weeks, meaning that the body

can eliminate most of it within a month or two [42]. But scientists don't know whether deca-BDE can break down into penta-BDE and other forms in the human body. Such a reaction does occur in fish, and Dr. Birnbaum points out that there is also evidence that deca can be broken down into other kinds of PBDEs through microbial action, through the metabolism of animals that consume them, and under sunlight. She notes that, "nobody has studied how far down breakdown goes. Taking an animal at the top of the food chain and just giving it deca doesn't show what happens as deca moves up the food chain." Dr. Birnbaum's concern is that even if deca-BDE is harder for the human body to absorb, because it is taken in by animals lower in the food chain it may be converted to penta, tetra or other varieties of PBDEs more easily absorbed by animals and humans who eat them.

Products And Food Containing PBDEs

To date, PBDEs have been measured in food and house dust, leading researchers to conclude that these routes of exposure may be the most likely for human beings. "Food plays a substantial role in the PBDE intake into humans," Dr. Schechter says, adding, "Dust or air may play a larger role as a route of daily intake of PBDEs than is the case for dioxins and PCBs, for which food is almost the exclusive route of intake. However, food, not dust, appears to be the major route of daily intake of PBDEs." Dr. McDonald agrees that the primary route of exposure to PBDEs for most individuals is currently believed to be from food.

PBDEs in Food

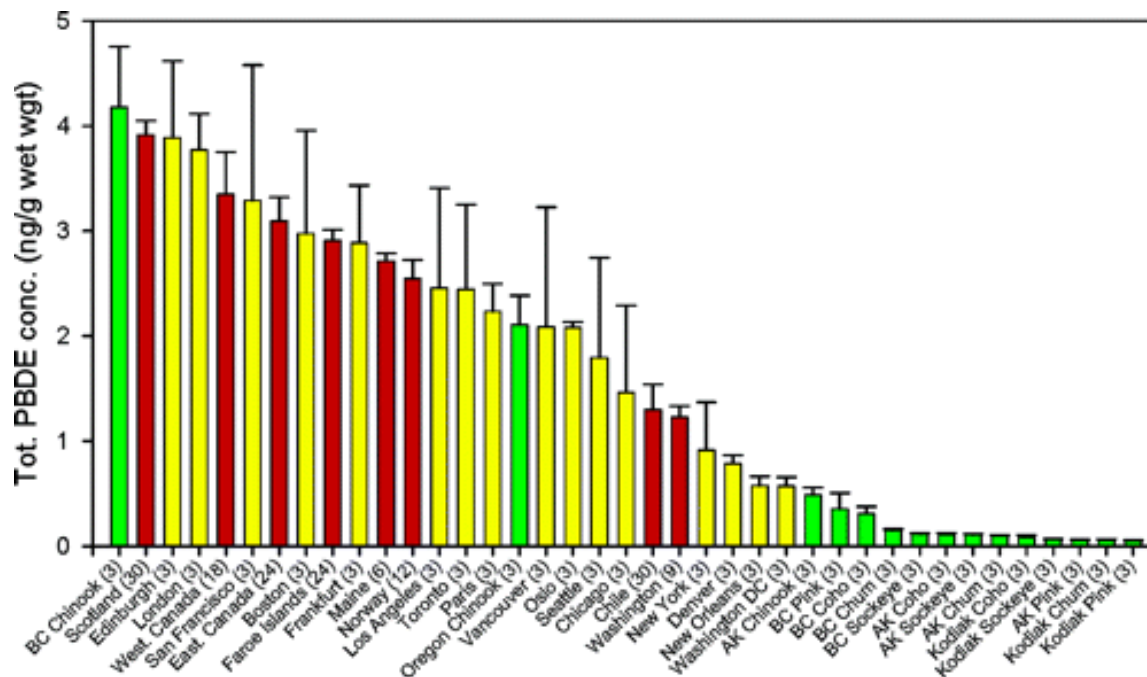
PBDEs are in catfish, salmon, hot dogs and the cheese we put on those dogs. In fact, excluding skim milk, every animal-derived product tested in Dr. Schechter's U.S. study was contaminated with PBDEs, though these levels varied greatly from salmon to evaporated milk, as the following charts show. A 2002 Japanese study in *Chemosphere*

found, "There was a strong positive relationship between PBDE concentrations in human milk and dietary intake of fish and shellfish, which was established in the women from responses to a questionnaire on food consumption habits" [34].

Studies show that farmed salmon and catfish have the highest food levels of penta-BDEs. According to findings by Dr. Hites, this may be because farmed-fish feed is contaminated with flame retardants [16] (see Chart 1). Dr. Hites measured concentrations of PBDEs in 13 samples of salmon feed from two different companies and found the concentrations of PBDEs in the feed to be similar or greater than that in the farmed salmon. Dr. Hites's study measured PBDEs in more than 700 different fish from the top salmon-producing regions in the world, including northern Europe, North America and Chile. As the chart below makes dramatically clear, PBDE levels for most wild fish were only a fraction of those found in farmed fish bought from farms or stores. In fact, 75 percent of wild salmon showed no more than .3 ppb PBDEs (and 50 percent had less than .1 ppb PBDEs), while most farmed and store-bought salmon from Europe and America ranged from 1 to 3 ppb, ten times the wild-caught levels.

Private studies by the fish-farming industry have found similar results, according to Alex Trent of Salmon of the Americas. Chinook salmon was the only wild-caught species with high PBDE levels, possibly, Dr. Hites suggests, because this species eats more fish than other salmon do and grows larger. "It's very similar to what we saw with dioxins, PCBs, dibenzofurans and other organic pollutants," Dr. Schechter says. "There's just a concentration of these in farmed catfish and other farm-grown fish. Usually, farm-grown fish are higher in levels of PCBs, dioxins and brominated flame retardants among the persistent organic pollutants in my experience and from the literature."

Chart 1: PBDE Levels in Salmon [16]



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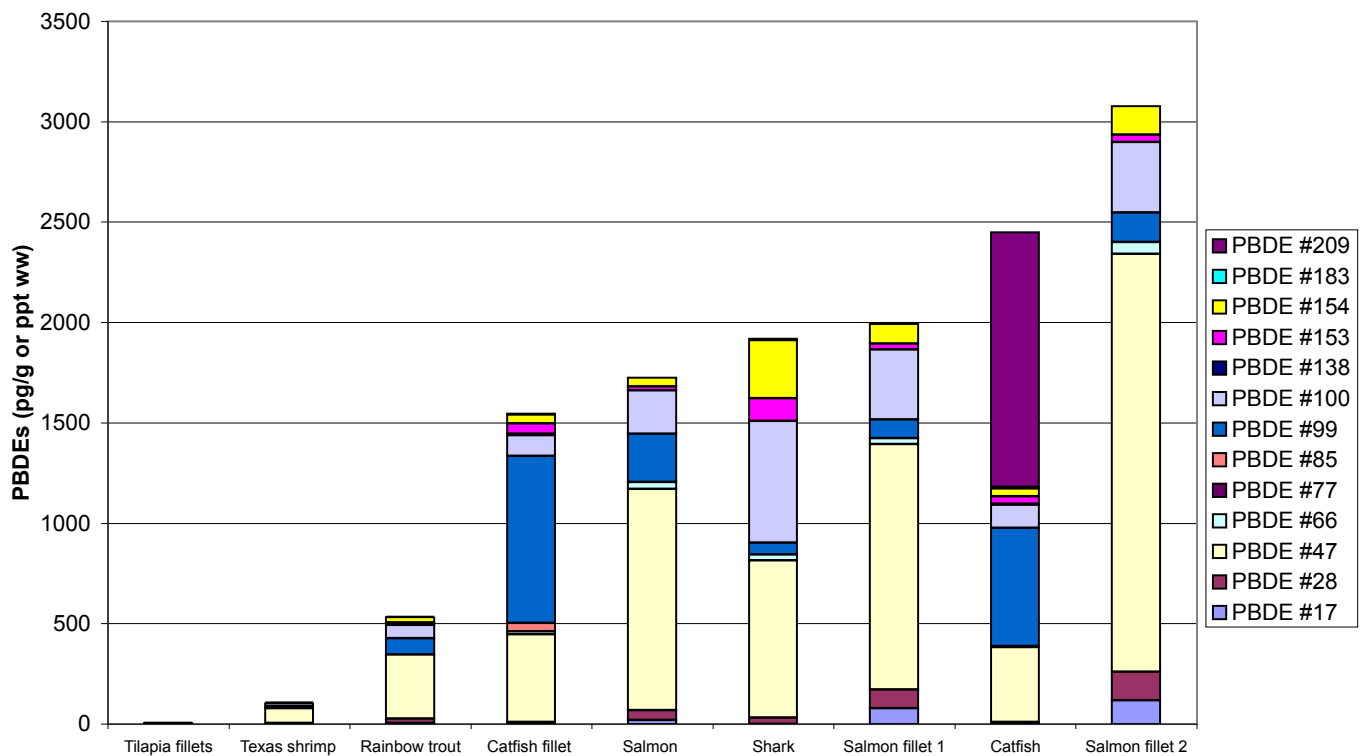
NOTE: red indicates farmed-raised, green indicates wild and yellow indicates supermarket-purchased. The bars represent margin of error.

Schechter’s study is the first U.S. survey of PBDEs in a variety of foods beyond just meat and fish bought at supermarkets, testing samples of 30 different food items to test for PBDEs. While Dr. Schechter is careful to point out that the sample size is currently not large enough to be representative of the U.S. food supply, it can, he says, be used to estimate our possible daily exposures to PBDEs from food. His team is collecting more samples now to make the study more representative.

The study also found greater than expected amounts of deca-BDEs in cheese (.481 ppb) and in a sample of freshwater catfish (1.269 ppb), which Schechter notes “may be a major contributor in some food supplies,” meaning in regions where catfish or cheese are dietary staples. [40] “We’re seeing deca in food and in human samples, and it is the only PBDE still manufactured, so we can expect to see its presence grow in foods,” says Schechter.

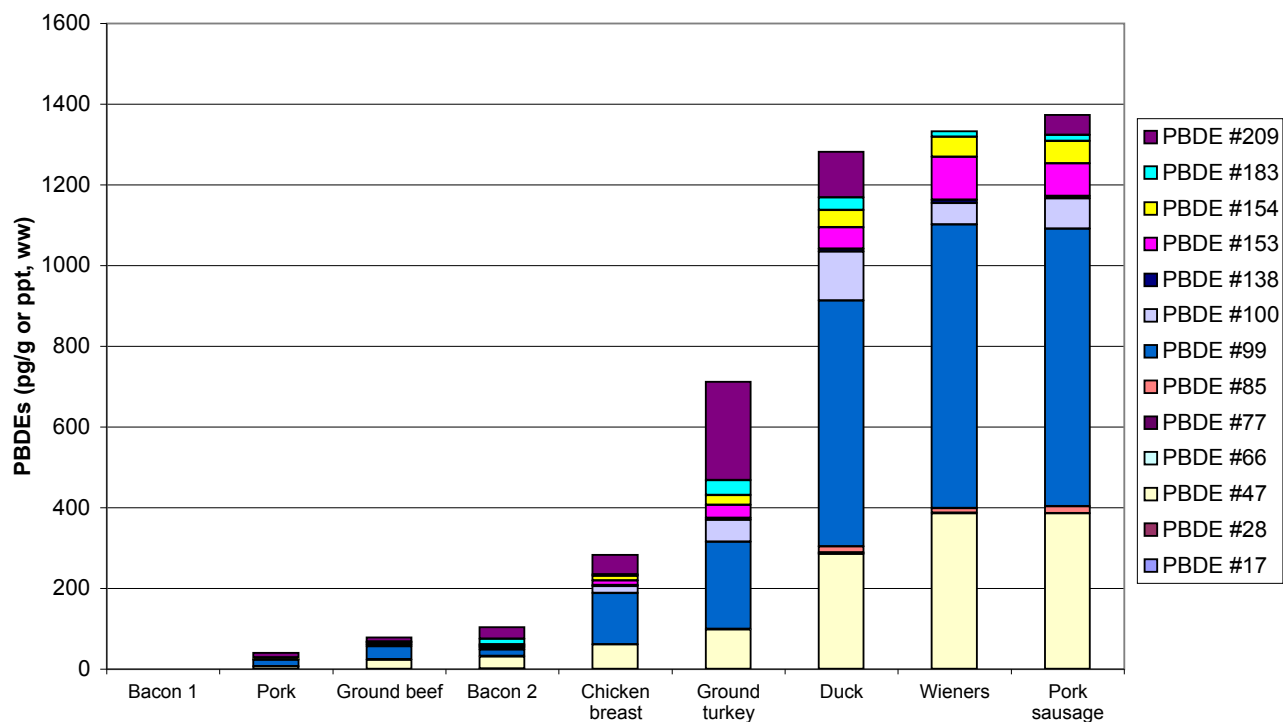
The amounts of PBDEs listed in the charts below, measured in parts per trillion, may seem small, but they add up to daily averages of 2.342 ng/kg BW/day, according the Dr. Schechter. These remain in the body for years, resulting in the levels of PBDEs doubling in Americans’ blood every five years.

Chart 2: PBDE Levels in Selected Fish from Dallas Supermarkets in 2003 [40] (see Appendix 1: Understanding Congeners)



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Chart 3: PBDE Levels in Selected Meat Items from Dallas Supermarkets in 2003 [40]



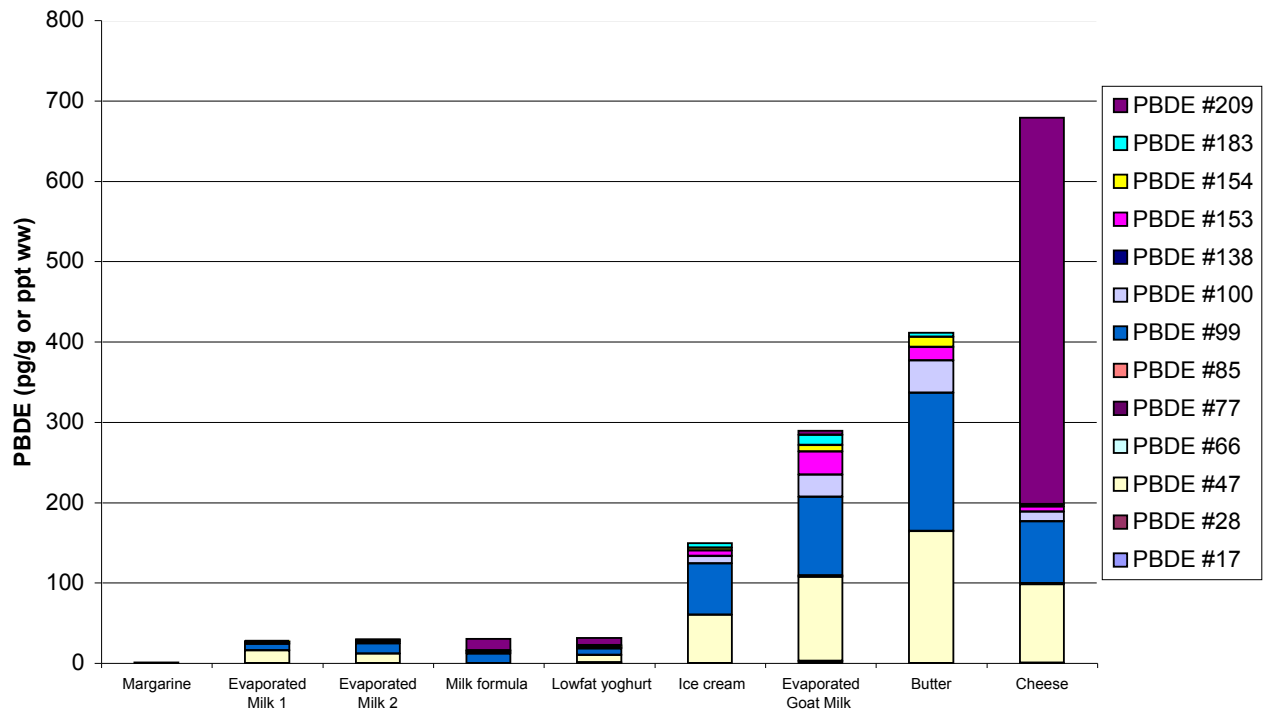
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Fish and meat contain by far the most PBDEs of all food groups in Dr. Schecter's study, and similar findings have been repeated in the U.S., Japan and Spain [23, 18, 34, 4]. Another market-basket study conducted in Sacramento and El Dorado Hills, California, in December 2003 and February 2004 revealed even greater fish contamination, with one wild swordfish fillet measured at PBDEs levels of 4,955 parts per trillion (ppt), almost 2,000 ppt higher than the most contaminated salmon fillet in Schecter's study [23]. But as studies by Dr. Hites, Dr. Schecter and Luksemburg have all shown, farmed fish have higher PBDE levels in almost every case than wild fish [23].

Penta (penta #s 99 and 47, see Congeners in Appendix) PBDE congeners are the main variety found in duck, hot dogs, pork sausage and fish. As noted above, penta-BDEs threaten brain development, learning and sperm counts [26].

Intriguingly, among meats tested in 2004 by Janice Huwe, Ph.D., research chemist at the U.S.DA's Bioscience Research Laboratory, ground beef was one of the least PBDE-contaminated, while pork and fowl had much higher levels. This is contrary to the pattern seen with dioxins, for which cattle tested higher [18]. Dr. Huwe noted that PBDE exposure in cattle might come from a different source than their forage, to which cattle dioxin levels correlate. Alternatively, Dr. Huwe suggests that cattle may be better able to digest and excrete PBDEs than they are dioxins. Unfortunately, this appears not to be the case for people.

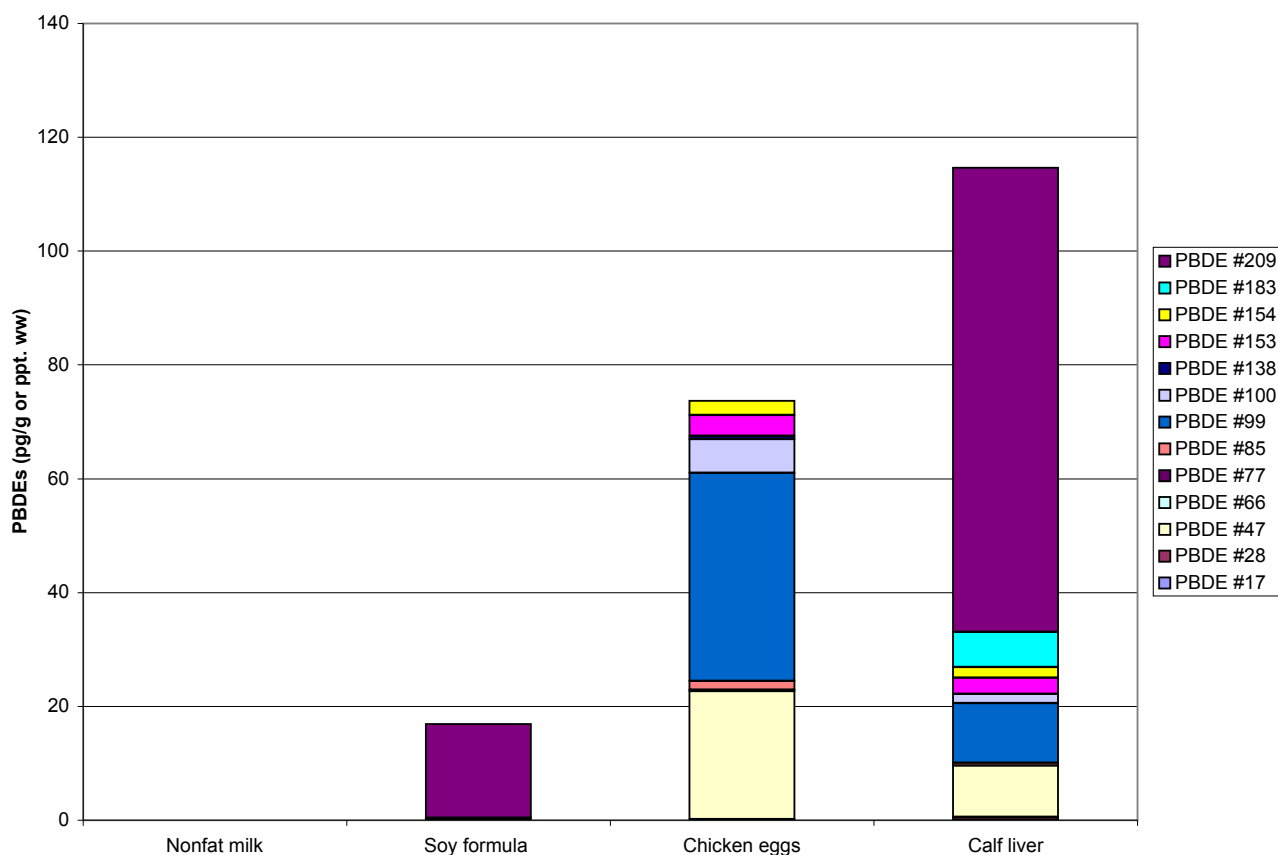
Chart 4: PBDE Levels in Selected Dairy Items from Dallas Supermarkets in 2003 [40]



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High amounts of deca-BDE (PBDE #209) are the most striking aspect in the PBDE levels listed in the dairy chart above. Computer recycling plants have been shown to be major sources of deca-BDE contamination in the bodies of those who work there, but it is not yet known how deca-BDEs are entering the food supply [42].

Chart 5: PBDE Levels in Miscellaneous Items from Dallas Supermarkets in 2003 [40]



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Dr. Schechter was surprised to see PBDEs in soy infant formula, a vegetable-based product. He suggests this may have been due to factory contamination and may not be representative of the U.S. food supply.

Dr. Schechter’s research and that of Drs. Hites and Huwe, highlight the problem of PBDEs in our animal-based foods, the fats of which also often contain PCBs and dioxins. Longer-lived animals (such as swordfish) and those that spend their lives eating (or been fed) other animals showed the greatest bioaccumulations of PBDEs. For this reason, a heart-healthy diet that limits consumption of animal fats is a good way to avoid PBDEs and other POPs. Interestingly, researchers in Japan and Spain did find PBDEs in some vegetables though these were among the lowest levels measured; both studies found fish had the highest levels by far [34, 4]. Of the vegetables with PBDES, potatoes and spinach have also been shown by Environmental Working Group to contain high levels of pesticides such as DDT, so choosing organic varieties is advisable as part of a general healthy diet. See the Solutions section (p. 20) for shopping suggestions.

PBDEs in Products

As the table below indicates, brominated flame retardants have been used in many different commercial products, but a key question remains: How do PBDEs move from products into our food and our bodies?

Table 1: Major PBDEs used in Commercial Products [49]

PBDE	Products
Penta-BDE	flexible polyurethane foam cushioning: upholstered furniture, mattresses, carpet underlayment
Deca-BDE	Hard plastics in computer and television casings, electrical and electronic components, back coatings for synthetic draperies, polyester upholstery fabric

History of PBDE Use in Products

Flame-retardant standards were set by the Consumer Product Safety Commission (CPSC) for mattresses in late 1974, when close to 2,000 Americans died annually in mattress fires. Today, that number has been reduced to just over 300 deaths a year, according to the CPSC, due in part to the very flame-retardant chemicals that are discussed in this report used in mattresses. Public education and the decline in cigarette smoking also may have played a role, since slightly over half of mattress fires are caused by cigarettes (in 1999, out of 330 mattress fire deaths, 160 were caused by smoking [31]). The CPSC standards do not require that any particular flame retardant be used, only that a cigarette left on the mattress will burn out rather than ignite the fabric.

California's furniture regulations (and as of 2005, the state's mattress regulations) had an even more stringent test, requiring that furniture not catch fire when exposed to an open flame. Like CPSC standards, California's are performance standards, leaving it up to furniture manufacturers to select materials and/or chemical additives to pass the open-flame test. Companies selling in the state have to be licensed, and furniture and mattresses must have labels noting the item's filling content and flammability [30]. For most companies, penta-BDEs were the most affordable and readily available solution allowing polyurethane foam to meet these open flame standards. Now that California's Bureau of Home Furnishings has adopted the open-flame standards for mattresses as well, the CPSC is considering changing standards similarly for the entire nation.

Unfortunately, dust tests across the country indicate that flame retardants that were supposed to protect our health are now in household dust and the air we breathe, providing routes for PBDEs to enter and accumulate in our bodies. Out of health concerns, California is now banning penta- and octa-BDEs, and the Great Lakes Chemical Corporation is voluntarily cancelling production of both of these BDEs. To replace penta-BDE, EPA's Design for the Environment Program has completed a draft assessment of 14 alternatives.

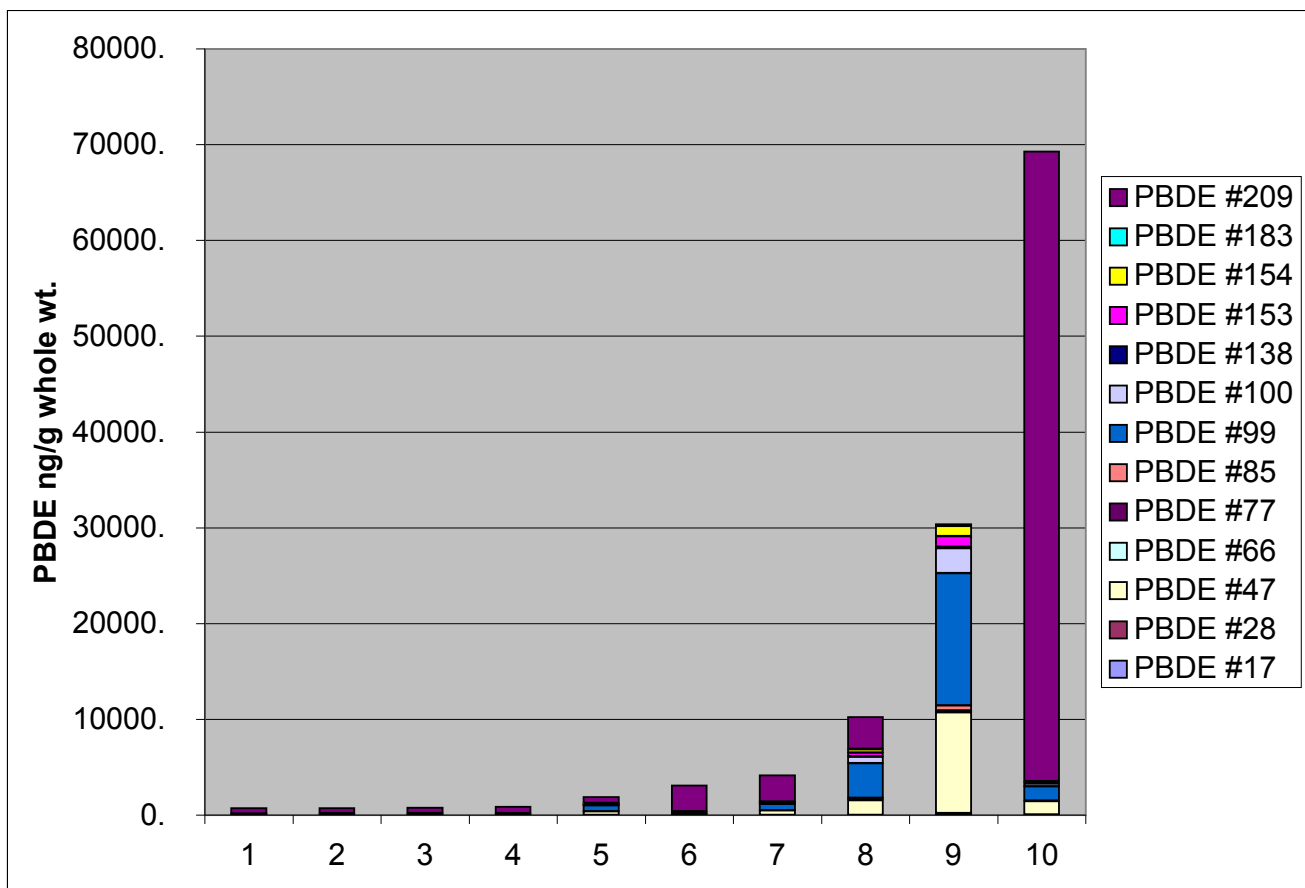
The polyurethane-foam industry insists that its members' products are not responsible for penta-BDEs appearing in household dust across the country. According to Bob Luedeka, associate director of the Polyurethane Foam Association, in a letter to *The Green Guide*, member companies have only used penta-BDEs to a limited extent, and only in California [30]. But as Rajinder Sandeu, a chemist with California's Bureau of Home Furnishings, noted, most other states follow the flammability standards California sets. Studies that sampled dust from houses across North America indicate that penta-BDEs are found in homes from Oregon to Cape Cod. And the presence of polyurethane foam in the household is strongly associated with high levels of contamination [41, 37, 38]. Biomonitoring of PBDE levels in people and wildlife

across the country does not indicate that California is appreciably different from other states, according to Dr. McDonald.

House dust may prove to be the missing link that explains the wide discrepancy in body levels of PBDEs in Europeans and Americans. Dr. Birnbaum says. “Some recent studies show very high levels of PBDE dust in indoor air, which may be a route of exposure,” she adds, referring to, among other studies, Dr. Schecter’s 2005 examination of dust taken from vacuum cleaners and around computers. Other recent studies share findings similar to Dr. Schecter’s [15, 2, 37, 41].

In a test of vacuum-sweeping samples from eight houses in Dallas, Texas, Dr. Schecter found that each contained PBDEs (see chart below) [38]. The amounts of PBDEs “are surprisingly high,” Shecter says. “I would not want my new 3- or 4-month-old granddaughter eventually toddling around a new carpet with these flame retardants on it.”

Chart 6: PBDE Levels in U.S. Household Dust [38]



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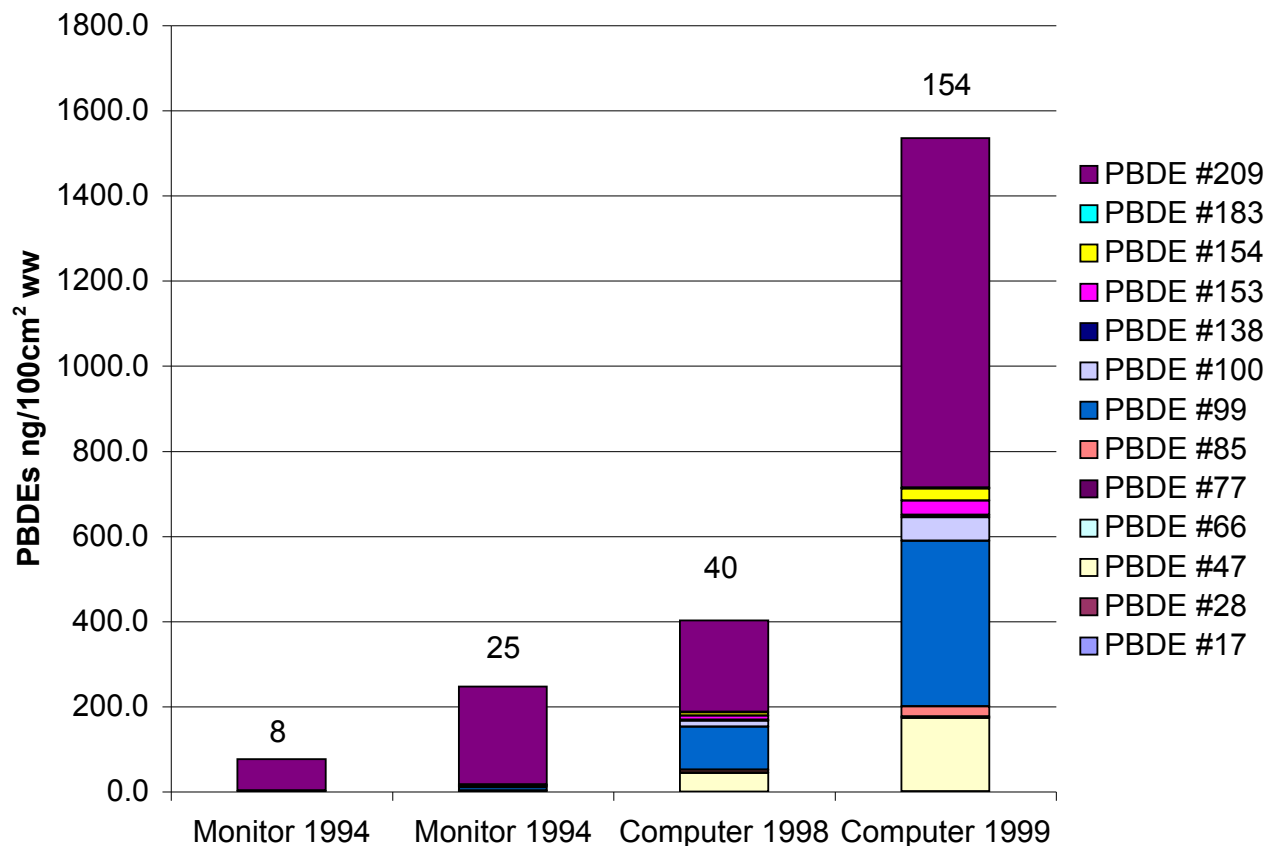
PBDEs Migrating Out of Mattresses, Carpets and Furniture

Approximately 20 to 40 percent of the PBDEs found in Dr. Schecter's study were the penta-variety from polyurethane foam for upholstered furniture, mattresses and carpet underlayments. Although the Great Lakes Chemical Corporation stopped production of penta-BDEs last year, the chemicals will still be sold in furniture until PBDE-laced foam stocks run out and will remain in households containing these furnishings for years to come. Alex Wilson, the executive editor of *Environmental Building News*, recounts, "My wife and I were considering buying a new sofa two weeks ago [December 2004] from a local dealer (in Brattleboro, Vermont). The local furniture store sold a line of sofas made in North Carolina (where most U.S. furniture is made). I expressed concern about the flame retardants, and the local dealer called the furniture maker, who in turn contacted the foam supplier (Carpenter Foam). Carpenter faxed a sheet about its use of penta-PBDE-and why there's nothing wrong with it." Unfortunately, there is.

In a 2004 dust study, the Environmental Working Group found penta-BDEs in household dust across the nation, with highest concentrations appearing in homes in Oregon, Montana and Washington, D.C. The study, *In the Dust*, notes that levels were unexpectedly high in every house sampled, averaging 4,600 ppb [41]. In late 2004, Clean Production Action tested for chemicals in vacuum-cleaner sweepings from 70 U.S. homes (10 homes from 7 states), finding PBDEs in every sample (with an average of 8,900 ppb); deca-BDEs made up 52 percent of the PBDEs found, and the penta mixture made up 46 percent [7].

From 33 to 95 percent of the PBDEs found in Dr. Schecter's nine vacuum samples were from the deca-BDE mix used in computer casings. Deca is the only commercial PBDE still produced, appearing as well in televisions, stereos and other technical equipment. In addition to sampling dust from vacuum sweepings, Dr. Schecter's dust study also examined residues inside the cases of two computer monitors and two desktop computers; not surprisingly, deca-BDE was found to be the most prevalent PBDE.

Chart 7: PBDE Levels in Dust from Computers [38]



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In another 2004 study, the Computer Takeback Campaign and Clean Production Action performed a nationwide study of computer-dust samples, finding PBDEs in the dust around each of the 16 machines tested. Decas prevailed in their sampling, with the highest levels found on the top surface of a new flat screen [27].

The Solutions: How To Reduce Our Personal Exposures To PBDEs Through Safer Consumer Choices

Michele Hammond, referring to the PBDE testing on her family, says, “Before this study was done I didn’t think about what I bought. But now I’m going to ask questions about everything I buy. Next time I buy a couch, I’m going to ask if it has any fire retardants.” Informed consumer choice is essential, but it isn’t always easy to find out if beds, computers or other items are PBDE-free. Manufacturers should, but do not always, include proper labeling of flame retardants in all products—furniture, carpets, mattresses and electronic items. For now, here are practical options for reducing your family’s exposures without breaking the bank.

The answer is not a restrictive diet focused solely on PBDEs but a heart-healthy diet, which, by reducing animal fats, will also lower amounts of PCBs, PBDEs, dioxins and other bioaccumulating, persistent organic pollutants (POPs) in the diet. “The bottom line is, people should eat a heart-healthy diet, and if you do you’ll reduce your exposure to a lot of unhealthy chemicals,” Dr. Birnbaum recommends.

- Eat a diet high in vegetables, fruit and whole grains, choosing organic and locally-grown items from your farmers’ markets and your local store
- Broil, or cut fats from, meat and fish.
- Eat leaner meats and less high-fat dairy foods like cheese, butter and ice cream.
- Choose salmon that is wild-caught rather than farmed. In particular, avoid European farmed salmon, which has the highest levels of PBDEs in farmed fish, as well as high levels of PCBs and dioxins.

- Drink skim milk: it’s PBDE- and dioxin-free. [40]
- And for your heart’s sake, rather than PBDE concerns, avoid trans fatty acids (look for partially hydrogenated vegetable oils on ingredients labels), and cook with mono- and polyunsaturated vegetable oils, such as canola, olive and corn oils.

Feeding Baby

Remember: Breast-feeding is best for your baby’s growth and development. Continue breast-feeding through your child’s first year of life if you can.

Seek out wild salmon. Look for country-of-origin labeling, which is required on fish as of April 2005. This label will tell where fish is from and if it is wild or farmed. Also look for the Marine Stewardship Council’s certification that the fish is truly wild. Remember that wild fresh Alaskan salmon appears in markets between May and September. If in doubt, buy canned salmon, a wild-caught product.

- Ask for leaner cuts and for fat to be removed from meats
- Ask if prepared or processed foods contain trans fatty acids or look for partially hydrogenated vegetable oils on ingredients labels
- Look for certified organic produce, which has been found to contain 2/3 fewer pesticides on average, than conventional food.

See PBDE Smart Shopper’s Card at the end of this report.

For more information on obtaining healthy foods and choosing the right fish, see:

- “Organic Foods: Internet and Mail Order Resources” thegreenguide.com/doc.mhtml?i=93&s=organicfoods
- Smart Shopper’s guides to produce and beef at thegreenguide.com/doc.mhtml?i=99&s=food
- The Meat Product Report for leaner grass-fed beef at thegreenguide.com/reports
- “Fish Story” (GG #103) with Smart Shopper’s Fish Picks Card thegreenguide.com/doc.mhtml?i=103&s=fish. Fish Picks fridge magnets are available for \$3.50 at <https://ssl.thegreenguide.com/cart/docs.mhtml?i=pdfssc>.

There’s no need to fear your foam furnishings unduly. Although scientists know that PBDEs are in household dust, they can’t tell us how much may come from any given item in our homes. Instead, think maintenance: keep dust down, and you’ll reduce your family’s exposures to PBDEs and other contaminants that collect in it.

Use a HEPA filter vacuum that traps fine particles of dust (to which PBDEs bind), soot and pollen, or wet-mop regularly, and keep your home well-ventilated. This will also help reduce concentrations of other forms of indoor air pollution, which for some pollutants (such as petrochemical-based cleaners) can be much greater than outdoor air pollution. For more information, see *The Green Guide’s* product reports on vacuum cleaners and air purifiers at thegreenguide.com/reports.

Carpets

Vacuum regularly and (especially if you have infants at delicate stages of growth) consider gradually replacing carpets and underlayment—this will rid your house of a trap for allergens and a source of PBDEs. Washable throw or area rugs

made from natural fibers are good substitutes for wall-to-wall carpets, which collect dust and chemicals.

For natural fiber rugs:

Rugmark, dedicated to ending child labor in India (rugmark.com, 202-347-4205)

Yayla Tribal Rugs offers wool rugs with natural dyes in traditional Tibetan designs (yayla.com, 617-576-3249)

Eco-Choices sells chemical-free wool rugs with backings made of jute, hemp and cotton (ecobydesign.com, 626-969-3707).

Furniture

Do consider removing worn-out, damaged foam furniture, especially if the foam is exposed, loose and crumbling. Or cover and seal rips in upholstery that expose polyurethane foam. When you buy furniture, consider investing in Forest Stewardship Council-certified wood furniture from well-managed forests. Ask about the composition of seating and back cushions on wood-framed chairs and sofas to make sure they don’t contain chemical flame retardants. Furniture filled and covered with non-synthetic fibers, such as naturally fire retardant wool, makes a good alternative (see below).

Ikea’s products have been PBDE-free since 2001, and now that penta-BDEs are no longer made, many more PBDE-free items will be available. However, since penta production ceased only in 2004, ask salespeople to confirm with the furniture manufacturer that the product is PBDE-free. As Dr. McDonald notes, if you can afford to, wait before buying new, since you’ll have many more PBDE-free furniture options in the years to come.

For PBDE-free upholstered furniture:

Furniture sells custom organic cotton, natural latex and wool upholstered chairs and sofas (furniture.com, 800-326-4895)

Bean Products sells natural latex upholstered chairs and sofas (beanproducts.com, 800-726-8365)

Ikea (ikea-usa.com)

Keep your bedroom well-vacuumed and dusted to reduce PBDE exposures. Check the “Do Not Remove” label on your mattress to see if it contains polyurethane foam. If so, ask the manufacturer whether the foam contains PBDEs and if it does consider purchasing a tightly woven allergen barrier mattress casing to reduce leaching.

Since babies and children, with their developing brains, are most vulnerable, replacing infant crib mattresses with natural-fiber options may be a top priority. When your own mattress is tired, seek out a natural-fiber mattress or futon with a wool wrap acting as a natural fire barrier or choose one of Ikea’s PBDE-free mattresses. Choosing a wool-wrapped mattress that has met California’s Bureau of Home Furnishing’s TB106 “open flame” standard as stated on the mattress tag will give you the safest natural-fiber mattress available.

For PBDE-free mattress and futons:

Lifekind Organic and Naturally Safer Mattresses (lifekind.com, 800-284-4983)

Gaiam’s natural latex mattress with wool topper (gaiam.com, 877-989-6321)

Abundant Earth’s wool and organic cotton futons (abundantearth.com, 888-513-2784)

Ikea (ikea-usa.com)

Mattress encasings and other healthy allergen barrier products:

Allergy Control Products (allergycontrol.com, 800-422-3878)

Gazoontite (sneeze.com, 800-4MY-NOSE)

For more information, see the *Green Guide’s* Carpet, Wood Furniture, Mattress product reports at thegreenguide.com/reports.

What to Ask When Shopping for Furniture, Futons, Mattresses and Pillows:

Ask to see the tag showing what the cushioning is made of and, for safety’s sake, if it’s been certified according to California’s stricter open-flame requirements. If the cushion contains foam, ask what flame retardants it contains. If the store doesn’t know, check the date the product was made (the back of the tag should say). If that date is prior to 2005, there’s a good chance its foam contains PBDEs. With items produced in 2005 and later, if the store doesn’t know what flame retardant it includes, have them contact the manufacturer or see thegreenguide.com for updates.

Computers and Television

Keep your computer and television turned off when not in use to avoid heating up and burning off of flame retardants. The World Health Organization reported in 1994 that carcinogenic chemicals known as dibenzofurans are found in the air around television sets [45]. These toxic POPs, which are similar to dioxins, are formed by deca-BDEs combusting in hot TV sets. Regularly clean your computer, the monitor and nearby surfaces with a cloth.

Vacuum regularly to avoid PBDEs and other pollutants from building up in dust.

When it’s time to retire your old machine, choose a reliable recycler from the list below. For a new computer or television, choose products by Sony, Apple and others below, which have promised to remove PBDEs from their products.

The EPA is currently preparing its Electronic Product Environmental Assessment Tool (EPEAT), procurement guidelines for purchasing more environmentally-friendly electronics. Although they have not yet selected products, nor determined if they will require items to be deca-free, you can see

an overview of the program at peat.net.

Electronics/Tech Companies Removing PBDEs from Products [27]

Apple
Dell
Fujitsu Siemens
Hewlett Packard
Hitachi
IBM
Intel
Matsushita/Panasonic (removing all brominated flame retardants from products by March 31, 2006)
Motorola
NEC
Philips Semiconductors
Sony
Toshiba

Computer Recyclers

IBM will recycle any old PC (IBM or not) for a fee of \$29.99 including shipping (888-SHOP-IBM or ibm.com)

Ebay and the Rethink Initiative offer ways to sell, donate and recycle old computers. See pages.ebay.com/rethink.

Hewlett Packard offers recycling for all brands of computers through its website: hp.com/hpinfo/globalcitizenship/environment/recycle/

Dell recycles old computers, charging a fee for models other than their own: www1.us.dell.com/content/topics/segtopic.aspx/dell_recycling?c=us&s=19&l=en&s=dhs

Per Scholas will recycle computers shipped to the company (perscholas.org, 800-877-4068).

For other recyclers check the National Recycling Coalition's Electronics Recycling Initiative page, nrc-recycle.org/resources/electronics/index.htm

What to Ask When Shopping for Computers and Televisions

Since deca-BDEs will continue to be used in computers and televisions, ask for products designed to reduce or eliminate the need for them. Look for metal cases or those made with inherently flame-resistant plastic, such as Toshiba's polyphenylene sulfide and NEC's biobased plastic [27]. Europe's Restrictions on use of certain Hazardous Substances (RoHS) directive requires that PBDEs, including deca-BDEs, be removed by July 1, 2006 [11]. Although these rules only affect Europe, as noted in a recent article in *The Economist*, electronics manufacturers may not be able to afford to produce two different lines—one for Europe and one for the rest of the world—much to the benefit of rest of the world [9].

John Katz, pollution prevention coordinator at the EPA's San Francisco office, suggests selecting a computer certified by Europe's TCO ecolabel, which requires machines to be deca-BDE free. This takes homework, since the same models are sold in the U.S. but without the TCO label on them. To find one, visit tcodevelopment.com to look up model numbers and ask for one of those models when shopping. Currently, many of Dell's optiplex line are TCO-certified.

Join *The Green Guide* in urging the EPA to include in its EPEAT procurement guidelines the requirement that electronics must have no deca-BDEs. With the heft of government purchasing behind the move to eliminate deca, computer, TV and tech industries will be much more likely to act.

Help protect your family from the threat of fire by making certain your home has a working fire alarm with a functioning battery outside of each bedroom.

Legislation

California has passed legislation banning penta- and octa-BDE from products sold there as of 2006 (voting to move this date ahead from 2008). Maine

and Hawaii will also ban penta- and octa-BDEs by 2006, while Oregon and Illinois are currently looking at targeting deca, says Dr. McDonald. Maine will also ban almost all uses of deca-BDE in 2008, the only state in the nation to do so, although in April 2005 Washington State proposed a law banning all three varieties by 2007 [27]. Even though penta- and octa- are no longer produced, banning is necessary to avoid their use later, particularly in products from countries, like China, with laxer regulatory standards. This state-by-state approach may be the best the U.S. will get, since federal legislation to ban PBDEs died in subcommittee in 2004. "What's most striking to me," notes Dr. Schecter, "is that Congress banned all PCBs, they didn't say 'Let's ban Arachlor 1242 and 1248 but not Arachlor 1254 and Arachlor 1260. To protect the public health we will ban PCB production and use period.' What's happening now with these chemicals that are similar to PCBs is that compromises are being allowed both here and in Europe. The juxtaposition of the two approaches is striking. Maybe there's a reason to say one formulation is more toxic, but that's not what we did in the seventies."

TAKE ACTION: While we should push ahead with urging our federal representatives to ban ALL PBDEs, including deca, we should also urge our state congressional representatives to follow the lead of Maine, California and other states enacting bans on brominated flame retardants. Incremental action will eventually succeed in getting the U.S. Congress to act on this issue. To reach your congressperson, call the Capital Switchboard at 202-244-3121 or visit senate.gov and house.gov.

See also "Take My Computer Back!" for a letter to computer companies encouraging them to catch up to European and Japanese regulatory standards: thegreenguide.com/doc.mhtml?i=int&s=computers.

CONCLUSION

The research of Dr. Schecter and others into the contamination of our foods by PBDEs highlights the prevalence of these and other persistent organic pollutants, such as PCBs and dioxins, in

our environment. Testing shows that they may be approaching dangerous levels in the bodies of Americans.

But as Sweden and other European countries have demonstrated, we can reduce our PBDE levels and protect our children from these chemicals, which have been shown to cause learning and hormonal problems in animals.


The good news is that we have many safer alternative choices. Major steps have already been taken by halting production of penta- and octa-BDEs, but deca-BDEs may pose a similar threat. As consumers, we can demand PBDE-free televisions, computers, furniture and other products, and avoid PBDEs in our food as part of a sensible, healthy diet. We can reduce PBDEs in our household air by simple steps such as vacuuming and covering mattresses and furniture. When shopping, take along the Smart Shopper's card below.

As citizens, we can urge our representatives and regulatory agencies to remove these persistent, bioaccumulating toxins from our environment.

In this way, we can protect our children, care for wildlife and reduce the planet's burden of toxic chemicals

PBDE Smart Shopper's Card

Cut along dotted line



**SMART SHOPPER'S
PBDE Card**

from
THE GreenGUIDE

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◀

**DON'T EAT AND BREATHE TOXIC FLAME RETARDANTS!
HERE'S HOW TO AVOID PBDES:**

Consume fewer animal fats, where PBDEs and other toxins collect.

Eat a heart-healthy diet, high in vegetables, fruit and whole grains.

Broil meat and fish and trim fat.

Eat leaner meats and less high-fat dairy food like cheese, butter, ice cream.

Drink skim-milk: It's PBDE- and dioxin-free.

Keep PBDEs out of house dust: Choose reduced-PBDE electronics/computers.

Sony, Motorola and Intel use no PBDEs.

HP monitors are PBDE-free.

Apple, Canon, Hitachi, Panasonic, NEC and Toshiba have reduced PBDEs.

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Choose PBDE-free furniture.

PBDE-free foam furniture	IKEA (ikea-usa.com) and Berkeley Mills (berkeleymills.com)
PBDE-free natural latex mattresses and cribs	Lifekind (lifekind.com) and Gaiam (gaiam.com)
PBDE-free and natural fiber mattresses and cribs (wool is naturally fire-retardant)	IKEA (ikea-usa.com); Ecobaby (ecobaby.com) Organic Bliss Innerspring Mattress (tomorrowworld.com); Natura Sleep Systems (naturalhomeproducts.com); Natural Aurora Mattress (greenfeet.com)
PBDE-free futons	Gaiam (gaiam.com); Abundant Earth (abundantearth.com); Organic Cotton Alternatives (organiccottonalts.com); Tonkatinkers Kreationen (tonkatinkers.com/futons.htm)

For more information go to www.thegreenguide.com

created 12/30/04

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Appendix 1

PBDE Varieties

PBDEs belong to a family of chemicals known as brominated flame retardants (BFRs). PBDEs come in several varieties based on the number of bromine atoms in the molecule. For example, five bromine atoms are in the penta-BDE variety, eight in octa-BDE and ten in deca-BDE. This chemistry makes a difference: molecules with fewer bromine atoms, such as penta-BDE, are more likely to be absorbed by the body than those with more bromine atoms, and also may have different toxic effects. PBDEs are further categorized as *congeners* (see below).

Table 2: Metric Tons of PBDEs sold per year in the Americas, Europe and Asia (2001)] [17, 5]

	Americas	Europe	Asia	Rest of World	Total
Penta-BDE	7,100	150	150	100	7,500
Octa-BDE	1,500	610	1,500	180	3,790
Deca-BDE	24,500	7,600	23,000	1,050	56,100
TOTAL	33,100	8,360	24,650	1,330	67,390

Understanding PBDE Congeners

When looking at PBDE levels in food or dust, it helps to understand PBDE congeners. Congeners are different molecular forms based on the number and position of the bromine atoms. Since there are 209 different possible versions of PBDE molecules, PBDE mixes such as penta can be made up of several different molecules with one type predominating. The commercial penta mix, for example, is composed mostly (50-60 percent) of penta-BDEs (whose congeners are referred to as 85, 99, 100), along with 20-30 percent tetra-BDEs (congeners 47, 66, 77) and 4-8 percent hexa-BDE (congeners 138, 153,154). It’s important to know these details because when foods and dust are tested, scientists look for the congeners present in them. In most cases, key numbers to watch for are 47 and 99, indicating the penta mix, and 209, indicating the deca mix.

Table 3: Commercial PBDE Mixes, Their Compositions and Congeners [38]

Commercial Name	Composition	Congeners
Penta-BDE	50-60% penta	85, 99, 100
	20-30% tetra	47, 66, 77
	4-8% hexa	138, 153, 154
Octa-BDE	35-37% octa	203
	44% hepta	183
	10-12% hexa	138, 153, 154
	10-11% nona	206, 207, 208
	<1% deca	209
Deca-BDE	97% deca	209
	<3% nona	206, 207, 208
	trace octa	203

Appendix 2

Alternatives to PBDEs

The electronics industry has found that some safer fire retardants are not compatible with plastics, and for this reason design change, shifting from plastic to metal cases as Apple is doing, may be a better choice [27]. Alternatively, Toshiba is working with an “inherently” flame-resistant plastic, polyphenylene sulfide, for its cases. However, companies such as Dow, Bayer AG, GE Plastics and BASF are working with organic phosphorus compounds compatible with plastic casings that don’t generate dioxins and inhibit smoke, including diphenylphosphate (DPK), triphenyl phosphate (TPP), resorcinol-bisdiphenylphosphate (RDP) and bisphenol A diphenyl phosphate (BADP) [27]. Unfortunately, not all of the organic phosphorus compounds are regarded as better for the environment and human health.

As an alternative to the brominated flame retardant TBBPA used in circuit boards, mineral-based fire retardants and reactive phosphoric acid compounds are being evaluated. And Germany has a Green TV project, which is looking into design options and types of thermoplastics that would avoid BFRs.

The German government has provided its own ranking of fire retardants based on their potential for bioaccumulating; chronic and acute toxicity; recyclability; emissions from production, use and disposal; and fire by-products. Those alternatives they find acceptable include: red phosphorus (though this can’t be used with plastic casings), ammonium polyphosphate (AP), used with plastics, and the mineral-retardant aluminum trihydroxide (ATH), also used with plastics.

As for polyurethane foams, melamine cyanurate (MC) is a commonly mentioned substitute for BFRs in Europe, according to Bob Luedeka of the Polyurethane Foam Association. The German government, however, found it could not make a recommendation due to lack of information about human toxicity and evidence that MC has been found in the dust of manufacturing facilities, where it may pose a workplace hazard. Because most foam sold in the U.S. is less dense than that sold in Europe, melamine is not as appropriate, but the EPA's Design for the Environment Program has completed a draft assessment of 14 alternatives.