



# THE POLLUTION WITHIN

Thanks to modern chemistry, eggs don't stick to the pan, underarms are fresh all day, SUVs hit 60 in six seconds. But such convenience has a price: Chemicals that suffuse modern life—from well-known toxins to newer compounds with unknown effects—are building up in our bodies and sometimes staying there for years.

Lead paint chips speckle the gut of a two-year-old Cleveland girl. Phased out decades ago, lead paint is still injuring children who swallow it.



PHOTO OF QUINT: AMELIA DAVIS

**FEAR IN THE AIR** There's no proof that chemicals wafting from an oil refinery triggered breast cancer in three women from Richmond, California. But Marleen Quint, with graphic proof of her ordeal, suspects living in sight of the plant was a factor. "My mother is 79 and has all her body parts," she says. Quint, Wanna Wright, center, and Etta Lundy hope to force the Chevron plant to reduce "flaring" of excess gases.

By **David Ewing Duncan**

Photographs by **Peter Essick**

**My journalist-as-guinea-pig experiment is taking a disturbing turn.**

A Swedish chemist is on the phone, talking about flame retardants, chemicals added for safety to just about any product that can burn. Found in mattresses, carpets, the plastic casing of televisions, electronic circuit boards, and automobiles, flame retardants save hundreds of lives a year in the United States alone. These, however, are where they should not be: inside my body.

Åke Bergman of Stockholm University tells me he has received the results of a chemical analysis of my blood, which measured levels of flame-retarding compounds called polybrominated diphenyl ethers. In mice and rats, high doses of PBDEs interfere with thyroid function, cause reproductive and neurological problems, and hamper neurological development. Little is known about their impact on human health.

“I hope you are not nervous, but this concentration is very high,” Bergman says with a light Swedish accent. My blood level of one particularly toxic PBDE, found primarily in U.S.-made foam pads, mattresses, and furniture, is 10 times the average found in a small study of U.S. residents and more than 200 times the average in Sweden. The news about another PBDE variant—also toxic to animals—is nearly as bad. My levels would be high even if I were a worker in a factory making the stuff, Bergman says.

In fact I’m a writer engaged in a journey of chemical self-discovery. Last fall I had myself tested for 320 chemicals I might have picked up from food, drink, the air I breathe, and the products that touch my skin—my own secret stash of compounds acquired by merely living. It includes older chemicals that I might have been exposed to decades ago, such as DDT and PCBs; pollutants like lead, mercury, and dioxins; newer pesticides and plastic ingredients; and

the near-miraculous compounds that lurk just beneath the surface of modern life, making shampoos fragrant, pans nonstick, and fabrics water-resistant and fire-safe.

The tests are too expensive for most individuals—National Geographic paid for mine, which would normally cost around \$15,000—and only a few labs have the technical expertise to detect the trace amounts involved. I ran the tests to learn what substances build up in a typical American over a lifetime, and where they might come from. I was also searching for a way to think about risks, benefits, and uncertainty—the complex tradeoffs embodied in the chemical “body burden” that swirls around inside all of us.

**Now I’m learning more than I really want to know.**



AUTHOR DAVID EWING DUNCAN COOKS BREAKFAST AT HOME.  
ON THE MENU: PBDES, PHTHALATES, PCBS, AND A SIDE OF PFAS.

**Bergman wants to get to the bottom of my flame-retardant mystery. Have I recently bought new furniture or rugs? No.** Do I spend a lot of time around computer monitors? No, I use a titanium laptop. Do I live near a factory making flame retardants? Nope, the closest one is over a thousand miles away. Then I come up with an idea.

“What about airplanes?” I ask.

“Yah,” he says, “do you fly a lot?”

“I flew almost 200,000 miles last year,” I say. In fact, as I spoke to Bergman, I was sitting in an airport waiting for a flight from my hometown of San Francisco to London.

“Interesting,” Bergman says, telling me that he has long been curious about PBDE exposure inside airplanes, whose plastic and fabric interiors are drenched in flame retardants to meet safety standards set by the Federal Aviation Administration and its counterparts overseas. “I have been wanting to apply for a grant to test pilots and flight attendants for PBDEs,” Bergman says as I hear my flight announced overhead. But for now the airplane connection is only a hypothesis. Where I picked up this chemical that I had not even heard of until a few weeks ago remains a mystery. And there’s the bigger question: How worried should I be?

The same can be asked of other chemicals I’ve absorbed from air, water, the nonstick pan I used to scramble my eggs this morning, my faintly scented shampoo, the sleek curve of my cell phone. I’m healthy, and as far as I know have no symptoms associated with chemical exposure. In large doses, some of these substances, from mercury to PCBs and dioxins, the notorious contaminants in Agent Orange, have horrific effects (“A World of Hurt,” page 139). But many toxicologists—and not just those who have ties to the chemical industry—insist that the minuscule smidgens of chemicals inside us are mostly nothing to worry about.

“In toxicology, dose is everything,” says Karl Rozman, a toxicologist at the University of Kansas Medical Center, “and these doses are too low to be dangerous.” One part per billion (ppb), a standard unit for measuring most chemicals inside us, is like putting half a teaspoon of red dye into

an Olympic-size swimming pool. What’s more, some of the most feared substances, such as mercury, dissipate within days or weeks—or would if we weren’t constantly re-exposed.

Yet even though many health statistics have been improving over the past few decades, a few illnesses are rising mysteriously. From the early 1980s through the late 1990s, autism increased ten-fold, one type of leukemia was up 62 percent, male birth defects doubled, and childhood brain cancer was up 40 percent. Some experts suspect a link to the manmade chemicals that pervade our food, water, and air. There’s little firm evidence. But over the years, one chemical after another that was thought to be harmless turned out otherwise once the facts were in.

The classic example is lead. In 1970 the U.S. Surgeon General declared that lead levels of 40 micrograms per deciliter of blood were safe. It’s now known that any detectable lead can cause neurological damage in children, shaving off IQ points. From DDT to PCBs, the chemical industry has released compounds first and discovered damaging health effects later. Regulators have often allowed a standard of innocent until proven guilty in what Leo Trasande, a pediatrician and environmental health specialist at Mount Sinai Hospital in New York City, calls “an uncontrolled experiment on America’s children.”

Each year the U.S. Environmental Protection Agency reviews an average of 1,700 new compounds that industry is seeking to introduce. Yet the 1976 Toxic Substances Control Act requires that they be tested for any ill effects before approval only if evidence of potential harm exists—which is seldom the case for new chemicals. The agency approves about 90 percent of the new compounds without restrictions. Only a quarter of the 82,000 chemicals in use in the U.S. have ever been tested for toxicity.

Until recently, no one had even measured average levels of exposure among large numbers of ordinary Americans. No regulations required it, the tests are expensive, and technology sensitive enough to measure tiny levels didn’t exist.

Last year the Centers for Disease Control and Prevention took a step toward closing that gap when it released data on 148 substances that



**EVERYDAY EXPOSURE** Ruby Alcorn, three, inhales fire-retarding chemicals in dust from fabrics, furniture, and other home products—adding to the dose she took in as a breast-fed baby. Another class of chemicals, called phthalates, is added to plastics, including some food wraps (right), for pliability. Both can cause developmental problems in lab animals, even in the low doses people encounter.



ranged from DDT and other pesticides to metals, PCBs, and plastic ingredients, measured in the blood and urine of several thousand people. The study said little about health impacts on the people tested or about how they might have encountered the chemicals. “The good news is that we are getting real data about exposure levels,” says James Pirkle, the study’s lead author. “This gives us a place to start.”

**I began my own chemical journey on an October morning at the Mount Sinai Hospital in New York City,** where I gave urine and had blood drawn under the supervision of Leo Trasande. Trasande specializes in childhood

exposures to mercury and other brain toxins. He had agreed to be one of several expert advisers on this project, which began as a Sinai phlebotomist extracted 14 vials of blood—so much that at vial 12 I felt woozy and went into a cold sweat. At vial 13 Trasande grabbed smelling salts, which hit my nostrils like a whiff of fire and allowed me to finish.

From New York my samples were shipped to Axys Analytical Services on Vancouver Island in Canada, one of a handful of state-of-the-art labs specializing in subtle chemical detection, analyzing everything from eagle’s eggs to human tissue for researchers and government agencies. A few weeks later, I followed my samples to



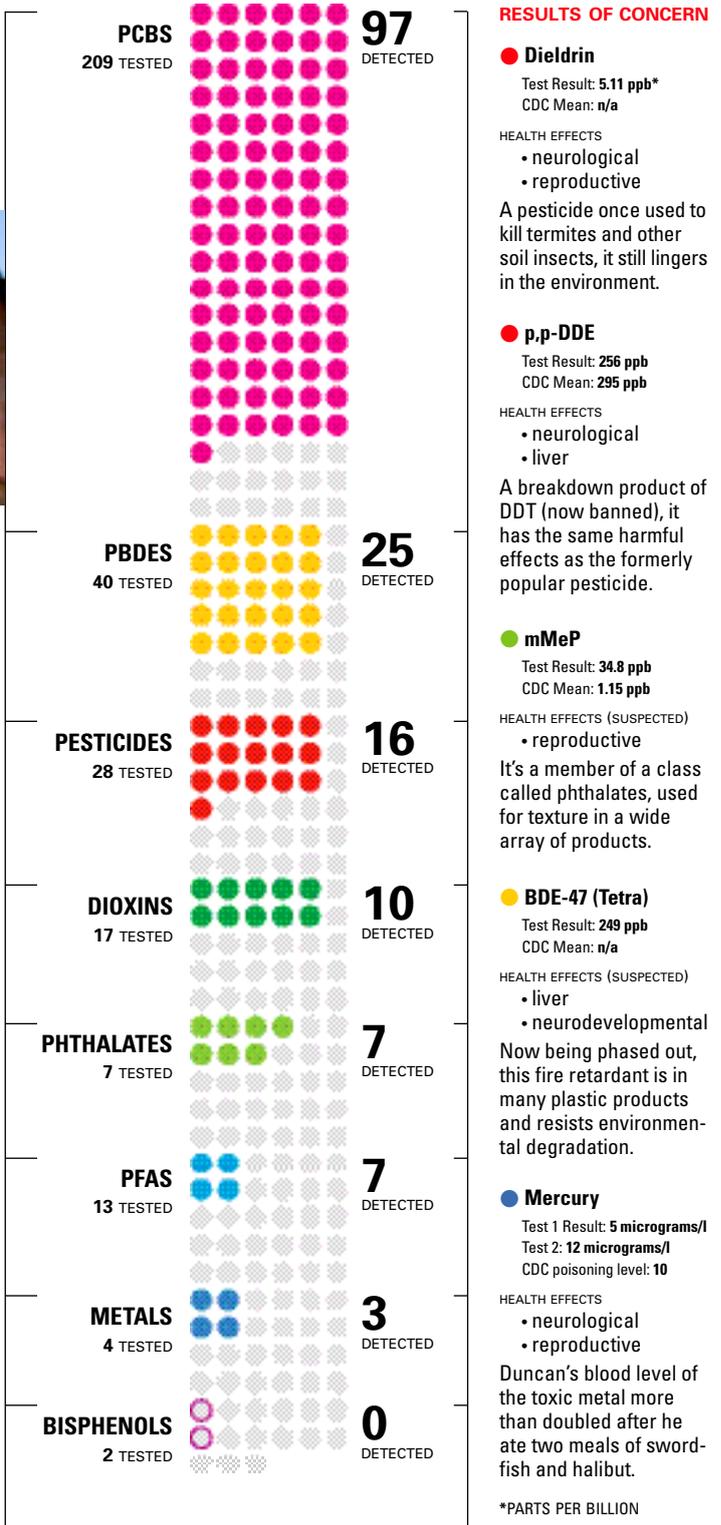
**YOU ARE THE EXPERIMENT** Want a formaldehyde hit? Apply the wrong cologne on a summer day. "Suddenly, there's chemistry going off all around your head," says University of Texas environmental engineer Richard Corsi. To test the "near-head environment," Corsi applies products similar to those shown and sticks his head in the box. Even natural fragrances can react with ozone in the air to make toxins.

# OUR AUTHOR'S CHEMICAL REPORT CARD



What's inside David Ewing Duncan? To find out, he submitted to a huge battery of blood and urine tests to detect traces of industrial chemicals, dangerous metals, and pollutants he has picked up over a lifetime. As it turns out, Duncan can go toe-to-toe with a mid-western corn field for pesticide variety—16 of the 26 tested for were found. Don't try to set him on fire either, as his blood is rich in PBDE-47, a common fire retardant. Does this make Duncan a freak of the chemical age? Hardly. In fact there may be nothing unusual about his chemical profile. Many of his results were no higher than the CDC mean levels for Americans. So what's in you?

320 CHEMICALS TESTED | 165 CHEMICALS DETECTED



Canada to see how Axys teased out the tiny loads of compounds inside me.

I watched the specimens go through multiple stages of processing, which slowly separated sets of target chemicals from the thousands of other compounds, natural and unnatural, in my blood and urine. The extracts then went into a high-tech clean room containing mass spectrometers, sleek, freezer-size devices that work by flinging the components of a sample through a vacuum, down a long tube. Along the way, a magnetic field deflects the molecules, with lighter molecules swerving the most. The exact amount of deflection indicates each molecule's size and identity.

A few weeks later, Axys sent me my results—a grid of numbers in parts per billion or trillion—and I set out to learn, as best I could, where those toxic traces came from.

Some of them date back to my time in the womb, when my mother downloaded part of her own chemical burden through the placenta and the umbilical cord. More came after I was born, in her breast milk.

Once weaned, I began collecting my own chemicals as I grew up in northeastern Kansas, a few miles outside Kansas City. There I spent countless hot, muggy summer days playing in a dump near the Kansas River. Situated on a high limestone bluff above the fast brown water lined by cottonwoods and railroad tracks, the dump was a mother lode of old bottles, broken machines, steering wheels, and other items only boys can fully appreciate.

This was the late 1960s, and my friends and I had no way of knowing that this dump would later be declared an EPA superfund site, on the National Priority List for hazardous places. It turned out that for years, companies and individuals in this corner of Johnson County had dumped thousands of pounds of material contaminated with toxic chemicals here. "It was started as a landfill before there were any rules and regulations on how landfills were done," says Denise Jordan-Izaguirre, the regional representative for the federal Agency for Toxic Substances and Disease Registry. "There were metal tailings and heavy metals dumped in there. It was

unfenced, unrestricted, so kids had access to it." Kids like me.

Now capped, sealed, and closely monitored, the dump, called the Doepke-Holliday Site, also happens to be half a mile upriver from a county water intake that supplied drinking water for my family and 45,000 other households. "From what we can gather, there were contaminants going into the river," says Shelley Brodie, the EPA Remedial Project Manager for Doepke. In the 1960s, the county treated water drawn from the river, but not for all contaminants. Drinking water also came from 21 wells that tapped the aquifer near Doepke.

**When I was a boy, my corner of Kansas was filthy, and the dump wasn't the only source of toxins.** Factories owned by Ford, Colgate-Palmolive, the Kansas Power and Light Company, Bayer CropScience, and many others lined the river a few miles away. When we drove past the plants toward downtown Kansas City, we plunged into a noxious cloud that engulfed the car with smoke and an awful chemical stench. Flames rose from fertilizer plant stacks, burning off mustard-yellow plumes of sodium, and raw sewage poured into the river. In the nearby farmland, trucks and crop dusters sprayed DDT and other pesticides in great, puffy clouds that we kids sometimes rode our bikes through, holding our breath and feeling very brave.

Today the air is clear, and the river free of effluents—a visible testament to the success of the U.S. environmental cleanup, spurred by the Clean Air and Clean Water Acts of the 1970s. But my Axys test results read like a chemical diary from 40 years ago. My blood contains traces of several chemicals now banned or restricted, including DDT (in the form of DDE, one of its breakdown products) and other pesticides such as the termite-killers chlordane and heptachlor. The levels are about what you would expect decades after exposure, says Rozman, the toxicologist at the University of Kansas Medical Center. My childhood playing in the dump, drinking the water, and breathing the polluted air could also explain some of the lead and dioxins in my blood, he says.

**I went to college at a place and time that put me at the height of exposure for another set of chemicals** found inside me—

PCBs, once used as electrical insulators and heat-exchange fluids in transformers and other products. PCBs can lurk in the soil anywhere there's a dump or an old factory. But some of the largest releases took place along New York's Hudson River from the 1940s to the 1970s, when General Electric used PCBs at factories in the towns of Hudson Falls and Fort Edward. About 140 miles downstream is the city of Poughkeepsie, where I attended Vassar College in the late 1970s.

PCBs, oily liquids or solids, can persist in the environment for decades. In animals, they impair liver function, raise blood lipids, and cause cancers. Some PCBs—there are 209 of them—chemically resemble dioxins and cause other mischief in lab animals: reproductive and nervous system damage, as well as developmental problems. By 1976, the toxicity of PCBs was unmistakable; the United States banned them, and GE stopped using them. But until then, GE legally dumped excess PCBs into the Hudson, which swept them all the way downriver to Poughkeepsie, one of eight cities that draw their drinking water from the Hudson.

In 1984, a 200-mile stretch of the Hudson, from Hudson Falls to New York City, was declared a superfund site, and plans to rid the river of PCBs were set in motion. GE has spent 300 million dollars on the cleanup so far, dredging up and disposing of PCBs in the river sediment under the supervision of the EPA. It is also working to stop the seepage of PCBs into the river from the factories.

Birds and other wildlife along the Hudson are thought to have suffered from the pollution, but its impact on humans is less definitive. One study in Hudson River communities found a 20 percent increase in the rate of respiratory diseases, while another, more reassuringly, found no increase in cancer deaths in the contaminated region. But among many of the locals, the fear is palpable.

"I grew up a block from the Fort Edward plant," says Dennis Prevost, a retired Army officer

and public health advocate, who blames PCBs for the brain cancers that killed his brother at age 46 and a neighbor in her 20s. "The PCBs have migrated under the parking lot and into the community aquifer," which Prevost says was the source of Fort Edward's drinking water until municipal water replaced wells in 1984.

Ed Fitzgerald of the State University of New York at Albany, a former staff scientist at the state department of health, is conducting the most thorough study yet of the health effects of PCBs in the area. He says he has explained to Prevost and other residents that the risk from the wells was probably small because PCBs tend to settle to the bottom of an aquifer. Eating contaminated fish caught in the Hudson is a more likely exposure route, he says.

I didn't eat much Hudson River fish during my college days in the 1970s, but the drinking water in my dorm could have contained traces of the PCBs pouring into the river far upstream. That may be how I picked up my PCB body burden, which was about average for an American. Or maybe not. "PCBs are everywhere," says Leo Rosales, a local EPA official, "so who knows where you got it."

**Back home in San Francisco, I step into my shower, which is loaded with a newer generation of industrial chemicals—**

compounds that are not banned, and, like flame retardants, are increasing year by year in the environment and in my body. Lathering my hair, I'm probably exposing myself to bisphenol A, an ingredient in plastics from shampoo containers to shower curtains. Bisphenol A causes reproductive system abnormalities in animals. My levels were so low they were undetectable—a rare moment of relief in my toxic odyssey.

And that faint lavender scent as I wash out the suds? Credit it to phthalates, molecules that dissolve fragrances, thicken lotions, and add flexibility to PVC, vinyl, and some intravenous tubes in hospitals. The dashboards of most cars are loaded with phthalates, and so is some plastic food wrap. Heat and wear can release phthalate molecules, and humans swallow them or absorb them through the skin. Because they dissipate

**GANTLET OF FRESHNESS** A whiff of household products sends Betty Kreeger into fits of wheezing, nausea, and confusion. Like other multiple chemical sensitivity sufferers, she flees fragrances when she can and dons an air-filtering mask when she can't.



after a few minutes to a few hours in the body, most people's levels fluctuate during the day.

Like bisphenol A, phthalates disrupt reproductive development in mice. An expert panel convened by the National Toxicology Program recently concluded that although the evidence so far doesn't prove that phthalates pose any risk to people, it does raise "concern," especially about potential effects on infants. "We don't have the data in humans to know if the current levels are safe," says Antonia Calafat, a CDC phthalates expert. I scored higher than the mean in five out of seven phthalates tested. One of them, monomethyl phthalate, came in at 34.8 ppb, in the top 5 percent for Americans—perhaps, says Leo Trasande, because I gave my urine sample in the morning, just after I had showered and washed my hair.

My inventory of household chemicals also includes PFAs—tough, chemically resistant compounds that go into making nonstick and stain-resistant coatings. 3M also used them in its Scotchgard protector products until it found that the specific PFA compounds in Scotchgard

were escaping into the environment and phased them out. In animals these chemicals damage the liver and thyroid and cause birth defects and perhaps cancer, but not much is known about them in humans.

Long-range pollution left its mark on my results as well: My blood contained low, probably harmless, levels of dioxins, which escape from paper mills, certain chemical plants, and incinerators. Out in the environment, dioxins settle on soil and in the water, then pass into the food chain. They build up in animal fat, and most people pick them up from meat and dairy products.

And then there is mercury, a neurotoxin that can permanently impair memory, learning centers, and behavior. Coal-burning power plants are a major source of mercury, sending it out their stacks into the atmosphere, where it disperses in the wind, falls in rain, and eventually washes into lakes, streams, or oceans. There bacteria transform it into a compound called methylmercury, which moves up the food chain after plankton absorb it from the water and are



**NOT SAFE AT HOME** When Christine Larson was six months old, her blood lead was over twice the level the government says is safe; even lower levels can reduce IQ, stunt growth, and cause behavior problems. The vintage Cleveland-area house her parents had recently bought had lead paint, illegal for residential use since 1978. The lead sources are now gone, and Christina is “smart as a whip,” her mother says.

eaten by small fish. Large predatory fish at the top of the marine food chain, like tuna and swordfish, accumulate the highest concentrations of methylmercury—and pass it on to seafood lovers.

For people in northern California, mercury exposure is also a legacy of the gold rush a century and a half ago, when miners used quicksilver, or liquid mercury, to separate the gold from other ores in the hodgepodge of mines in the Sierra Nevada. Over the decades, streams and groundwater washed mercury-laden sediment out of the old mine tailings and swept it into San Francisco Bay.

I don’t eat much fish, and the levels of mercury in my blood were modest. But I wondered what would happen if I gorged on large fish for a meal or two. So one afternoon I bought some halibut and swordfish at a fish market in the old Ferry Building on San Francisco Bay, both caught in the ocean just outside the Golden Gate. That night I ate the halibut with basil and a dash of soy sauce; I downed the swordfish for breakfast with eggs (cooked in my nonstick pan).

Twenty-four hours later I had my blood drawn and retested, and the effect of those old mines was plain to see: My level of mercury had more than doubled, from 5 micrograms per liter to a higher-than-recommended 12. Mercury at 70 or 80 micrograms per liter is dangerous for adults, says Leo Trasande, and much lower levels can affect children. “Children have suffered losses in IQ at 5.8 micrograms.” He advises me to avoid repeating the gorge experiment.

**It’s a lot harder to dodge the PBDE flame retardants responsible for the most worrisome of my test results.** My world—and yours—has become saturated with them since they were introduced about 30 years ago.

Scientists have found the compounds planetwide, in polar bears in the Arctic, cormorants in England, and killer whales in the Pacific. Bergman, the Swedish chemist, and his colleagues first called attention to potential health risks in 1998 when they reported an alarming increase in PBDEs in human breast milk, from none in milk preserved in 1972 to an average of four ppb in 1997.

The compounds escape from treated plastic and fabrics in dust particles or as gases that cling to dust. People inhale the dust; infants crawling



**SEEKING PURITY** At a spa in Maharishi Vedic City, Iowa, John Moore (above) hopes to speed the elimination of PCBs, which are stored in fat for years. Technicians ply him with oils in a purification process based on Indian ayurveda tradition. At a Marin County, California, mall (right) teens taking part in the Campaign for Safe Cosmetics show off makeup free of chemicals linked to cancer and birth defects.



on the floor get an especially high dose. Bergman describes a family, tested in Oakland, California, by the *Oakland Tribune*, whose two small children had blood levels far higher than mine. When he and his colleagues summed up the test results for all PBDE forms, they found total levels of 390 ppb in the five-year-old girl and 650 ppb—twice my total—in the 18-month-old boy.

In 2001, researchers in Sweden fed young mice a PBDE mixture similar to one used in furniture and found that they did poorly on tests of learning, memory, and behavior. Last year, scientists at Berlin's Charité University Medical School reported that pregnant female rats with PBDE levels no higher than mine gave birth to

male pups with impaired reproductive health.

Linda Birnbaum, an EPA expert on these flame retardants, says that humans would probably start seeing detrimental effects at about four times the baby boy's level. She says I shouldn't worry. Bergman isn't so sure, and he says that in a pregnant woman my levels would be of concern. "Any level above 100 parts per billion is a risk to newborns," he guesses. Neither he nor Birnbaum really know for sure.

Any margin of safety may be narrowing. In a review of several studies, Ronald Hites of Indiana University found an exponential rise in people and animals, with the levels doubling every three to five years. Now the CDC is putting a

comprehensive study of PBDE levels in the U.S. on a fast track, with results due out late this year. Pirkle, who is running the study, says my seemingly extreme levels may no longer be out of the ordinary. "We'll let you know," he says.

Given the stakes, why take a chance on these chemicals? Why not immediately ban them? In 2004, Europe did just that for the penta- and octa-BDEs, which animal tests suggest are the most toxic of the compounds. California will also ban these forms by 2008, and in 2004 Chemtura, an Indiana company that is the only U.S. maker of pentas and octas, agreed to phase them out. Currently, there are no plans to ban the much more prevalent deca-BDEs. They reportedly break down more quickly in the environment and in people, although their breakdown products may include the same old pentas and octas.

Nor is it clear that banning a suspect chemical is always the best option. Flaming beds and airplane seats are not an inviting prospect either. The University of Surrey in England recently assessed the risks and benefits of flame retardants in consumer products. The report concluded: "The benefits of many flame retardants in reducing the risk from fire outweigh the risks to human health."

Except for some pollutants, after all, every industrial chemical was created for a purpose. Even DDT, the arch-villain of Rachel Carson's 1962 classic book *Silent Spring*, which launched the modern environmental movement, was once hailed as a miracle substance because it killed the mosquitoes that carry malaria, yellow fever, and other scourges. It saved countless lives before it was banned in much of the world because of its toxicity to wildlife. "Chemicals are not all bad," says Scott Phillips, a medical toxicologist in Denver. "While we have seen cancer rates rise," he says, "we also have seen a doubling of the human lifespan in the past century."

The key is knowing more about these substances, so we are not blindsided by unexpected hazards, says California State Senator Deborah Ortiz, chair of the Senate Health Committee and the author of a bill to monitor chemical exposure. "We benefit from these chemicals,

but there are consequences, and we need to understand these consequences much better than we do now." Sarah Brozena of the industry-supported American Chemistry Council, thinks safeguards are adequate now, but she concedes: "That's not to say this process was done right in the past."

The European Union last year gave initial approval to a measure called REACH—Registration, Evaluation, and Authorization of Chemicals—which would require companies to prove the substances they market or use are safe, or that the benefits outweigh any risks. The bill, which the chemical industry and the U.S. government oppose, would also encourage companies to find safer alternatives to suspect flame retardants, pesticides, solvents, and other chemicals. That would give a boost to the so-called green chemistry movement, a search for alternatives that is already under way in laboratories on both sides of the Atlantic.

**As unsettling as my journey down chemical lane was, it left out thousands of compounds, among them pesticides,** plastics, solvents, and a rocket-fuel ingredient called perchlorate that is polluting groundwater in many regions of the country. Nor was I tested for chemical cocktails—mixtures of chemicals that may do little harm on their own but act together to damage human cells. Mixed together, pesticides, PCBs, phthalates, and others "might have additive effects, or they might be antagonistic," says James Pirkle of the CDC, "or they may do nothing. We don't know."

Soon after I receive my results, I show them to my internist, who admits that he too knows little about these chemicals, other than lead and mercury. But he confirms that I am healthy, as far as he can tell. He tells me not to worry. So I'll keep flying, and scrambling my eggs in Teflon, and using that scented shampoo. But I'll never feel quite the same about the chemicals that make life better in so many ways.

○ **Home sick home** Learn about the toxins we encounter every day in an interactive graphic, and explore related links at [ngm.com/0610](http://ngm.com/0610).

# OUR TOXIC HOMES

We can't run home to escape chemicals that infiltrate our bodies. Our dwellings are rife with them—some clearly toxic, others only suspected of being harmful.

## PBDEs

### They stop fires but stay around in people

● Polybrominated diphenyl ethers (PBDEs), used as flame retardants, are building up rapidly in people's bodies. They cause developmental problems in lab animals. The most worrisome of these compounds have been phased out, but the PBDE varieties still used in the U.S. may also be harmful.

**HOW TO AVOID**  
PBDEs are found in many appliances and some fabrics, and are unavoidable.

## PHthalates

### The chemical additive for all seasons

● These chemicals have a huge array of uses, from making baby chew toys soft to giving lotions the right consistency. In lab animals, they have caused problems in the sexual development of males, and recent human studies suggest that the same things might be happening to baby boys.

**HOW TO AVOID**  
A few cosmetics companies have made a point of shunning them, but there are myriad sources of exposure.

## PEsticides

### They're harming more than just the bugs

● Some, like DDT, have been banned, while others, such as atrazine, are restricted. But the list of those still commonly in use for killing everything from household roaches to exotic crop fungi is long, and researchers have linked some to asthma and neurological, developmental, and immunological problems.

**HOW TO AVOID**  
Wash produce well, or buy organic. In agricultural areas, limit buildup at home by frequent vacuuming.

## PFA's

### Convenient but maybe carcinogenic

● Used in scratch- and stain-resistant coatings, they take years for the body to eliminate. The 3M Corporation phased out one type, perfluorooctane sulfonate (PFOS), the main ingredient of Scotchgard, after it was found to pervade the global environment. Another type, perfluorooctane acid (PFOA), is still used in fabrics and to make nonstick pans and is a suspected carcinogen.

**HOW TO AVOID**  
Found in air, water, and food, they are unavoidable.

## PCBs

### Long banned, they are still around

● Polychlorinated biphenyls (PCBs) were wonder substances. Hard to set aflame, they were common coolants and insulators in electrical systems. Their durability has a dark side: They don't break down in the environment, and they build up in animal and human tissues. The effects include liver damage and cancer in lab animals.

**HOW TO AVOID**  
Now banned, they remain pervasive. Avoid eating fish or game from areas known to be contaminated.

## DIOXINS

### Industrial by-product, presidential poison

● Similar in toxicity to PCBs, dioxins result from industrial activities and fires. They enter the food chain in contaminated areas and build up in plant and animal fats. Deliberately tainted soup may have been the vehicle used to poison Ukrainian President Victor Yushchenko, leaving his face disfigured. Cancer and birth defects are among other likely dioxin effects.

**HOW TO AVOID**  
Avoid fatty meats and areas known to be contaminated.

## BISPHEenols

### Hormones in your water bottle

● Polycarbonate plastics, found in some rigid plastic bottles, are made with bisphenol-A, a synthetic estrogen that may leach into liquid over time as the plastic degrades. Researchers have found evidence in lab animals that these estrogen mimics may cause reproductive harm to male and female fetuses.

**HOW TO AVOID**  
Avoid hard plastic bottles. That may not eliminate all risk if, as some research suggests, background levels are now high enough to be harmful.

## METALS

### Deadly poisons hiding in plain sight

● Toxic metals are some of the most common industrial poisons in the home. Old paint contains lead, fish like tuna contains mercury, and your pressure-treated deck can expose your family to arsenic. The effects on young children can be profound, ranging from subtle developmental delays to death.

**HOW TO AVOID**  
Remove or seal up old paint and pressure-treated lumber. Pregnant women and children should be cautious about eating certain fish.



## BEDROOM / BATHROOM

- PBDEs: Foam mattress and pillows, chair cushions, hair dryer, telephone
- PESTICIDES: Antimicrobial soap, pet flea collar
- METALS: Old lead paint
- PHthalates: Shower curtain, nail polish, shampoo, perfume, deodorants, lotion, soap, hair spray, medicines, vinyl flooring, toothpaste, plastic bath toys

## LIVING ROOM

- PBDEs: Couch cushions, chair cushions, electronics (TV, computer), carpets and carpet padding, electronic games, pet bed
- BISPHEenols: Plastic baby bottle
- PHthalates: Extension cords, vinyl wallpaper and blinds
- PESTICIDES: Tracked indoors, drifting in window, on pet flea collar
- PFA's: Furniture fabric, microwave popcorn bag



## KITCHEN / DINING ROOM

- PHthalates: Plastic containers and bottles, some food wraps, vinyl flooring
- DIOXINS: Fatty meats, dairy products, fish
- PCBs: Food
- METALS: Mercury-contaminated fish
- BISPHEenols: Plastic containers, lining of canned foods
- PFA's: Nonstick pans
- PBDEs: Coffee maker, blender, microwave, toaster

## OUTDOORS

- METALS: Pressure-treated wood table (arsenic and chromium), power plant emissions (mercury)
- PESTICIDES: On lawn and garden
- DIOXINS: Grilled fatty meats and fish
- PHthalates: Water bottles, lawn furniture, garden hose, vinyl toys, roof membrane with PVC, outdoor extension cord with PVC
- PBDEs: TV, boom box

ART BY BONNIE TIMMONS



More than the roar of motorbikes fills the air in Ho Chi Minh City, Vietnam, where bicyclists are now a minority. There's also acrid smoke, or as toxicologists would say, polycyclic aromatic hydrocarbons (PAHs): chemicals from incompletely burned fuel that can cause cancer in lab animals.



For most of us, environmental chemicals come in tiny doses, and any harm is hard to discern. But accidents and contaminated hotspots can deluge people with toxins. The effects are anything but subtle.

## A WORLD OF HURT

**For most people, tiny residues of pesticide in food are a nagging worry.** But for banana plantation workers in Central America during the 1970s and 1980s, pesticide exposure had devastating consequences. A chemical called DBCP, used to control root worms, left as many as 30,000 men sterile for life.

This is the dark side of industrial chemistry, which gives us convenient products and abundant food but exacts a human cost. The cost is never more apparent than when accidents or chemical “hot spots” expose people to pesticides, heavy metals, and other substances at levels many times higher than most of us experience. The victims are often the world’s poor and powerless—people who live close to the smokestacks and dumps and work in the riskiest jobs. Tragic in themselves, these high exposures also raise troubling questions about the much smaller, parts-per-billion traces we all pick up in daily life (“The Pollution Within,” page 116).

To find out whether or not these chemical traces are dangerous, scientists give high doses to animals, looking for threshold levels at which signs of toxicity appear and trying to understand the nature of the damage. But extreme human exposures also provide clues. “These tragedies provide us with information that comes from people,” says John Osterloh, chief medical officer for the National Center for Environmental Health at the U.S. Centers for Disease Control.

Wake-up calls about the dangers of methylmercury, the form of mercury found in water and seafood, came decades ago from accidents and hot spot exposures. In a notorious case from the 1950s, 68 people living on Japan’s Minamata Bay died and hundreds suffered brain damage after eating fish contaminated with mercury dumped by a nearby chemical plant. In 1971-72,

**WAR VICTIM?** A young girl lies helpless in a Ho Chi Minh City facility for children thought to be victims of the dioxin-containing defoliant Agent Orange, with which the United States contaminated large areas of Vietnam. She suffers from Fraser syndrome, a genetic disorder marked by deformities including fused eyelids and digits. It can’t be definitely linked to dioxin, but the Vietnamese are convinced.

**This is the dark side of industrial chemistry. The victims are often the world's poor and powerless—people who live close to the smokestacks and dumps and work in the riskiest jobs.**

at least 459 people died and 6,500 were hospitalized in Iraq during a famine, when they ate bread made from seed grain that had been treated with a methylmercury-containing fungicide to hold down mold growth. The seeds were safe to plant, but not to eat. In Denmark's Faroe Islands, where people eat whale meat and fish containing high levels of mercury, studies of the cognitive development of children born to mercury-exposed women helped other countries set standards for safe levels of mercury.

Tragedy has also provided graphic evidence of the dangers of dioxin, a pollutant emitted by burning wood and trash and generated by chemical plants. During the Vietnam War, U.S. forces sprayed millions of acres of jungle with Agent Orange, which stripped foliage from trees. The spray was tainted with dioxin, a by-product of the manufacturing process. Over the years, people living in the defoliated areas and soldiers who applied the Agent Orange or marched through afterwards have developed cancer and diabetes in unusual numbers. In 1976, a tank exploded in a chemical factory in Seveso, Italy, releasing a cloud of dioxin that led to a long-term increase in cancer among the 37,000 people exposed. These disasters helped prompt measures that reduced dioxin emissions from U.S. and European factories by more than half.

Related to dioxins are PCBs, once so widely used as coolants and electrical insulators that the U.S. was producing 85 million pounds a year in the mid-1970s. By then, however, the warning signs were hard to ignore. In 1968 thousands of people on the island of Kyushu, Japan, had eaten rice oil contaminated with PCBs during manufacture. Nearly 1800 fell ill, and 112 died of acute

poisoning, cancer, and other ailments. Children born to the victims had immune system and developmental problems. News of disaster and a drumbeat of reports about PCB contamination of water, food, and wildlife alarmed the public, and the U.S. banned the compounds in 1977.

Toxic exposures aren't always due to accidents or ignorance about a chemical's true dangers. The U.S. banned the pesticide DBCP in 1977 after such heavy use that traces still linger in groundwater across much of the country. Yet Central America's banana growers continued to apply it for years, and workers there still spray toxic pesticides without protective clothing or masks.

In 1987, 6 percent of paid banana workers in Costa Rica acknowledged a pesticide accident, the highest rate of reported on-the-job accidents in the world, according to the World Health Organization. Injuries included head pains, dizziness, faintness, burns, eye inflammation, and respiratory problems. Today workers in the developing world continue to be exposed to chemicals banned in the U.S. and Europe, and to toxic waste and pollution at levels unacceptable in the developed world.

For newer chemicals, such as the phthalates found in cosmetics and plastics and the flame retardants in fabrics and electronics, headline-grabbing accidents and worker poisonings are rare—perhaps because safety measures have improved, or because the chemicals are not as acutely toxic as older compounds. Whether they are less harmful in the long run is not clear.

Scott Philips, a medical toxicologist in Denver, cautions against comparing the effects of high doses with the smidgens inside us. "Any substance, even seemingly harmless ones, can be dangerous in certain quantities and under the right circumstances," he says. Leo Trasande, a toxicologist at Mount Sinai Hospital in New York City, thinks it can be equally risky to ignore the lessons from high exposures. "The extreme cases show us what can happen," he says.

While science searches for answers, one thing is certain: The known horrors inflicted by high doses of chemicals make the small amounts inside each of us even more unsettling.

—David Ewing Duncan



**HEALTHY CROP** To raise tobacco fit for export cigars, workers at a Nicaragua farm (above) waded through clouds of fungicide. A few days after falling ill from fumes, sprayer Medardo Bellorini (below, washing off chemicals after work) was back in the fields. Pesticides have been linked to cancer and endocrine and nervous system disorders.





**UNDER DARK CLOUDS** A rustic brick kiln in San Luis Potosí, Mexico (left), belches black smoke at brick makers, who sustain invisible damage with each day of work. The smoke is rich in PAHs from incompletely burned wood and oil used to heat the furnace. Scientists have documented DNA damage in some children at the site, likely caused by toxic exposure.

Along with pollution from decades of PCB production in their city, Anniston, Alabama, residents learned in recent years of another hazard: decommissioned chemical weapons at a nearby military depot. Sha-Nekia Pittman and her daughter, Tikyia Jackson (above), practice donning government-issued gas masks, their sole defense against a leak. j