BodyBurden

The Pollution in People.

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EXECUTIVE SUMMARY

In a study led by Mount Sinai School of Medicine in New York, in collaboration with the Environmental Working Group and Commonweal, researchers at two major laboratories found 167 chemicals, pollutants, and pesticides in the blood and urine of nine adult Americans. Study results appear in a recently-published edition of the journal *Public Health Reports* (Thornton, et al. 2002) – the first publicly available, comprehensive look at the chemical burden we carry in our bodies.

Scientists have not studied the health risks of exposures to complex chemical mixtures, such as those found in this study.

None of the nine volunteers works with chemicals on the job. All lead healthy lives. Yet the subjects contained an average of 91 compounds each – most of which did not exist 75 years ago.

Scientists have not studied the health risks of exposures to complex chemical mixtures, such as those found in this study. For two-thirds of the chemicals found, many of which are banned, researchers have partially studied the extent to which these chemicals can harm human health. They have found that these 112 compounds can threaten nearly every organ in the body at every stage of life (Table 1).

In total, the nine subjects carried:

- 76 chemicals linked to cancer in humans or animals (average of 53),
- 94 chemicals that are toxic to the brain and nervous system (average of 62),
- 86 chemicals that interfere with the hormone system (average of 58),
- 79 chemicals associated with birth defects or abnormal development (average of 55),
- 77 chemicals toxic to the reproductive system (average of 55), and
- 77 chemicals toxic to the immune system (average of 53).

The blood and urine from the nine volunteers were tested for 210 chemicals that can be divided into seven basic groups (Table 2). Of the chemical groups tested, the most prevalent were those contained in 24 classes of semivolatile and volatile chemicals, with 77 detected. These classes include well-known industrial solvents and gasoline ingredients, such as xylene and ethyl benzene, that are used in a variety of common products like paints, glues, and fire retardants. The laboratory found 48

Table 1: The chemicals we found are linked to serious health problems

Average number found in 9 people	Health Effect or Body System Affected	Total found in all 9 people	Range (lowest and highest number found in all 9 people)
53	cancer [1]	76 [2]	36 to 65
55	birth defects / developmental delays	79 [3]	37 to 68
5	vision	11 [4]	4 to 7
58	hormone system	86 [5]	40 to 71
59	stomach or intestines	84 [6]	41 to 72
54	kidney	80 [7]	37 to 67
62	brain, nervous system	94 [8]	46 to 73
55	reproductive system	77 [9]	37 to 68
55	lungs/breathing	82 [10]	38 to 67
56	skin	84 [11]	37 to 70
42	liver	69 [12]	26 to 54
55	cardiovascular system or blood	82 [13]	37 to 68
34	hearing	50 [14]	16 to 47
53	immune system	77 [15]	35 to 65
47	male reproductive system	70 [16]	28 to 60
42	female reproductive system	61 [17]	24 to 56

* Some chemicals are associated with multiple health impacts, and appear in multiple categories in this table.
Source: Environmental Working Group compilation.

FOOTNOTES

[1] Chemicals listed as linked to cancer are those classified by the National Toxicology Program as "known" human carcinogens, or "reasonably anticipated" to be human carcinogens; or those classified by the Environmental Protection Agency as "known" or "probable" human carcinogens.

[2] Cancer: 3 heavy metals, 1 phthalate, 9 organochlorine pesticides, 8 furans, 7 dioxins and 48 PCBs

[3] Birth defects / developmental delays: 4 heavy metals, 2 phthalates, 7 organochlorine pesticides, 8 furans, 7 dioxins, 48 PCBs and 3 other semivolatile or volatile organic compounds

[4] Vision: 1 heavy metal, 1 phthalate, 2 organochlorine pesticides and 7 other semivolatile or volatile organic compounds

[5] Hormone system: 4 heavy metals, 5 phthalates, 3 organophosphate pesticides and metabolites, 9 organochlorine pesticides, 8 furans, 7 dioxins, 48 PCBs and 2 other semivolatile or volatile organic compounds

[6] Stomach or intestines: 3 heavy metals, 3 phthalates, 2 organophosphate pesticides and metabolites, 9 organochlorine pesticides, 8 furans, 7 dioxins, 48 PCBs and 4 other semivolatile or volatile organic compounds

[7] Kidney: 4 heavy metals, 5 phthalates, 3 organochlorine pesticides, 8 furans, 7 dioxins, 48 PCBs and 5 other semivolatile or volatile organic compounds

[8] Brain, nervous system: 4 heavy metals, 4 phthalates, 7 organophosphate pesticides and metabolites, 9 organochlorine pesticides, 8 furans, 7 dioxins, 48 PCBs and 7 other semivolatile or volatile organic compounds

[9] Reproductive system: 4 heavy metals, 2 phthalates, 8 organochlorine pesticides, 8 furans, 7 dioxins and 48 PCBs

[10] Lungs/breathing: 4 heavy metals, 3 phthalates, 2 organophosphate pesticides and metabolites, 5 organochlorine pesticides, 8 furans, 7 dioxins, 48 PCBs and 5 other semivolatile or volatile organic compounds

[11] Skin: 3 heavy metals, 5 phthalates, 2 organophosphate pesticides and metabolites, 4 organochlorine pesticides, 8 furans, 7 dioxins, 48 PCBs and 7 other semivolatile or volatile organic compounds

[12] Liver: 4 heavy metals, 6 phthalates, 3 organochlorine pesticides, 48 PCBs and 8 other semivolatile or volatile organic compounds

[13] Cardiovascular system or blood: 4 heavy metals, 2 phthalates, 2 organophosphate pesticides and metabolites, 7 organochlorine pesticides, 8 furans, 7 dioxins, 48 PCBs and 4 other semivolatile or volatile organic compounds

[14] Hearing: 1 heavy metal, 48 PCBs and 1 other semivolatile or volatile organic compound

[15] Immune system: 4 heavy metals, 1 phthalate, 6 organochlorine pesticides, 8 furans, 7 dioxins, 48 PCBs and 3 other semivolatile or volatile organic compounds

[16] Male reproductive system: 4 heavy metals, 5 phthalates, 2 organochlorine pesticides, 7 dioxins, 48 PCBs and 4 other semivolatile or volatile organic compounds

[17] Female reproductive system: 2 heavy metals, 2 phthalates, 1 organochlorine pesticide, 7 dioxins, 48 PCBs and 1 other semivolatile or volatile organic compound

PCBs in the nine people tested. PCBs were banned in the United States in 1976 but are used in other countries and persist in the environment for decades. Their most common use was as an insulating fluid in electrical capacitors and transformers, vacuum pumps, and gas-transmission turbines. Lead was found in all 9 participants, and methylmercury was found in 8.

Health professionals are not trained to link health problems to an individual's chemical exposure, but it is increasingly evident that background exposures to industrial chemicals and pesticides are contributing to a portion of the steady increase in some health problems in the population. A number of significant health effects potentially linked to chemical exposures are increasingly prevalent:

- *Cancer*. Between 1992 and 1999, cancer incidence increased for many forms of the disease, including breast, thyroid, kidney, liver, skin and some forms of leukemia. The incidence of childhood cancer increased by 26 percent between 1975 and 1999, with the sharpest rise estimated for brain and other nervous system cancers (50 percent increase) and acute lymphocytic leukemia (62 percent increase). The incidence of testicular cancer also rose between 1973 and 1999 (NCI 2002). The probability that a US resident will develop cancer at some point in his or her lifetime is 1 in 2 for men and 1 in 3 for women (ACS 2001). Just 5 to 10 percent of all cancers are linked to inherited, genetic factors (ACS 2001). For the remainder, a broad array of environmental factors plays a pivotal role.

  We found 76 carcinogens in nine people. On average, each study participant contained 53 chemical carcinogens.

- *Major nervous system disorders*. Several recent studies have determined that the reported incidence of autism may be increasing, and is now almost 10 times higher than in the mid-1980's (Byrd 2002, Chakrabarti and Fombonne 2001, CDC 2000, Yeargin-Allsopp et al. 2003, Bertrand et a. 2001). The number of children being diagnosed and treated for attention deficit disorder (ADD) and attention deficit hyperactivity disorder (ADHD) has also increased dramatically in the past decade (Robison, et al. 1999, Robison, et al. 2002, Zito, et al. 2000). The causes are largely unexplained, but environmental factors, including chemical exposures, are considered a potential cause or contributor. Environmental factors have also been

It is increasingly evident that background exposures to industrial chemicals and pesticides are contributing to a portion of the steady increase in some health problems in the population.

increasingly linked with Parkinson's disease (Checkoway and Nelson 1999, Engel, et al. 2001).

We found 94 chemicals toxic to the nervous system in nine people. On average, each study participant contained 62 nervous system toxicants.

- *Defects of the reproductive system*. Studies show that sperm counts in certain parts of the world are decreasing (Swan, et al. 2000, Toppari, et al. 1996). Scientists have measured significant regional differences in sperm count that cannot be explained by differences in genetic factors (Swan, et al. in press). Girls may be reaching puberty earlier, based on comparing current appearance of breast development and pubic hair growth with historical data (Herman-Giddens, et al. 1997). Incidence of hypospadias, a birth defect of the penis, doubled in the United States between 1970 and 1993, and is estimated to affect one of every 125 male babies born (Paulozzi, et al. 1997). The incidence of undescended testicles (cryptorchidism) and testicular cancer also appear to be rising in certain parts of the world (Bergstrom, et al. 1996, McKiernan, et al. 1999, Toppari, et al. 1996). Testicular cancer is now the most common cancer in men age 15 to 35 (NCI, 2000). Several studies have suggested links between developmental exposure to environmental contaminants and cryptorchidism or testicular cancer (Hardell, et al. in press, Hosie, et al. 2000, Toppari, et al. 1996, Weidner, et al. 1998).

  We found 77 chemicals linked to reproductive damage in nine people. On average the nine subjects contained 55 reproductive toxicants.

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Toxic effects do not require high doses

Hundreds of studies in the peer-reviewed literature show that adverse health effects from low dose exposures are occurring in the population, caused by unavoidable contamination with PCBs, DDT, dioxin, mercury, lead, toxic air pollutants, and other chemicals. The health effects scientists have linked to chemical exposures in the general population include premature death, asthma, cancer, chronic bronchitis, permanent decrements in IQ and declines in other measures of brain function, premature birth, respiratory tract infection, heart disease, and permanent decrements in lung capacity (EPA 1996, EPA 2000, Gauderman, et al. 2002, Jacobson and Jacobson 2002, Jacobson, et al.

2002, Kopp, et al. 2000, Longnecker, et al. 2001, NAS 2000, NTP 2002, Pope, et al. 2002, Salonen, et al. 1995, Sydbom, et al. 2001).

A growing body of literature links low dose chemical exposures in animal studies to a broad range of health effects previously unexplored in high dose studies. In low dose testing, scientists are using sophisticated techniques to measure subtle but important changes in the functioning of apparently undamaged organ systems, including alterations in immune function (such as antibody response), enzyme activity, hormone levels, cellular changes in tissues, neurobehavioral parameters, organ growth, and hormone and neurotransmitter receptor levels. Importantly, many low dose effects are detected following developmental exposure. These tests focus on the effects of chemical exposures comparable to those that occur in the general population, and far below the levels that have traditionally been considered safe based on the results of studies that feed lab animals high doses

Table 2: 167 compounds from seven chemical groups were found in the nine people tested

	Number of chemicals tested for in all 9 people	Total number of chemicals found in people tested	Average number of chemicals found in people tested	Range of chemical concentrations found in people tested
PCBs	73	48	33	57,290 to 455,790 pg/g in blood lipid
Dioxins and furans	17	15	14	15.7 to 36.6 pg/g TEQ in blood lipid
Organophosphate pesticide metabolites	9	7	3	
Organochlorine pesticides and metabolites	23	10	4	615 to 3084 ug/L in urine
Phthalates	6	6	4	97.2 to 904.8* ug/g in blood lipid
Other semivolatile and volatile chemicals (24 classes)	77	77	31	not quantified
Metals	5	4	2	varies by metal
Total	210	167	91	

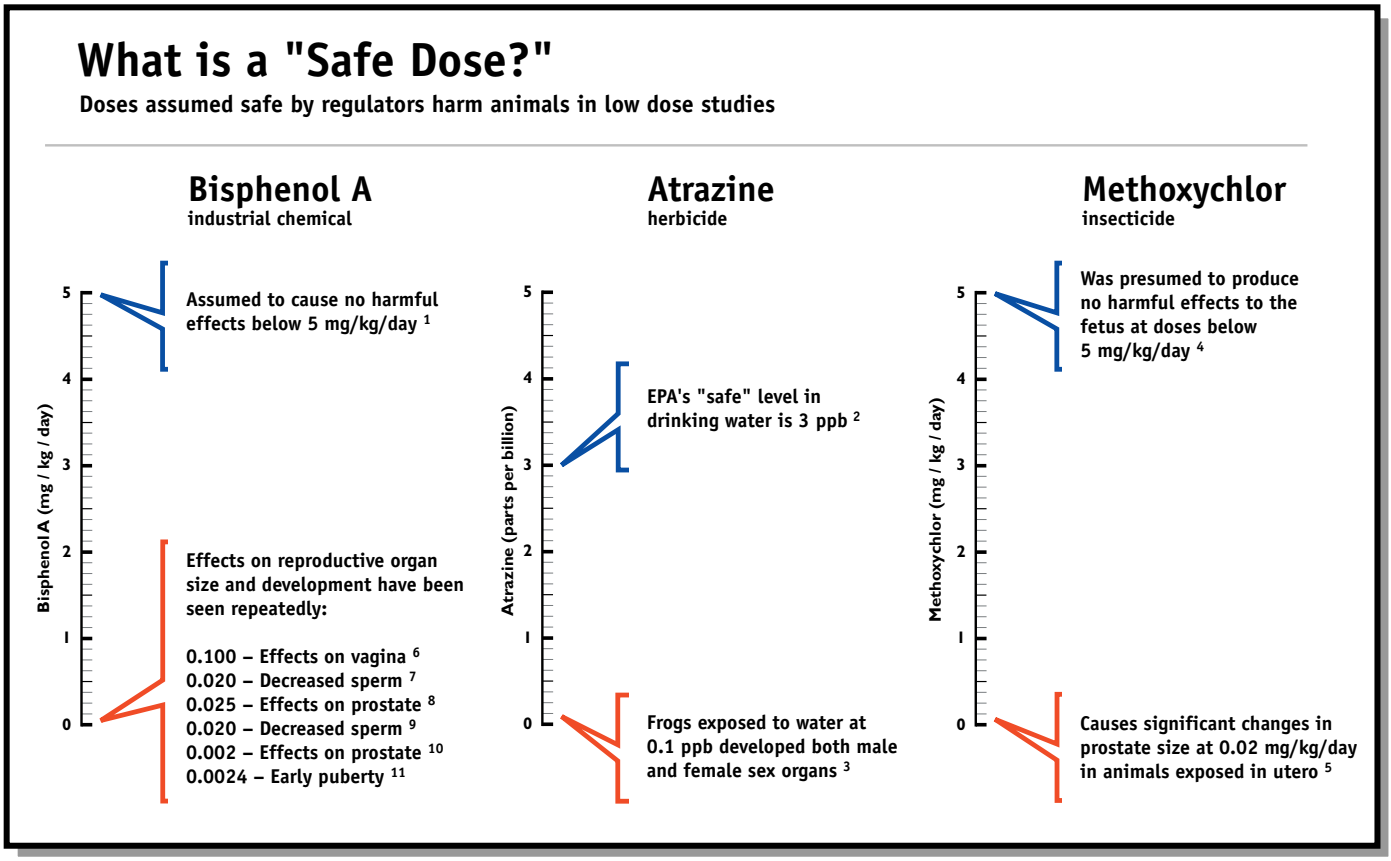
Source: EWG compilation of blood and urine analysis from two major national laboratories

of a given compound. Using these protocols, scientists are finding that low doses of chemicals can be far more harmful than previously believed (Figure 1).

Low dose studies often identify toxic effects at levels far below those identified as the "no effect" level in high dose studies. For instance, through low dose studies of bisphenol A (BPA), a plasticizer chemical commonly used in dental sealants and plastic water bottles, scientists have revealed health effects at levels 2,500 times lower than EPA's "lowest observed effect" dose, with adverse outcomes ranging from altered male reproductive organs and aggressive behavior, to abnormal mammary gland growth, early puberty, and reduced breast feeding (Figure 2).

In the face of a powerful and growing body of literature linking low dose chemical exposures and health harms in the general population, the chemical industry continues to claim that low

Figure 1



Source: EWG compilation; footnotes at the end of the chapter.

dose exposures to hundreds of chemicals simultaneously are safe. These claims, however, are nearly always based on a *lack* of scientific information on the toxicity of dose exposures, not on a definitive, scientific proof of safety.

High dose animal studies provide the foundation for federal exposure limits for contaminants in consumer products, drinking water, food, and air. Indeed, the nation's regulatory system for chemical exposures is dependent on the notion that high dose studies reveal all the toxic properties of a chemical being tested. We now know that this is not true. A number of factors, each of which can be as important as the exposure dose, determine a compound's toxicity:

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- *Timing*. The timing of a dose can often determine the toxicity of the chemical. Low dose chemical exposures during fetal development or infancy are known to produce more serious toxic effects than similar exposures during adulthood for many chemicals. Lead and mercury are the classic examples, where low dose exposures *in utero* and during infancy cause permanent brain and nerve damage, while the same doses cause no observable effects in adults. Few high dose studies, with the exception of those required for food use pesticides, target vulnerable periods of development. Most high dose studies include only adult animals. Low dose studies almost always involve *in utero* exposures.

- *Genetic vulnerability*. Some people are more susceptible to environmental contaminants because of genetic factors. For example, EPA-funded research has documented a 10,000-fold variability in human respiratory response to airborne particles (including allergens and pharmaceuticals) (Hattis, et al. 2001). This variability explains, in part, why we all breathe the same air, but not all of us have asthma attacks. Laboratory animal studies, often conducted with genetically-uniform animals, cannot reveal genetically-induced adverse effects that may occur in a small but significant percentage of a highly diverse human population.

- *Mechanisms*. Chemicals produce a spectrum of health effects that can both vary with dose, and affect the target organ in different ways depending on dose. For instance, some chemicals produce opposite effects at high and low doses – a phenomenon call biphasic dose response. Some produce different effects at high and low doses. Some produce adverse effects at low doses, but not at higher doses. DES, a potent synthetic estrogen, has been shown to stimulate prostate growth at 0.02, 0.2, and 2 μg/kg-day, but inhibit prostate growth at doses of 100 and 200 μg/kg-day (vom Saal, et al. 1997). Perchlorate, a component of

rocket fuel that contaminates drinking water, causes changes in the size of certain parts of the brain at 0.01 – 1 mg/kg-day, but not at 30 mg/kg-day (Argus 1998). Current government testing regimes do not require tests to define different effects of chemicals across a wide range of doses.

Another problem with the assertion that low dose exposures are safe, or trivial, simply because they are small, is that the toxicity of mixtures is almost never studied. Current high dose studies, like those required for pesticides used on food, are conducted with purified single chemicals. In the real world, people are exposed to low dose mixtures of several hundred chemicals. Scientists do not understand the toxicity of these mixtures, and with few exceptions are not investigating them.

Scientists refer to the chemical exposure documented here as an individuals' "body burden" – the consequence of lifelong exposure to industrial chemicals that are used in thousands of consumer products and linger as contaminants in air, water, food, and soil.

In the rare cases in which scientists have studied the effects of mixtures, they have found adverse health effects. In two recent studies scientists dosed laboratory animals with a mixture of 16 organochlorine chemicals, lead, and cadmium, each applied at its individual regulatory "safe" dose, and found that the animals developed impaired immune response and altered function of the thyroid, a gland that is critical for brain development (Wade, et al. 2002a, Wade, et al. 2002b).

Our body burden

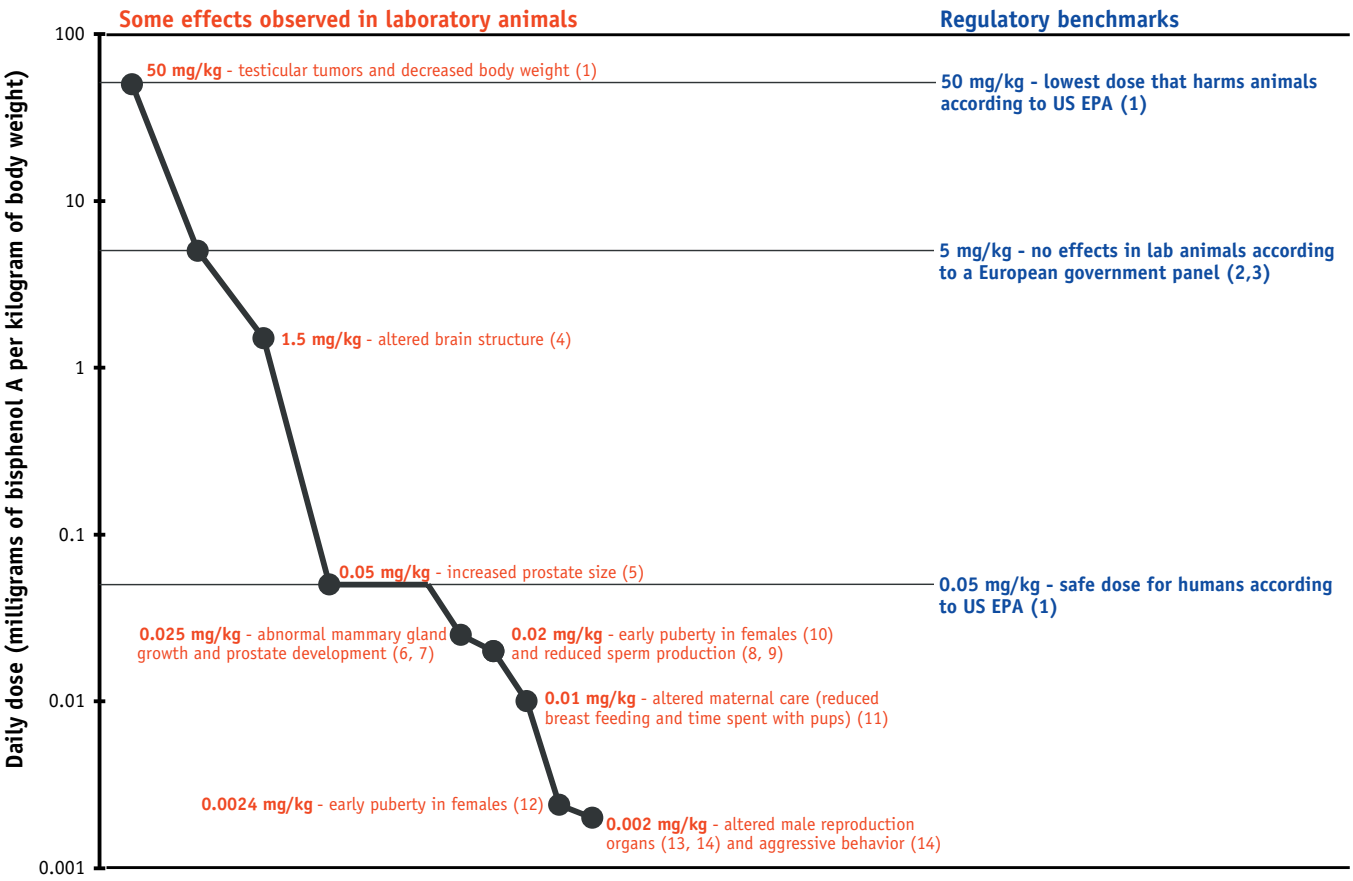
Scientists refer to the chemical exposure documented here as an individuals' "body burden" – the consequence of lifelong exposure to industrial chemicals that are used in thousands of consumer products and linger as contaminants in air, water, food, and soil. There are hundreds of chemicals in drinking water, household air, dust, treated tap water and food. They come from household products like detergent, insulation, fabric treatments, cosmetics, paints, upholstery, computers and TVs, and they accumulate in fat, blood and organs, or are passed through the body in breast milk, urine, feces, sweat, semen, hair and nails. (Easton, et al. 2002, EPA 2002d, OECD 2002, Rudel, et al. 2001, Thornton, et al. 2002, USGS 2002).

We know that:

- U.S. chemical companies hold licenses to make 75,000 chemicals for commercial use. The federal government registers an average of 2,000 newly synthesized chemicals each year.

- The government has tallied 5,000 chemical ingredients in cosmetics; more than 3,200

Figure 2: Many studies show harmful effects far below doses that regulators consider "safe"



Source: EWG compilation; footnotes at the end of the chapter.

chemicals added to food; 1,010 chemicals used in 11,700 consumer products; and 500 chemicals used as active ingredients in pesticides (EPA 1997b, EPA 2002b, EPA 2002c, FDA 2002a, FDA 2002b, FDA 2002c).

- In 1998 U.S. industries reported manufacturing 6.5 trillion pounds of 9,000 different chemicals (EPA 2001), and in 2000 major U.S. industries reported dumping 7.1 billion pounds of 650 industrial chemicals into our air and water (EPA 2002a).

At least 20 major peer-reviewed scientific journals are devoted almost entirely to studies of health effects from chemical exposures. But despite the ever-growing volume of data on the nature and consequences of exposure to industrial chemicals, scientists and doctors cannot answer the most basic questions:

What health effects can be linked to the mixtures of industrial chemicals found in the human body?

Beyond a handful of chemicals, the answer is not known. The reason: there is no legal requirement to test most chemicals for health effects at any stage of production, marketing, and use.

Under the Toxic Substances Control Act (TSCA), chemical companies can continue making chemicals and putting new compounds on the market without conducting studies of their effects on people or the environment. Some companies conduct rudimentary screening studies prior to production, but fewer than half of all applications to the EPA for new chemical production include any toxicity data at all. The government approves 80 percent of these applications with no restrictions, usually in less than three weeks. When data are provided, they are typically cursory in nature, because the government lacks the authority to request anything more than that. Eight of 10 new chemicals win approval in less than three weeks, at an average rate of seven a day. If there are no data, the government justifies approval with results of computer models that estimate if a chemical will harm human health or the environment (EPA 1997a, GAO 1994).

There is no legal requirement to test most chemicals for health effects at any stage of production, marketing, and use... In practice, this means that studies are required only *after* independent scientists have accumulated a body of evidence demonstrating potential harm, a process that typically takes decades.

For chemicals that are already on the market, the EPA can request data only when it can substantiate that the chemical is causing harm, which it generally cannot do without the toxicity data it is seeking to request. In practice, this means that studies are required only *after* independent scientists have accumulated a body of evidence demonstrating potential harm, a process that typically takes decades.

What mixtures of industrial chemicals are found in the bodies of the general population in the U.S.?

Not known (even this study defines only a fraction of the chemicals in the nine people tested). The reason: beyond chemicals that are added to food or used as drugs, there is no requirement for chemical manufacturers to: disclose how their chemicals are used or the routes through which people are exposed; understand the fate of their chemicals in the environment; measure concentrations of their products in the environment or in people; or develop and make public analytical methods that would allow other scientists to gather information.

Companies sometimes develop methods to test for chemicals in the blood or urine of their workers, but they do not routinely disclose the methods or results to the government or the public.

The government has spearheaded most of the limited testing that has been performed for the general population in studies funded by taxpayers. The government's studies have not kept pace with the ever-expanding array of new toxic chemicals. The country's most comprehensive program for detecting industrial chemicals in the human body is run by a government program that reported on 27 chemicals in 2001 (CDC 2001). The chemical industry provided direct funding for none of this multi-million dollar effort, but instead paid their trade association's press office to educate the national media on the safety of industrial chemicals in the days following the government's report release. In their upcoming report on chemical exposures, CDC is expected to release information on 116 chemicals, or about 70 percent of the number identified in this study.

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A few types of consumer products, such as cosmetics and home pesticides, must carry partial ingredient labels so consumers can make informed choices. Federal law, however, does not require the chemical industry to disclose ingredients in most household consumer products, including cleaners, paints and varnishes, and chemical coatings on clothing and furniture, or the so-called "inert" ingredients in pesticides, which are typically more than 95 percent of the retail product. The EPA has compiled a database of more than 1,000 chemicals they believe might be present in 11,700 consumer products, using data the Agency gathered from chemical encyclopedias, air sampling studies in the open scientific literature, and manufacturers. But the companies have classified the chemical recipes for 9,300 of these products as "confidential business information."

The EPA attempts to track local exposures to chemical pollutants through two testing programs, one for tap water and another for ambient air. But testing captures only a small fraction of the chemicals a person is exposed to over the course of a day. By contrast, some local and state air monitoring programs track only five chemical contaminants, most of them linked to automobile exhaust. Water suppliers test tap water for 70 contaminants, but the list excludes hundreds of chemicals known to contaminate public water supplies [e.g., (USGS 2002)].

Can an individual participate in a testing program to learn what industrial chemicals are in his or her body?

Not easily. In this study the laboratory costs alone were $4,900 per person. Scientists spent two years designing the study, gaining approval of the study plan from Mount Sinai School of Medicine's Institutional Review Board, and recruiting subjects. People can request body burden tests through their personal

physicians, but in general the methods used by available commercial labs are not sensitive, the available tests are limited, or both. The CDC lists "availability of analytical methods" as one of two major constraining factors in its national biomonitoring program (CDC 2002).

Conclusions and Recommendations

This study, combined with work from the Centers for Disease Control and Prevention, and a thorough review of the scientific literature reveals ubiquitous and insidious pollution of the human population with hundreds of chemicals, pollutants, and pesticides. In large measure this is the result of a regulatory system that leaves the EPA with few tools to study the health effects or the extent of human exposure to the thousands of chemicals found in consumer products. The widespread use of poorly studied chemicals in the absence of any meaningful regulatory structure to control them has led to:

The chemical industry tightly controls the testing and the information flow on any issue related to their products.

- Pervasive contamination of the human population with hundreds of chemicals at low dose mixtures that have not been examined for potential health effects.

- An industry that has no legal obligation to conduct safety tests or monitor for the presence of its chemicals in the environment or the human population – and a financial incentive not to do so.

- A federal research establishment that is unequipped, both technically and financially, to monitor the human population for commercial chemicals or to study their health effects.

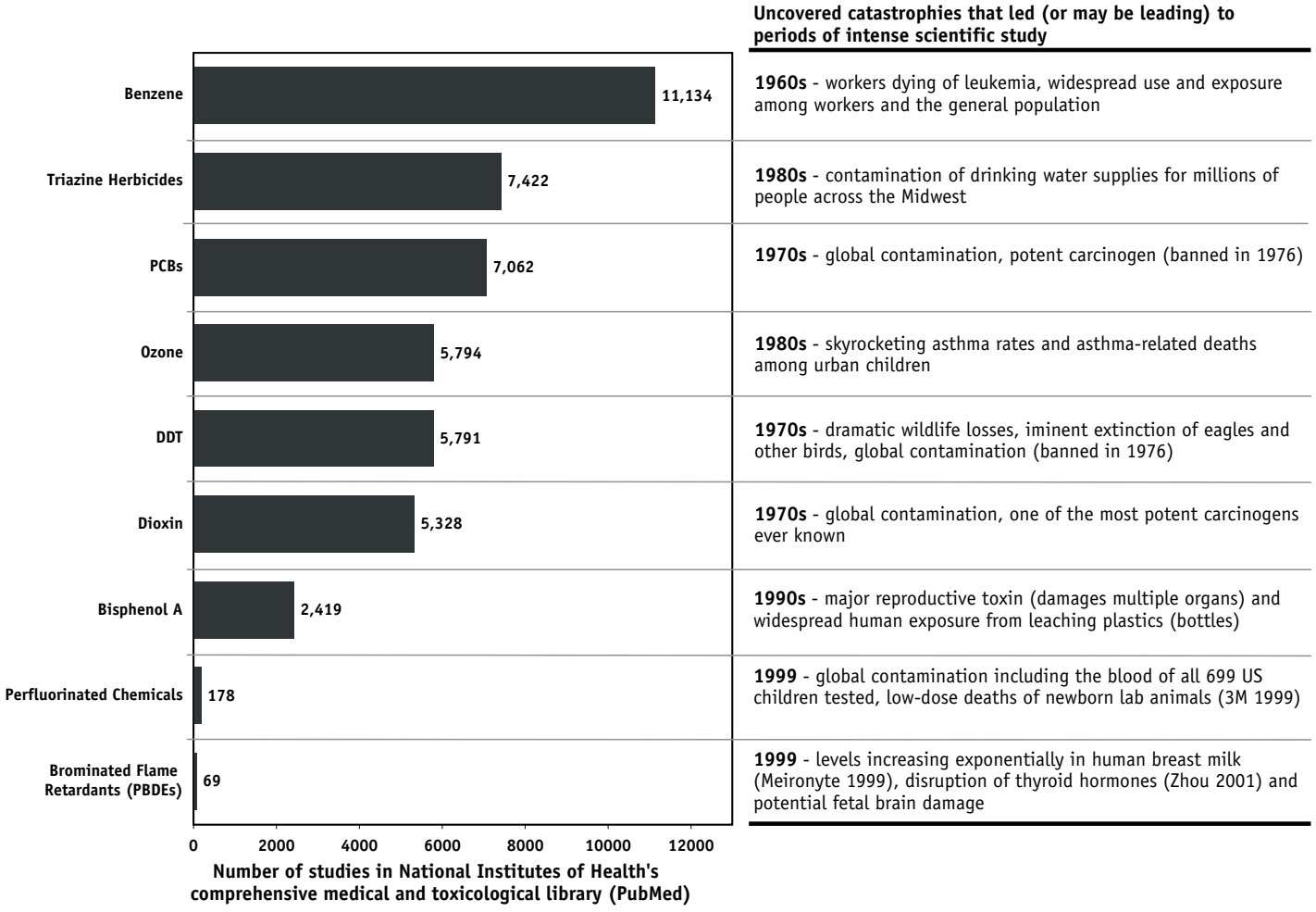
- An ever-increasing load of chemical contamination in the human population and global environment that is comprised of poorly studied chemicals, nearly all of which have never before been encountered in all of evolutionary history.

The chemical industry tightly controls the testing and the information flow on any issue related to their products. In general, the more recently a chemical has been introduced into commerce, the less scientists understand its toxicity, and the less likely it is that scientists will know how to test for it in people and the environment. The few chemicals or chemical families that have been well-studied are those for which scientists uncovered, often accidentally, environmental catastrophes that can include

widespread pollution of the environment or human population (Figure 3).

Chemical companies are not required to disclose methods that could be used to test for their chemicals in the environment or the human body. Typically only after a compound has been on the market for decades, and has contaminated a significant portion of the environment, do independent scientists learn how to detect and quantify it. At that point, CDC may choose to include the chemical in its national biomonitoring program. Even then there is no guarantee that the manufacturer will provide CDC with the methodology to detect it, or that the methods will be reliable. For example, three years after 3M announced that it was removing perfluorinated chemicals in Scotchgard from the market, chiefly because 3M found that the human population is widely contaminated with the chemicals, the CDC has yet to develop

Figure 3: Chemicals are intensively studied only after they harm human health or contaminate the biosphere



Source: EWG compilation

a method it considers reliable that would allow it to add the chemicals to its national biomonitoring program.

This situation is unacceptable.

At a minimum, people have a right to know what chemicals are in their bodies and what harm they might cause. The sole source of this information is the chemical manufacturers themselves, who historically have resisted all efforts to make basic health information on their products available to the public, regulators and independent scientists.

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Without disclosure of information on the environmental fate, human contamination, and health effects of these chemicals, regulators cannot effectively prioritize efforts to reduce the health risks from the current contaminant load in the human population.

Regardless of whether or not Congress revises the nation's laws or policies:

- The chemical industry must submit to EPA and make public on individual company web sites, all internal studies on the properties, environmental fate, potential human exposure pathways and exposure levels, concentrations in workers and the general population, levels in the environment, worker and community health, measured effects in wildlife, toxicity, mechanisms of action and any other information relevant to human exposures and potential health effects for all chemicals reasonably likely to be found in people, drinking water, or indoor air.

Revisions to the nation's laws and policies governing chemical manufacture and use include the following provisions:

- Industry must be required to prove the safety of a new chemical before it is put on the market.

- The EPA must have the unencumbered authority to request any and all new data on a chemical that is already on the market.

- The EPA must have the clear authority to suspend a chemical's production and sale if the data requested are not generated, or if they show that the chemical, as used, is not safe for the most sensitive portion of the exposed population.

- Chemicals that persist in the environment or bioaccumulate in the food chain must be banned.

- Chemicals found in humans, in products to which children might be exposed, in drinking water, food, or indoor air, must be thoroughly tested for their health effects in low dose, womb-to-tomb, multi-generational studies focused on known target organs, that include sensitive endpoints like organ function and cognitive development. Studies to define mechanisms of action (how a chemical harms the body) must be conducted.

- The chemical industry must develop and make public analytical methods to detect their chemicals in the human body, and conduct biomonitoring studies to find the levels of their chemicals in the general population.

- Chemical manufacturers must fully disclose the ingredients of their products to the public.

* * *

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CHAPTER 1: The Study and Methodology

In this study, led by scientists at Mount Sinai School of Medicine in New York City, nine adults from six states volunteered to submit blood and urine samples for a broad suite of chemical analyses. The tests targeted 210 industrial chemicals, including 7 dioxins, 10 furans, 73 PCBs, 5 heavy metals, 9 organophosphate pesticide metabolites, 23 organochlorine pesticides and metabolites, 6 phthalates, and 77 other semivolatile and volatile organic compounds from 24 chemical classes.

A total of 167 industrial chemicals, pollutants and pesticides were found in the blood and urine of nine individuals. On average, analysts found 91 chemicals per person, with a range of from 77 to 106 pollutants and pesticides in the nine individuals studied.

The investigation was a pilot study for a larger, planned investigation of attitudinal responses to provide information about one's personal body burden inventory. The study design was approved by Mount Sinai's Institutional Review Board (Baltz et al. 2000). Study results appear in a recently-published edition of the journal *Public Health Reports* (Thornton *et al.* 2002).

Blood and urine samples were collected in Summer 2000. Five questionnaires were administered to subjects immediately following blood sample collection focusing on patient demographics and exposure history, knowledge of body burden issues, typical personal choices on environmentally-relevant consumer decisions, awareness of prominent environmental issues, and attitudes about environmental policies. These questionnaires were developed by Mount Sinai for use in future assessments of the relationship between an individual's knowledge of their personal body burden and their willingness to act on issues of toxic pollution.

Scientists spent two years designing the study, gaining approval of the study plan from Mount Sinai School of Medicine's Institutional Review Board, and recruiting subjects. The goal of the study was to test a small group of people for a broad range of industrial contaminants. Ideally, researchers would have liked to identify all chemical contaminants in the blood and urine of the participants. Reaching this goal was not possible for three reasons. First, no one knows exactly what compounds to look for in people among the thousands of chemicals in commerce today. Second, methods are not publicly available to find all the

chemicals that are believed to contaminate people. Third, the cost of testing for the chemicals known to contaminate people is prohibitive, well beyond the $4,900 per person costs of this limited study.

Limitations of the study

Extent of contamination not known

The suite of chemicals to which a person is exposed over the course of a day or a year is not measured or defined by any scientific testing program. The federal government attempts to track local exposures to chemical pollutants through two basic testing programs, one for tap water and another for ambient air. The government also requires a few types of consumer products - cosmetics and home pesticides, for instance - to carry partial ingredient labels so consumers can make more informed choices at the store. The State of California requires companies to post a warning on the label if a product contains a chemical linked to cancer or birth defects. But testing, monitoring and labeling requirements capture only a small fraction of the chemicals a person is exposed to over the course of a day. Even if Mount Sinai investigators had records on each subject's use of consumer products, and results from their public tap water testing and local air pollution monitoring, the investigators would have few clues to the specifics of the suite of industrial chemicals present in that person's body.

Water suppliers test tap water for 70 contaminants, typically every year or every few years. The list of 70 is largely not coincident with the hundreds of chemicals now known to contaminate public water supplies. And even for these 70 chemicals, the mandated test methods are often outdated and insensitive. CDC's methods for finding chlorinated volatile organic chemicals in human blood – some of them common tap water contaminants linked to cancer and birth defects - are about 1000 times more sensitive than the standard methods used by water suppliers to find the same chemicals in tap water.

Available air testing is even less complete. Some state or local governments test city air for five chemical pollutants, most of them linked to gasoline combustion. Although a series of population-wide studies have linked these chemical pollutants to premature death, asthma, chronic bronchitis, respiratory tract infection, heart disease and permanent decrements in lung capacity (Gauderman, et al. 2002, Kagawa 2002, Kopp, et al.

2000, Sakaue, et al. 2001), the CDC includes only one of the five in its blood and urine testing program.

Federal law does not require the chemical industry to disclose ingredients in most household consumer products, including cleaners, paints and varnishes, and chemical coatings on clothing and furniture. The EPA has compiled a database of 1,000 chemicals they believe might be present in 11,700 consumer products, using data the Agency gathered in large part from air sampling studies and product formulation information in the open scientific literature (EPA 1997b). Any of these chemicals, and countless combinations, could be present in the human body.

Methods for detection not available or too expensive

Testing for chemicals has more to do with available methods, technologies, and cost than it does with foreknowledge of chemicals that are known or expected to occur in a particular person's body.

For the vast majority of industrial chemicals in the human body, scientists have yet to develop a test method for body fluids or tissues. Only three years ago Dr. John Brock of the Centers for Disease Control and Prevention reported that he had developed a method to detect chemical plasticizers called phthalates in the human body (Blount, et al. 2000). Although manufacturers of cosmetics and plastics have used phthalates widely for at least fifty years, the analysis of these chemicals in human fluids had eluded scientists until Brock's innovation.

Because of their prevalence in consumer products, phthalates are ubiquitous contaminants in the air and dust of cars, homes, offices, and even analytical laboratories testing samples of human fluids and tissues. Scientists struggle to distinguish the difference between "background" contamination and the phthalates present in human samples. Brock's test instead targets one of the body's breakdown products of phthalate chemicals, and ignores the background contaminants. The CDC can now reliably test for phthalates in human urine.
Most commercial laboratories, however, do not offer tests for phthalate breakdown products in human urine, presumably because the demand is low. A person could contract with a laboratory to analyze a urine sample, but would likely be faced with method start-up costs that could run in the thousands of dollars.

The same is true for a chemical solvent called m-xylene that scientists find in human blood (Ashley, et al. 1994) and that manufacturers use in vinyl flooring and varnish removers. The chemical is affordable - a liter bottle of m-xylene runs about $20 from chemical supply companies, and a quart of varnish remover in the hardware store costs about half that. But consumers would face a $1000 charge for chemical analysis to quantify levels of m-xylene in their blood, assuming they manage to locate one of the handful of laboratories in the country with the necessary testing equipment willing to take on a project as small as a single blood sample.

Scotchgard provides another example. Three years after 3M withdrew its family of Scotchgard chemicals from the market — following an accidental discovery that the chemicals have contaminated the human population — the government still has not developed a test method of sufficient reliability to include the chemicals in its biomonitoring program. CDC names the "availability of analytic methods to measure levels of the chemical in people" as one of two major criteria used to select chemicals for testing in their national biomonitoring program (CDC 2002).

And even when methods are available, testing costs are high, and well outside the reach of most individuals who might be interested in knowing their own body burden. For instance, the laboratory used by Mt. Sinai charged $1,250 for analysis of 17 dioxins and furans in a single blood sample. Largely because of budget constraints and limits in the availability of test methods, Mount Sinai scientists chose not to test for major classes of chemicals known to occur in humans, including the tens or perhaps hundreds of chemicals found in carpet, clothing, furniture, and food packaging from perfluorinated chemical families and the family of brominated flame retardants.

Study Participants

Andrea Martin, Sausalito, Calif.; Contaminants found: 95. Andrea is a cancer survivor, and the founder and former Executive Director of the Breast Cancer Fund in San Francisco. Recognized as one of the nation's leading advocates for cancer survivors, Martin's group pushes for a national action agenda for environmental causes of breast cancer. Her ascent of Mount Fuji two years ago with nearly 500 breast cancer survivors and supporters epitomizes her group's commitment to celebrate the courage and faith of the 3 million women in the U.S. living with

this devastating disease. She has recently undergone surgery to remove a brain tumor unrelated to breast cancer.

Bill Moyers, New Jersey; Contaminants found: 84. During his 25 years in broadcasting, Bill Moyers has pursued a broad spectrum of journalism. In presenting Moyers with one of his two prestigious Gold Batons, the highest honor of the Alfred I. DuPont Columbia University Awards, Columbia University President Michael Sovern called Moyers "a unique voice, still seeking new frontiers in television, daring to assume that viewing audiences are willing to think and learn." Moyers reported the results of his body burden tests in his Emmy award-winning expose of the chemical industry, "Trade Secrets: A Moyers Reports," which first aired on PBS in March, 2001

Sharyle Patton, Bolinas, Calif.; Contaminants found: 105. Sharyle Patton is co-director of the Collaborative on Health and Environment, a group of individuals and organizations interested in linkages between environment and health. She was previously the northern co-chair of the International Persistent Organic Pollutants (POPS) Elimination Network, a network of over 350 non-governmental organizations around the world which worked successfully for the positive conclusion of the UN treaty on POPS, signed in May 2001. She has been active in UN conferences on women's reproductive health and sexual rights issues.

Lucy R. Waletzky M.D., Pleasantville, NY; Contaminants found: 78. In addition to her work as a physician and practicing psychiatrist, Dr. Waletzky is board member of the National Audubon Society, and one of the group's prominent experts on the effects of pesticides and toxic chemicals on the environment. She also serves on the Board of the Memorial Sloan Kettering Cancer Society and is a member of the Westchester County Pest Management Committee.

Davis Baltz, Berkeley, Calif.; Contaminants found: 106. Davis moved to California with his family when he was four months old, and grew up in Berkeley, California. His chemical body burden is the product of his childhood and current exposures in the U.S., as well as chemical exposures accumulated during seven years of work and travel across Asia and Africa. Among his diverse experiences, Davis has evaluated farmer training

programs to reduce pesticide use in Indonesia, supervised refugee resettlement in Thailand's refugee camps, observed elections in Sri Lanka, edited news in Korea, and assisted community organizing efforts with farmer groups in the Philippines. He holds a Masters degree in International Community Economic Development. He currently acts as a Senior Research Associate for Commonweal in Bolinas, California, where he works to eliminate the use of toxic chemicals in the healthcare industry.

Michael Lerner, Bolinas, Calif.; Contaminants found: 101. Michael Lerner is president and founder of Commonweal, a health and environmental research institute in Marin County, California. He has worked for thirty years with at-risk children, people with cancer, and environmental health initiatives. He is married to Sharyle Patton, who was also a participant in the Body Burden Study.

Lexi Rome, Mill Valley, Calif.; Contaminants found: 86. As co-director of the Commonweal Sustainable Futures Project, Rome led a collaborative learning program for leaders in the environmental, philanthropic, and policy-making communities in the San Francisco Bay Area, tackling such diverse problems as population, consumption, and a sustainable future. Now retired, she is pursuing volunteer opportunities, working on local environmental issues, and developing sustainable, organic ranching methods in Montana.

Monique Harden, New Orleans, La.; Contaminants found: 77. Monique is an attorney who specializes in environmental justice concerns in New Orleans, the city where she was raised. She organizes communities who live on the fenceline with polluting industries, using both litigation and advocacy to fight cases driven by economic justice concerns. Among the victories she can claim is a precedent-setting decision by the Environmental Protection Agency to deny a Clean Air Act permit to a company proposing a new facility in a neighborhood that was 80 percent African American and already surrounded by 12 industrial facilities responsible for 17 million pounds of air pollutants.

Charlotte Brody, Round Hill, Va.; Contaminants found: 85. Charlotte Brody, RN, is a founder and an Executive Director of the Health Care Without Harm Campaign — an international coalition of 390 organizations in 44 countries working to make health care more environmentally responsible and sustainable. A registered

nurse and mother of two, Charlotte has served as the Organizing Director for the Center for Health, Environment Justice in Falls Church, Virginia, the Executive Director of a Planned Parenthood affiliate in North Carolina and the Coordinator of the Carolina Brown Lung Association, an occupational safety and health organization focused on cotton textile workers.

Sample collection

Blood sample collection. Qualified health care personnel drew 13 vials (Vacutainers™) of blood from each subject. Filled vials were fitted into custom foam containers, placed in prepared coolers filled with ice packs, stored under refrigeration, and then shipped overnight to Midwest Research Institute in Kansas City, Missouri.

Urine sample collection. Each participant collected a 24-hour urine sample in a 3500 milliliter low density polyethylene urine collection container manufactured by Hedwin. Container was refrigerated or stored in a cooler between uses. Upon completing the 24-hour collection cycle, including one first morning void, study participants thoroughly mixed the sample by shaking, then poured the sample into four smaller plastic containers provided by the laboratory. Containers were prewashed with acid as necessary. Sample containers were shipped overnight to Pacific Toxicology in Woodland Hills, California.

Analytic methods

Analysis of PCBs, dioxins, and furans. The technical approach for analysis of blood samples for congener-specific PCBs, polychlorinated dibenzodioxins (dioxins), and polychlorinated dibenzofurans (furans) relies on techniques based on EPA methods 1613 and 1668, refined by Midwest Research Institute. Analysis was performed using high resolution gas chromatography/high resolution mass spectrometry (HRGC/HRMS). ^{13}C-labeled PCBs, dioxins and furans were added to each sample for use as internal standards.

Extraction was accomplished using end-over-end tumbling with a rugged rotary extractor. Extract was dried, concentrated, and transferred to a pre-weighed 1 dram vial. The sample lipid fraction was determined by a series of evaporation steps conducted until successive measurements of sample weight reached steady state.

Samples were prepared for chromatography using a modified acid/neutral silica gel chromatography solution, prepared according to EPA Methods 1613 and SOP MRI 5201, Revision 2, with micro-scale adaptation of the chromatography column. Sample extracts were split into two samples of equal volume, one for PCB analysis, one for dioxin and furan analysis. The dioxin and furan split was processed through alumina and carbon column chromatography cleanup procedures according to EPA Method 1613. The extract was further concentrated.

The extract designated for dioxin and furan analysis was analyzed according to a laboratory adaptation of EPA Methods 8290 and 1613 using an Autospec Ultima HRMS and an OpusQuan Data system. The calibration range was extended by a factor of 10 below the range specified in EPA methods. The extract designated for PCB analysis was analyzed on a VG-70S HRMS and an OpusQuan data system according to EPA Method 1668 with modifications to include calibration standards for each of the 75 target PCB congeners over the relevant concentration range.

Congener-specific PCBs were analyzed using a high resolution mass spectrometer, operating at 10,000 mass resolving power in the selected ion monitoring (SIM) mode, according to EPA Method 1668 with target analyte list of 75 specific PCB congeners.

Data reduction of PCBs, dioxins and furans was performed by OpusQuan data systems to calculate the concentrations of analyte responses against radiolabeled internal quantitation standards and recovery standards.

Analysis of organochlorine pesticides, phthalates, and other VOCs and SVOCs. The extraction method described for PCBs, dioxins, and furans was also used for pesticides, phthalates, and SVOCs. Co-extracted biological interferences were separated from the pesticides and other VOCs and SVOCs using gel permeation chromatography column cleanup according to EPA SW-846 Method 3640 followed by Florisil solid phase extraction (Method 3620). Sample extracts were split into two samples of equal volume, one for pesticide analysis, one for analysis of phthalates and other VOCs and SVOCs.

Sample extracts for pesticides were analyzed by high-resolution gas chromatography/electron capture detector (HRGC/ECD) based on EPA Method 8081. A Hewlett-Packard 6890 HRGC/ECD system was used for analysis and data were acquired and processed using a Turbochrom data system.

Sample extracts for phthalates and other VOCs and SVOCs were analyzed by high-resolution gas chromatography/mass spectrometry (HRGC/MS) based on EPA Method 8270C. A Fisons MD-800 quadruple GC/MS system was used for analysis and data were acquired and processed using LabBase data system. Deuterated PAHs were used as internal standards.

The VOCs and SVOCs were tentatively identified based on a NIST library search by the LabBase software. Spectral data of the chromatographic peaks were matched to data in the NIST library using a forward/reverse fit. The mass spectra of the identified compounds were manually verified against the identified library spectra and found to meet the 70 percent to 100 percent forward/reverse fit project specific objective.

Analysis of lead and mercury. Whole blood samples were analyzed for lead and methylmercury using Inductively Coupled Plasma/Mass Spectroscopy (ICP/MS). Samples were prepared by EPA Method 200.11. Lead analysis was performed according to EPA Method 200.8. Mercury speciation was performed using high performance liquid chromatograph (HPLC) to separate methylmercury from inorganic mercury, as described in the literature, prior to introduction into the ICP/MS.

Analysis of organophosphate pesticide metabolites. Urine was analyzed for organophosphate pesticide metabolites according to procedures described in CDC (CDC 2001), using gas chromatograph/flame photometric detector (GC/FPD) methods. Chlorpyrifos metabolite 3,5,6-trichloropyridinol was analyzed using gas chromatograph/mass spectrometry (GC/MS) methods. Malathion metabolites monocarboxylic acid and dicarboxylic acid were analyzed using GC/FPD methods.

Analysis of urinary metals. Speciated arsenic in urine was analyzed using gas chromatograph/atomic absorption spectrophotometery (GC/AAS) methods. Cadmium was analyzed using inductively coupled plasma/mass spectrometry (ICP/MS) methods, and chromium was analyzed using graphic furnace/ atomic absorption spectrophotometery (GF/AAS) methods.

Results

Chemicals detected. The laboratory detected 167 chemicals of 210 tested, including 48 PCBs, 15 dioxins and furans, 7 organophosphate pesticide metabolites, 10 organochlorine

Table 3: Exposures found in this study are largely unavoidable.

	Number of chemicals found in 9 people	Number of 9 people these were found in	Concentration range (average)	Units	Uses	Primary Sources of exposure
PCBs	48 of 73	9 of 9	57,290 to 455,790	pg/g in blood lipid basis	PCBs, banned in 1976, were used in adhesives, carbonless reproducing paper, cutting oils, dedusting agents, electrical capacitors, electrical transformers, vacuum pumps, gas-transmission turbines, fire retardants, hydraulic fluid, ink, lubricants, pesticide extenders, plasticizer, heat transfer systems, wax extenders	Contamination in seafood, meat and dairy products.
Dioxin-like PCBs	5 of 12	9 of 9	1.5 to 10.9	pg/g TEQ in blood lipid basis		
Dioxins and furans	15 of 17	9 of 9	15.7 to 36.6	pg/g TEQ in blood lipid basis	There are no industrial uses of dioxins or furans. Dioxins and furans are pollution from waste incineration and fuel combustion (e.g. wood, coal, or oil) and pollution formed during chlorine bleaching, chemical manufacturing, drinking water chlorination, and industrial processes.	Contamination in seafood, meat and dairy products.
Organophosphate pesticide metabolites	7 of 9	9 of 9	4.0 to 70.4	ug/L in urine	Organophosphate pesticides are used as fungicides, herbicides, insecticides and termiticides.	Contamination in fruits, vegetables, dairy, and meat products; Direct exposure from home use
Organochlorine pesticides and metabolites	10 of 23	9 of 9	615 to 3084	pg/g in blood lipid basis	Organochlorine pesticides are used as fungicides, insecticides and termiticides.	Contamination in fruits, vegetables, dairy, and meat products; Direct exposure from mosquito control spraying prior to the 1970s
Phthalates	6 of 6	9 of 9	97.2 to 904.8 [only Bis(2-ethylhexyl)phthalate was quantified]	ug/g in blood lipid basis	Phthalates are used as plasticizers, solvents, desensitizing agents, dye carriers, perfume fixatives, and defoaming agents, as well as in nail polishes and explosives.	Exposure occurs upon contact or consumption of plastics, cosmetics, contaminated food, carpet, explosives, sealants, varnishes, paints, and primers
Other semivolatile and volatile chemicals (24 classes)	77	9 of 9	not quantified		The SVOCs and VOCs found in these 9 people are used in products from aviation fuel to food flavorings.	Daily life: exposures may occur from contaminated food, paints, furniture, or any number of other common consumer products
Metals	4 of 5		*(see below)*			
Lead		9 of 9	1.01 to 3.23	ug/dL in whole blood	Lead is released as pollution from burning fossil fuels, mining and manufacturing. Lead is used in ammunition, aviation fuel, batteries, cables, x-ray shields, and ceramics. Lead has also been historically used in paint, crystal tableware, gasoline, and drinking water pipes.	Chipping paint in older homes and water from lead pipes or lead solder in homes built before 1986
Methylmercury		7 of 9	0.63 to 25.9	ug/L in whole blood	Methylmercury is created in the environment by bacteria converting mercury pollution, especially mercury from coal-fired power plants.	Canned tuna and other seafood that accumulates methylmercury from the environment
Arsenic, inorganic		1 of 9	21	ug/L in urine	Arsenic is used in pressure-treated lumber, alloying constituents, certain types of glass, doping agents in germanium and silicon solid state products, dipoles and other electronic devices, copper and lead alloys, and even medicines.	Contact with outdoor lumber decks and playsets treated with Chromated Copper Arsenate (CCA); Contaminated drinking water
Cadmium		3 of 9	0.5 to 0.7	ug/L in urine	Cadmium is released as pollution from mining and industrial operations and coal or waste combustion. Cadmium is used in baking enamels, batteries (Ni-Cd), electronics, fire protection systems, industrial machinery, lithography, machinery enamel, marine equipment, optics, pigments, nuclear reactor control rods, electroplating for automotive, aircraft & electronic parts, and to manufacture fungicides.	Foods contaminated with cadmium (shellfish, and some organ meats); Contaminated air near coal or waste combustion plants

Source: EWG compilation; * Analytical results for phthalates in blood can be affected by background contamination of laboratory equipment, but data from CDC show that phthalates are ubiquitous pollutants in people.

pesticides and metabolites, 6 phthalates, 77 semivolatile and volatile chemicals, and 4 metals (Tables 2 and 3).

Of the chemical groups tested, the most prevalent were those contained in 24 classes of semivolatile and volatile chemicals, with 77 detected. These classes include well-known industrial solvents and gasoline ingredients, including xylene and ethyl benzene, and are used in a variety of common products like paints, glues, and fire retardants. The laboratory found 48 PCBs in the nine people tested. PCBs were banned in the United States in 1976 but .are used in other countries and persist in the environment for decades. Their most common use was as an insulating fluid in electrical capacitors and transformers, vacuum pumps, and gas-transmission turbines. Lead was found in all 9 participants, and mercury was found in 8.

Assessment of health effects linked to each chemical detected in blood or urine. We compiled available information on adverse effects associated with each chemical detected in study participants' blood and urine. Information was drawn from 81 studies found in the peer-reviewed literature (indexed on the National Institutes of Health's PubMed database) and various government health effects assessments (such as those published by the Agency for Toxic Substances and Disease Registry and the Environmental Protection Agency).

Potential manufacturers, products, and uses of each chemical. We compiled data on potential manufacturers and uses of each chemical through a literature search that included review of nine standard industry, government, and academic references (Ash and Ash 2000, Burdock 1994, CDC 2001, CTFA 2002, EPA 1997b, Farm Chemicals Handbook 2001, Heinrich 2000, NIH 2002a, NIH 2002b).

Data we have compiled on consumer product uses of particular chemicals draws from a database compiled by EPA that contains product ingredient lists encompassing 1,000 chemicals in 11,700 consumer products. The Agency compiled the data from chemical encyclopedias, air sampling studies in the open scientific literature, and manufacturers. But the companies have classified the chemical recipes for 9,300 of these products as "confidential business information," so our final product analysis included only a fraction of the data submitted to EPA by the manufacturers.

These nine information sources show that the chemicals found in this group of nine people are associated with:

- 183 types of consumer products, including brake fluid, paint, pesticides, flame retardants (Table 4);

- 164 past or current manufacturers, including Shell, Union Carbide, Exxon, Dow, and Monsanto; and

- 64 chemical functions, including plasticizers, froth flotation agents, and defoaming agents.

Interpretation of Results for Semivolatile and Volatile Organic Chemical Scan

The tests that identified semivolatile and volatile organic chemicals in participants' blood were different from other tests run in this study, and require a different interpretation. These tests did not target and then verify specific industrial chemicals in the samples. Rather, lab technicians worked backwards, first scanning the blood extract for all semivolatile and volatile components, identifying the chemical "fingerprint" of the sample, and then tentatively identifying the blood components by matching the weights of molecules in the blood, identified with an instrument called a mass spectrometer, to molecular weights in an electronic library of thousands of chemicals.

Our search of standard government and industry references and Internet databases turned up information on 22 of 77 chemicals identified, including data on potential health effects from exposure, chemical manufacturers and commercial uses. Among the chemicals identified are some clearly linked to industrial uses, such as xylene and ethylbenzene, both components of gasoline and both used in a wide range of other consumer products. Other industrial chemicals found in study participants' blood are obscure – for example, health effect or use information is not available in standard references for 3-bromodecane or 3-bromo, 3-methyl pentane.

Some of the chemicals found may be natural components of human tissues, and may have industrial uses in addition to being present naturally. This is the case for palmitic acid, identified in all nine study participants. Palmitic acid is a natural component of human fat and the primary fat in meat and dairy products, but is also produced in high volume by the pine tree pulping industry, and added to pharmaceuticals, shampoo, soaps, shaving creams, soaps, and processed or baked foods. In a 1998 survey of high production volume chemicals, EPA found that basic health and safety studies have not been conducted for palmitic acid.

Table 4: Hundreds of consumer products contain the chemicals found in the nine participants in this study.

acrylic sprays	dental impression materials	lacquers	solder wire driers
adhesives	detergent	latex paint	solvents
aerosol adhesives	detergents	light switches in cars	spot cleaners
aerosol greases	drugs	liniment	spot removers
aerosol undercoatings	dyes	liquid nails	spray abrasives
aerosol undercoats	electronic equipment	liquid plastics	spray acrylics
airplane parts	enamel sprays	liquid soap	spray adhesives
ammunition	enamels	lotion	spray epoxys
anti-infective lotion	epoxy enamels	lozenges	spray films
anti-lock brakes	epoxy finishes	lubricants	spray lacquers
automobile undercoatings	epoxy sprays	medication	spray laquers
aviation fuel	erasable ink	mosquito repellent	spray lubricants
avicides (kills birds)	explosives	nail polishes	spray paints
bakeware	fireproofings	nematicides (kills nematode worms)	spray primers
banned insecticide	floor cleaners	oil finishes	spray varnishes
batteries	flooring	ointment	stain/lacquers
battery cleaners	fluorescent lamps	outdoor lumber (pesticide)	stain/sealers
battery protectors	foam insulations	paint	stain/varnishes
belt dressings	food (additive)	paint brush cleaners	stains
bleach	food (flavoring)	paint removers	starting fluids
brake fluid	food (pollutant)	paint thinners	steam cleaners
cables	food (synthetic flavoring)	paper	texture coatings
car parts	food packaging	particleboards	thermometers
car waxes	fungicides	perfume	thermoset overprints
carb cleaners	furniture	pesticides	thermostats
carbon cleaners	furniture refinishers	pigments	tire cleaners
carpet	gasket removers	plastic	tire shiners
caulking compounds	gasoline	plumbing cleaners	toothpaste
ceramics	general purpose cleaners	polishing compounds	Turkey red oil
chemotherapy drugs	germicides	polyshadess	vaccinations
child-proof wall finishes	glass	primers	vaginal pharmaceuticals
chipping paint in older homes	grease removers	rawhides	varnish
cleaners	gum cutters	rocket propellants	varnish remover
cleaning fluids	hair conditioners	rubber	VCR head cleaners
cold cream	hair spray	rubber moldings	VCR head lubricants
colognes	hair sprays	rubbing alcohol	vinyl floorings
computers	hand cleaners	rug shampoos	water from lead-soldered pipes in older homes
conditioners	hand cream	rust guards	wax strippers
contact cements	heat-sealable overprint (CAP)s	seafood	weapons and ammunition
contact lens cleaning solution	industrial and lubricating oils	sealant tapes	window cleaners
copper & brass polishes	inks	sealants	windshield cleaners
cosmetics	insect repellant	shampoo	wood finishes
cough syrup	insecticide	shaving cream	wood lighteners
crystal tableware	insecticide (banned in U.S.)	silicone sprays	wood preservatives
decorative ink	lacquer	silicones	x-ray shields
dental amalgams (fillings)	lacquer thinners	soap	

Source: EWG compilation from 10 government and industry sources on the 167 compounds found in the nine study participants.

The Agency requested additional data from the manufacturers, noting that palmitic acid is used commercially in a complex mixture, and that industry has yet to identify all the components of the mixture. While scientists know that ingestion of palmitic acid can raise levels of serum cholesterol, increasing risks of cardiovascular disease, scientists have not yet studied other basic health endpoints, particularly those that may be associated with the commercial mixture.

The laboratory did not quantify the levels of the chemicals identified in the scan, so these tests do not allow us to distinguish between components that may be both naturally occurring, and present in excess from exposures to the chemical as a contaminant in air, water, food, or as an ingredient in consumer products. For instance, hippuric acid is typically found in human urine, but is also formed when the body breaks down the common, carcinogenic industrial solvent called trichloroethylene (TCE), and is used as a marker to human exposures to TCE.

Broad scans such as the semivolatile and volatile chemical scans run in this study can provide valuable preliminary information to scientists that guide the design of more detailed, specific studies. For example, Dr. John Brock, formerly of the Centers for Disease Control and Prevention, developed new methods to test for phthalates in people after noticing the presence of phthalates in routine blood scans, and questioning the common explanation that phthalates appear in scans as an artifact of background laboratory contamination. His research found surprisingly high levels of phthalates in human urine, spurring four cosmetics companies to announce phthalate-free cosmetic lines because of concerns about the chemicals' ability to induce birth defects in laboratory animals.

CHAPTER 2: Chemical Exposure

Industrial chemicals are widespread

Chemicals end up in people from pollution in air, water and food; from pesticides and additives in food; through thousands of consumer products from stain repellants to paints and plastics; and from a wide array of new building materials. For infants and children, exposures can also come from their parents' workplaces, or from contamination in mother's milk.

Industries release millions of tons of industrial chemicals to the environment every year. An emissions tracking system in the US called the Toxics Release Inventory shows that companies discharged 7.1 billion pounds of 650 industrial chemicals to air and water in the year 2000 alone (EPA 2002a). This program monitors only a subset of US industries.

The federal government's National Toxicology Program considers 228 chemicals as either known human carcinogens, or "reasonably anticipated" to cause cancer in humans (NTP 2002). The State of California considers 475 chemicals to be carcinogenic, and 266 chemicals to be linked to birth defects (OEHHA 2002). No one is systematically tracking human exposure to any of these chemicals in spite of their known human health hazards.

In a 1992-2000 survey of 139 rivers and streams in 30 states, many of which are used as drinking water supplies, the U.S. Geological Survey identified 95 components of treated human sewage, including steroids, DEET insect repellant, antibiotics, and persistent breakdown products of cigarettes and detergents. Drinking water treatment facilities are not designed to remove these chemicals, and 85 percent of them are unregulated in drinking water and thus allowed to occur in any amount in treated tap water. USGS found 82 chemicals in one of the water bodies tested, and at least 10 chemicals in 35 percent of the streams and rivers tested (USGS 2002).

In recent tests of air and dust samples from homes, scientists in Massachusetts found a broad range of chemicals in each air sample, including phthalate plasticizers used in cosmetics, paints, and other consumer products, and brominated flame retardants used in upholstery, computers, and televisions (Rudel, et al. 2001). In its national water sampling programs, USGS routinely detects a broad range of pesticides in rivers and streams used for drinking water, including a neurotoxic insecticide called diazinon, found in nearly a third of the water bodies tested. 3M

CASE STUDY: DDT

In 1939 a Swiss chemist named Dr. Paul Hermann Muller discovered something new about a chemical called dichlorodiph enyltrichloroethane: it was effective as a contact poison for the common housefly, the mosquito, and louse. His chemical, called DDT, would become the world's most popular insecticide, and a life-saving tool in countries plagued by malaria-carrying mosquitoes and typhoid-spreading lice. The World Health Organization estimates that during its peak decades of use DDT saved 25 million lives, and Dr. Muller was awarded the 1948 Nobel Laureate in Medicine for his discovery.

Despite its clear public health benefits, the U.S. Environmental Protection Agency banned the use of DDT in 1973 when thirty years of scientific evidence on the unexpected, harmful consequences of DDT use overwhelmed the benefits of its continued application (EPA 1972). In a series of scientific studies, DDT was found not only to be linked to reproductive damage responsible for plummeting populations of bald eagles and alligators, but also to persist in human fat tissue and to contaminate human breast milk (ATSDR 2002a, IPCS 1989). Although DDT has been banned for three decades now, mothers in the U.S. – and across much of the world – continue to pass the persistent insecticide and its breakdown products on to their babies each time they nurse (ATSDR 2002a).

The National Toxicology Program considers DDT to be "reasonably anticipated to be a human carcinogen" (NTP 2002). DDT is also believed to disrupt the human hormone system in ways that can, for example, shut down human milk production sooner than normal, depriving newborns of their only source of natural nutrition (Gladen and Rogan 1995). In a recent study linking preterm birth to levels of a DDT metabolite in maternal blood, the authors estimate that DDT may have been responsible for as many as 15 percent of infant deaths in the US during the 1960s (Longnecker, et al. 2001).

recently released a study in which they report finding persistent Scotchgard chemicals in tap water from two of six cities tested (Columbus, Georgia and Pensacola, Florida) (3M 2001).

Companies win government approval to manufacture seven new chemicals every day, adding to the roster of more than 75,000 chemicals currently registered for commercial use in the U.S. These companies produce 15,000 chemicals in quantities of more than 10,000 pounds per year; 2,800 at a rate of more than a million pounds per year; and the top 50 chemicals at a combined rate of nearly one trillion pounds per year (Kirschner 1996). Hundreds if not thousands of these chemicals pass through or are stored in the human body after exposures to ingredients in consumer products or contaminants in air, water, food, and soil. The chemicals are lodged in human fat, blood, and organs, or excreted in breast milk, urine, semen, sweat, feces, hair, and nails.

Scientists know of many individual chemicals that are harmful to humans – certain chlorinated solvents and insecticides, lead, PCBs and methylmercury, to name only a few – but have generally not studied the health effects of complex mixtures of industrial chemicals in the human body. And scientists have yet to define the composition of these mixtures in individual humans.

The only program for detecting industrial chemicals in the human body is spearheaded not by the industries responsible for the exposures, but by the federal government's Centers for Disease Control and Prevention (CDC) in Atlanta, Georgia. Each year the CDC's national biomonitoring program analyzes stored human blood, serum, urine, and hair samples for a range of industrial chemicals and pollutants.

Last March, in their first national report to define chemical exposures in the general population, CDC reported on 27 chemicals (CDC 2001). The study represented the culmination of millions of dollars of taxpayer-funded research. The chemical industry provided direct funding for none of this effort, but instead paid their trade association's press office to educate the national media on the safety of these exposures in the days following CDC's report release.

CDC found two of the 27 chemicals in their study, or seven percent, at levels of potential concern. They found both of these chemicals - mercury (from contaminated seafood) and a plasticizer known as DBP (from cosmetics and other consumer products) - in women of childbearing age at levels that provide little to no margin of safety from levels associated with health

CASE STUDY: Perfluorinated organic chemicals. In 1976 Donald Taves, a dentist with the University of Rochester's School of Medicine and Dentistry, made an unexpected discovery when analyzing a sample of his own blood in his research on fluoride in drinking water. Instead of the simple fluoride chemicals used in tap water, he found complex organic fluoride chemicals in his blood, completely unrelated to fluoridated tap water. Dr. Taves and his collaborators identified one of the compounds as belonging to a broad chemical family called perfluorinated organics, manufactured by 3M and DuPont for Scotchgard and Teflon products. In further work, Dr. Taves found perfluorinated chemicals in all but two of 141 human blood samples – evidence of what he called "widespread contamination of human tissues" (Guy, et al. 1976). A total of nine studies published between 1972 and 1989 verified his findings in the U.S., Argentina, China, and Japan, and during that time 3M and DuPont ran testing programs tracking chemical levels in their workers.

Despite this evidence, 21 years later, in the summer of 1997, 3M's medical director expressed "complete surprise" when company-sponsored tests showed perfluorinated chemicals not only in workers' blood, but also in blood bank samples that were to be used as background controls in the tests (3M 2000). In a series of follow-up studies conducted over the past five years, 3M has found that their chemicals have universally contaminated humans and wildlife, including 100 percent of the children tested in the U.S., Arctic polar bears, and Great Lakes bald eagles (Giesy and Kannan 2001, Olsen, et al. 2002). Under pressure from EPA, 3M withdrew a small fraction of its perfluorinated chemicals from the market in May 2000 when 3M animal tests showed surprising death rates among newborn rats exposed to low levels of these chemicals, coincident with their studies proving global human and environmental contamination (Auer 2000). Three years after the phaseout, the government still lacks a reliable method that would allow the chemicals' inclusion in the CDC's national biomonitoring program.

CASE STUDY: Brominated flame retardants. Fifty years ago the plastics

effects in exposed human populations and laboratory animals. Both chemicals are linked to birth defects. Of the plasticizer DBP, CDC scientists noted that "from a public health perspective, these data provide evidence that...exposure is both higher and more common than previously suspected" (Blount, et al. 2000). DBP has been in wide commercial use in consumer products, particularly cosmetics, for 50 years.

Biomonitoring data from the CDC have been pivotal in efforts to focus regulatory agencies on the hazards of DBP and mercury in the U.S. population. Unlike industry biomonitoring data, CDC data are publicly available. EWG and other organizations have used these data to document DBP- and mercury-related health risks in the population that had previously been ignored or not well understood. In response to EWG analyses, the Food and Drug Administration (FDA) has agreed to reevaluate its health advisory for methylmercury. The FDA has taken no action on DBP, in spite of CDC data showing that a small but significant portion of the population is exposed to levels above federal safety limits. But several major cosmetics manufacturers have removed DBP from their products, a step that likely would not have occurred in the absence of biomonitoring data from the CDC.

industry began experimenting with chemical coatings that would allow their otherwise highly flammable plastics to meet fire and smoke regulations for consumer products. This work paid off, opening up nearly every niche of office and household goods to the world of polymer plastics, and resulting in a massive industry that produces a third of a trillion dollars of products each year in the U.S. alone. The current flame retardant market is dominated by brominated organic chemicals, many of which are now known to be persistent, toxic and to accumulate up the food chain and in humans.

These chemicals are still largely unknown to the public, but the products that contain them are quite familiar, ranging from computers and televisions to coffee makers, vacuum cleaners and sofa pillows. The most widely used compounds are PBDEs, or polybrominated diphenyl ethers.

Scientists are increasingly concerned about the PBDEs because they are similar to PCBs. They are persistent organic pollutants (POPs) that may cause cancer, birth defects, nerve damage, thyroid dysfunction and immune system suppression (Darnerud, et al. 2001, Hooper and McDonald 2000). They not only bioaccumulate but also biomagnify, with increasing concentrations found at higher levels in the food chain. Some types of PBDEs will be banned in the European Union beginning in 2003, but they remain unregulated in the United States and Canada (Darnerud, et al. 2001, Renner 2001).

PBDEs were first detected in human breast milk in 1972, and a recent Swedish study found that breast milk concentrations are doubling every five years (Meironyte, et al. 1999). The latest research indicates that the San Francisco Bay Area is a PBDE hot spot: A study by the California Department of Toxic Substances Control found that concentrations of PBDEs in breast tissue samples from Bay Area women were the highest detected worldwide – three to 25 times greater than European samples (She, et al. 2002). Recent samples from San Francisco Bay harbor seals found PBDE levels among the highest reported for that species, with concentrations rising almost 100-fold between 1989 and 1998 (She, et al. 2002).

CHAPTER 3: Low Doses Can Hurt You

Many of the exposures reported here are below the levels thought to be toxic in standard high dose toxicology studies relied upon by industry and regulators. The government's historic dependence on high dose studies has created an institutional and scientific bias that encourages regulators and industry to assert, with little supporting data, that low doses like those reported here cause no adverse effects.

In this context, the standard response by industry representatives to stories involving chemical contamination is that these "trace" doses are too tiny to cause adverse effects (ACSH 1999). The science, however, leads to the opposite conclusion. Adverse health effects from low dose exposures are occurring in the population, caused by unavoidable environmental contamination with PCBs, DDT, dioxin, mercury and lead.

Although the chemical industry will assert that low dose exposures to hundreds of chemicals simultaneously is safe, the safety claims are based on a *lack* of scientific information on the toxicity of low-dose exposures, not on definitive scientific proof of safety.

Roots of the myth of low dose safety

Chemical toxicology today falls into two camps: Regulatory toxicology, where scientists, generally in the pay of chemical companies, conduct high dose animal studies under prescribed protocols for the purpose of meeting government requirements; and research toxicology, primarily conducted at independent university and government research centers, where scientists focus on low dose exposures to chemicals that lead to harmful effects on the body.

Regulatory toxicology targets relatively crude measures of toxicity such as cancer, birth defects, and obvious signs of organ damage. Research toxicology goes beyond this to look at how chemicals can alter the functioning of organ systems that otherwise appear intact.

Many adverse effects are caused by low dose exposures that occur during critical periods of fetal development or infancy but do not manifest until later in life. Often these effects arise from insults that trigger a cascade of effects that alter the proper functioning of organ systems, sexual development, behavior or reproduction. Some examples include alterations of nervous system

INDUSTRIAL CHEMICALS AND HUMAN DISEASE

The onset or progression of most health problems can be influenced by environmental contaminants. The following diseases are prevalent and have shown an increased incidence not explained by better detection or longer lifespans. Evidence from many low dose toxicity studies indicates that trace exposures can target organs and cause effects that can contribute to the occurrence of these diseases in people.

Breast cancer. Among girls born today, one in eight is expected to get breast cancer and one in 30 is expected to die from it. Invasive female breast cancer increased an average of 1.5 percent per year between 1973 and 1996, for a total increase of 25.3 percent. Among those 65 and younger, breast cancer incidence rose 1.2 percent per year, corresponding to a doubling every two generations (58 years). If trends continue, the granddaughters of today's young women could face a one in four chance of developing breast cancer (NCI 1996, NCI 1997).

development that play out as behavioral problems or IQ deficits; or disruption of normal hormonal signaling that results in fertility problems, birth defects of reproductive organs, early puberty, or cancers of the reproductive organs. Alteration of immune system function can also occur, leading to increased susceptibility to illness and disease. Scientists are finding that many chemicals in widespread use today cause these types of effects at doses well below those thought to cause "no effect" in high dose regulatory studies.

Testicular cancer. At its current pace, the incidence of testicular cancer is doubling about every one and a half generations (39 years). In the U.S. the incidence of testicular cancer rose 41.5 percent between 1973 and 1996, an average of 1.8 percent per year (NCI 1996, NCI 1997). While rates of testicular cancer continue to drop among older men (65 and up), testicular cancer remains the most common cancer among young men, with the highest rate of diagnosis among men between the ages of 30 and 34.

Prostate cancer. Prostate cancer rates rose 4.4 percent a year between 1973 and 1992, or more than a doubling of risk in a generation. Since 1992, the incidence has declined, but it is still 2.5 times its 1973 rate. Part of this increase can be explained by better detection, but increased incidence has also been accompanied by an increase in mortality - which better detection cannot explain. Prostate cancer is now the most common cancer among U.S. men, and the second most lethal, killing an estimated 31,900 men in the year 2000 alone (NCI 1996, NCI 1997).

The following is a guide through some of the highlights and basic concepts of low dose chemical toxicity. The discussion is presented in greater detail below, but can be summarized as follows:

- In many cases low doses *are* toxic. Science has evolved considerably since the 16th century when Paracelsus coined the adage, "The dose makes the poison." We now know that many other factors, particularly the timing of the dose, genetic variability, and health status of the exposed individual, are equally, if not more important. Low doses of lead, mercury or PCBs at specific days of fetal development or infancy can cause permanent problems that are not manifest during exposure, but only later during childhood, adolescence and beyond (ATSDR 2000, Jacobson and Jacobson 1996, NAS 2000). The same dose in the adult may have little or no effect. Among people breathing the same polluted urban air, only some will develop asthma. A recent study evaluating differences in human response to airborne particles found that the most sensitive members of a population respond to doses 150 to 450-fold lower than median (50th percentile) responders (Hattis, et al. 2001). Factors that contribute to these differences include variations in breathing rates, deposition and elimination of air particles from the respiratory tract, and differences in lung response to the chemicals found in the air.

- Susceptibility to disease results from a complex interplay between biological factors, such as specific genetic traits, and the environment, which would include exposure to other chemicals (environmental, recreational or therapeutic) and lifestyle factors such as stress levels, nutrition, fitness, and smoking status. Genetic variation contributes to the incidence of diseases induced by industrial contaminants. For example, inherited mutations of the BRCA1 and BRCA2 genes account for five to ten percent of all breast cancers (Tripathy and Benz 1997).

- For most chemicals science provides little or no basis for assertions that low dose exposures are safe, particularly those that start *in utero* and continue to old age, as is the case with most of the chemicals identified in this study. This knowledge gap is due to study designs, dictated by food and drug regulations, that in general do not require testing of low doses, and in no cases expose animals to chemicals from conception through old age – a so-called womb to tomb study that most accurately comports with real world human exposures.

- Most safety claims for trace exposures are based on findings from high dose studies. Such extrapolations do not ensure safety. Low dose safety is not well predicted by the high dose studies required for chemicals used in foods and drugs. High dose studies tend to look for readily observable, overt toxic effects like cancer, malformations visible at birth, and organ damage, such as liver toxicity. High dose studies usually involve only adult animals. Low dose studies typically look for less obvious effects that involve impaired function of organ systems in animals exposed during development. Examples include decreased sperm counts, altered hormone levels, impaired immune function, altered growth and development of reproductive organs and behavioral and intelligence deficits. Low dose studies almost always involve exposures *in utero* or early life.

- Many chemicals produce different or even opposite effects at high and low doses – a phenomenon called biphasic dose response. For example, DES, a potent synthetic estrogen, has been shown to simulate prostate growth at 0.02, 0.2, and 2 μg/kg-day, but inhibit prostate growth at doses of 100 and 200 μg/kg-day (vom Saal, et al. 1997). Perchlorate, a component of rocket fuel and drinking water contaminant, causes changes in the size of certain parts of the brain at 0.01 – 1 mg/kg-day, but not at 30 mg/kg-day (Argus 1998).

- Current regulatory high dose studies are conducted with purified single chemicals. In the real world, people are exposed to exotic low dose mixtures of several hundred different chemicals. The toxicity of these mixtures is not known, and is not being investigated. In two recent studies scientists dosed laboratory animals with a mixture of 16 organochlorine pesticides, lead, and cadmium, each applied at its individual regulatory "safe" dose, and found

Declining sperm count. An analysis of 101 studies (1934-1996) by Dr. Shanna Swan of the University of Missouri confirms results of previous studies: average sperm counts in industrialized countries appear to be declining at a rate of about one percent each year (Swan, et al. 2000).

Hypospadias. Data from the Centers for Disease Control and Prevention (CDC) show that rates of hypospadias in the U.S. began climbing in about 1970, and continued this increase through the 1980s. This condition is a physical deformity of the penis in which the opening of the urethra occurs on the bottom of the penis instead of the tip. Currently the occurrence of hypospadias appears to be stable, at about 1 in 125 births (Paulozzi, et al. 1997).

Undescended testicles. This birth defect, where testicles fail to completely descend into the scrotum during pregnancy, occurs in two to five percent of full-term boys in Western countries. Rates of the defect increased greatly in the U.S. in the 1970s and 1980s. Men born with this defect are at higher risk for testicular cancer and breast cancer (Paulozzi 1999).

that the animals developed impaired immune response and altered function of the thyroid, a gland that is critical for correct brain development (Wade, et al. 2002a, Wade, et al. 2002b).

- Some people are more sensitive to low dose exposures than others. EPA-funded research has documented a 10,000 fold variability in human response to certain airborne particles (Hattis, et al. 2001). This genetic variability in response explains, in part, why we all breathe the same air, but not all of us have asthma attacks.

Documented low dose effects in people

The scientific evidence for human harm from industrial chemicals and pesticides extends far beyond occupational exposures. Countless studies in the peer-reviewed literature show that adverse health effects from low dose exposures are occurring in the population, caused by unavoidable contamination with PCBs, DDT, dioxin, mercury, lead, and other chemicals. Among the many health effects scientists have linked to chemical exposures in the general population, are premature death, asthma, cancer, chronic bronchitis, permanent decrements in IQ and declines in other measures of brain function, premature birth, respiratory tract infection, heart disease, and permanent decrements in lung capacity (EPA 1996, EPA 2000, Gauderman, et al. 2002, Jacobson and Jacobson 2002, Jacobson, et al. 2002, Kopp, et al. 2000, Longnecker, et al. 2001, NAS 2000, NTP 2002, Pope, et al. 2002, Salonen, et al. 1995, Sydbom, et al. 2001).

PCBs at 9.7 ng/ml (parts per billion or ppb) in maternal serum during fetal development can cause adverse brain development, and attention and IQ deficits that appear to be permanent (Jacobson and Jacobson 1996). Notably, it was the maternal PCB levels and *not* the PCB levels in children at 4 and 11 years of age (by which time child PCB levels had decreased substantially) that was associated with IQ deficit – underscoring the limitations of studies that try to correlate current body burdens with adverse health outcome in the absence of measuring *in utero* exposures.

Dioxin at 80 parts per trillion in paternal – but not maternal – serum causes a significant change in the sex ratio of children (Mocarelli, et al. 1996, Mocarelli, et al. 2000). At this tiny dose, men father nearly twice as many girls as boys. Eighty parts per trillion is equivalent to one drop of dioxin in a seven mile long string of bathtubs (7,400 bathtubs).

Lead above 100 parts per billion in the blood of a two year old can cause learning deficits, behavioral problems and a significant decrease in IQ in adolescence and adulthood (CDC 1997). The same dose has no effect on adults. One hundred ppb is the equivalent of 1 drop of water in 6 bathtubs. A 5/1,000ths ounce chip of lead paint can put a child in the emergency room with lead poisoning [Calculated based on (CDC 1997, EPA 1998a)].

Methylmercury causes measurable delays in brain function in children exposed to levels corresponding to 58 parts per billion in maternal blood (NAS 2000).

DDE above 15 ppb in maternal blood is associated with preterm birth, and low birth weight, with weight corrected for gestational age (Longnecker, et al. 2001). DDE is a metabolite of DDT. Using the associations derived from tests of archived samples from a pool of 42,000 women, researchers estimated that DDT exposures could have accounted for up to 15 percent of infant deaths during the 1960s. Low birth weight like that linked to DDE is increasingly recognized as a risk factor for insulin resistance or Type II diabetes, high blood pressure, and cardiovascular disease later in life (Godfrey and Barker 2001, Hales and Barker 2001). Even if these lower birth weight babies "catch up" later, the damage may have already been done. A substantial number of studies have found that low birth weight followed by an accelerated growth rate during childhood is a significant risk factor for high blood pressure, stroke, insulin resistance and glucose intolerance (Eriksson, et al. 2000a, Eriksson, et al. 2002, Eriksson, et al. 2000b, Eriksson, et al. 1999, Eriksson and Forsen 2002, Forsen, et al. 2000, Ong and Dunger 2002, Stettler, et al. 2002).

Chlorpyrifos (dursban) above 8 pg/g (parts per trillion) in the blood of non-smoking women was strongly associated with decreased birth weight and body length in babies of African American women in New York City (Perera, et al. 2003). In the same study, increased air exposure to PAHs was correlated with decreased birth weight – an effect that was independent from the chlorpyrifos finding – and decreased head circumference. The babies of women exposed to the highest PAH levels had a 10% reduction in body weight (Perera, et al. 2003).

Byproducts of tap water chlorination were linked to statistically significant increases in birth defects in New Jersey at 40 parts per billion in water, and miscarriages in California at 75 parts per billion (Bove, et al. 1995, Waller, et al. 1998).

Perchlorate in drinking water at levels as low as one to two ppb,

(0.2 to 0.4 ug/kg/day) is associated with altered thyroid hormone levels in infants (Schwartz 2001). Perchlorate is a component of rocket fuel that also was used in the 1960s as a drug to regulate thyroid hormone activity. Adequate levels of thyroid hormone are critical for normal brain development (Gruters, et al. 2002, Zoeller, et al. 2002).

Low dose effects in animals

As researchers continue to study the effects of exposure to low levels of contaminants, more effects are observed – especially in developmentally exposed organisms. In the natural environment, low dose effects are often observed in aquatic species, such as fish and frogs. This finding has prompted chemical industry representatives to belittle these results as irrelevant to human exposures. The truth, however, is not that simple. Even though the *specific* effects may differ between humans and wildlife, the general toxicity is often quite similar. For example, if a contaminant causes reproductive effects in fish - such as production of a hormone that humans don't possess or other effect not caused in humans - the chemical is also likely to affect reproduction in mammals. DES (a potent estrogen) increases levels of vitellogenin – a protein that humans do not produce – in fish. Vitellogenin is an indicator of estrogenic activity (Folmar, et al. 2002). In mammals, DES causes increased growth of uterine cells, again an indicator of estrogenic activity (EPA 1998c). In either case, DES causes adverse reproductive effects in fish, mammals and humans, although the specific endpoint may differ.

The dangers of nearly every chemical banned or restricted in the US were first identified in laboratory animals or wildlife. Animals are strong predictors of hazards to human health – a premise that applies to "all of experimental biology and medicine" (Klassen 1996). For instance, the vast majority of known and reasonably anticipated human carcinogens cause cancer in laboratory animals (NTP 2002).

Bisphenol A. A number of low dose studies have focused on effects of bisphenol A, a building block of polycarbonate plastics that is used in dental sealants and to line virtually all aluminum and steel cans, among many other uses. The seminal study, by Nagel et al (1997), found increased prostate weight in male mice exposed as fetuses to 2 μg/kg/d. In subsequent studies, scientists have now linked low dose bisphenol A exposures to altered development of the mammary gland (25 μg/kg/d and 100 μg/kg) (Colerangle and Roy 1997, Markey, et al. 2001), vagina (100 μg/kg/d) (Schonfelder, et al. 2002a) and prostate

(2 - 50 μg/kg/d) (Gupta 2000, Nagel, et al. 1997, Ramos, et al. 2001); earlier onset of puberty in female mice (2.4 and 20 μg/kg/d) (Honma, et al. 2002, Howdeshell, et al. 1999); effects on behavior (2 to 40 μg/kg/d) (Adriani, et al. in press 2003, Dessi-Fulgheri, et al. 2002, Facciolo, et al. 2002, Farabollini, et al. 1999, Kawai, et al. in press, Palanza, et al. 2002) and decreased sperm production (20 μg/kg/d) (Sakaue, et al. 2001, vom Saal, et al. 1998). Scientists found increased rates of embryonic development at 1 nM (0.23 ppb) ((Takai, et al. 2000a, Takai, et al. 2000b).

Infants ingest bisphenol A in formula at an estimated daily rate of 1.6 μg/kg-day (SCF 2002), giving little safety margin from the doses that cause effects in animal studies (doses as low as 2 ug/kg/d).

Human fetal plasma BPA levels were recently reported at between 0.2 to 9.2 ng/ml (ppb) (Schonfelder, et al. 2002b). The median BPA level in this study (2.3 ng/ml (ppb)) is consistent with a median of 2.2 ng/ml (ppb) reported in a recent Japanese study (Ikezuki, et al. 2002). Notably, some of the effects cause by BPA in animal studies appear to be increasingly common in some segments of the human population, including early onset of puberty (Herman-Giddens, et al. 1997) and decreased sperm production (Swan, et al. 2000, Toppari, et al. 1996).

Atrazine. Five studies published in the past year have found that exposure to 100 parts per *trillion* of atrazine in water causes deformities in frogs, including hermaphroditism (individuals with both male and female sex organs), underdeveloped testes, and a decrease in the number of germ cells (sperm and eggs) (Hayes, et al. 2002a, Hayes, et al. 2002b, Hayes, et al. in press, Tavera-Mendoza, et al. 2002a, Tavera-Mendoza, et al. 2002b). Hermaphroditism is extremely rare and was not detected in any unexposed frogs (Hayes, et al. 2002b). Atrazine is the most commonly used weed killer in U.S. agriculture, and is found in the tap water of 10 million people in corn belt states. The level that causes these effects, 100 parts per trillion, is commonly found in corn belt tap water and is 30 times less than the legal maximum contamination limit for atrazine of 3 parts per billion.

Aldicarb. Numerous studies have found that low doses of aldicarb impair immune function at low doses (Dean, et al. 1990a, Dean, et al. 1990b, Hajoui, et al. 1992, Olson, et al. 1987, Selvan, et al. 1989, Shirazi, et al. 1990). Immunologic effects were observed at concentrations as low as 0.1 to 1 ppb (Dean, et al. 1990b, Olson, et al. 1987, Selvan, et al. 1989).

Nonylphenol. An ingredient of certain plastics and a surfactant used in detergents and pesticides produces low dose effects in aquatic organisms (i.e. fish and frogs). Nonylphenol at less than 1 ppb in water produced female specific proteins in male fish (Tabata, et al. 2001), altered reproductive hormone levels (Giesy, et al. 2000, Harris, et al. 2001) and decreased sword length in swordtail fish (Kwak, et al. 2001). Slightly higher concentrations (~ 22 ppb) cause an increase in the number of female-appearing frogs (Kloas, et al. 1999). In frogs, low concentrations of NP (100 nM; ~ 22 ppb) decreased the number and differentiation of neural crest-derived melanocytes (pigment producing cells); and this effect was specific to estrogenic compounds tested (Bevan, et al. 2002). Nonylphenol is one of the most frequently detected contaminants of streams in the U.S. (Kolpin, et al. 2002). It was found in 50% of 139 streams in 30 states (median 0.8; max 40 μg/L or ppb).

DDT at 18 ng/ml (ppb) in the blood of mice caused significant increases in the height and thickness of uterine and vaginal epithelial cells respectively. These changes are considered to be indicators of estrogenic response. Changes in uterine epithelial cell height were also observed at β-HCH of 42 ng/ml (ppb) (Ulrich, et al. 2000).

Trenbolone, a synthetic androgen (male hormone) used in beef production, impaired reproduction of fish at 50 parts per trillion (decreased number of eggs spawned) (Ankley and Touart 2002), and caused the "masculinization" of female fish at doses as low as 5 μg/L (5 ppb) – the female minnows grew characteristic male spikes on the tops of their heads.

Regulatory requirements don't include low dose studies.

For most chemicals scientists have not studied the effects of low dose exposures, particularly *in utero*. Most available toxicity data comes from high dose studies on adult animals. The dearth of low dose data does not stop industry representatives from issuing blanket assurances about the safety of low dose exposures. When "experts" assert that low doses cause no effects in animals, it is almost always because they haven't looked.

Most experiments designed to identify low dose toxicity differ substantially from those used in standard high dose studies required for food additives and drugs. These low dose studies are sometimes referred to as non-guideline studies, because they involve investigations that extend beyond the narrow limits of agency study guidelines or protocols.

Research scientists (primarily academic and government researchers) have more flexibility to develop innovative study designs and investigate more sophisticated and subtle indices of toxicity. In contrast, industry scientists typically conduct "guideline" studies that fulfill minimal regulatory requirements, which are often based on decades old science and relatively crude endpoints.

High dose regulatory studies do not look for the outcomes that are most likely to arise from low dose exposures. For example, high dose study designs look for overt easily observable effects, like cancer, gross birth defects, acute poisoning, or overt organ damage. Low dose research studies typically examine functional deficits, where apparently healthy organs or systems, do not function properly. Outcomes are measured as altered growth and development of reproductive organs, behavioral changes, abnormal immune function, and changes in hormone levels.

The vast majority of "low dose" studies involve follow-up of developmentally-exposed animals (or humans) in ways not addressed by regulatory toxicology studies. For example, there is no regulatory study that follows animals exposed *in utero* to an age corresponding to old age – referred to as a "womb to tomb" study. Instead, animals exposed *in utero* are followed, at a maximum, until they are young adults (~ 4 to 5 months). This makes it impossible to address questions such as whether *in-utero* or early life exposure to industrial chemicals or pesticides can predispose an individual to cancer, degenerative nervous system disorders, diabetes, or other diseases more prevalent at the end of life for the vast majority of chemicals. In general, research studies follow developmentally exposed animals for longer periods of time and study endpoints in greater detail.

Low doses studies often reveal toxic effects at levels high dose studies consider safe.

High dose animal studies cannot accurately predict either the safety or hazard of low dose exposures. This is particularly true when high dose studies on adult animals are applied to low dose in-utero or infant exposures. Lead, mercury and PCBs are classic examples, where high dose animal studies on mature animals failed to identify the hazards of low dose fetal and childhood exposure.

In many other cases low dose research found adverse health effects at levels well below the supposed "no effect" level

determined in standard high dose regulatory guideline studies (Figure 1).

- Atrazine was presumed by pesticide manufacturers and the EPA to cause no effects below 3 ppb (EPA 2002). Subsequent work by Tyrone Hayes shows that atrazine produces frogs with both male and female sex organs at levels 30 times lower than this (Hayes, et al. 2002b).

- Methoxychlor, an insecticide and chemical relative of DDT, was presumed to cause no effects to the fetus at doses below 5 mg/kg/d (IRIS 2003b). Subsequent low dose research found that methoxychlor causes significant changes in prostate size at a dose 250 times lower in animals exposed *in utero* (Welshons, et al. 1999).

- Bisphenol A is assumed to cause no harmful effects below a dose of 5 mg/kg/d, according to a recent risk assessment conducted by European Commission Scientific Committee on Food (SCF 2002). Yet significant effects on reproductive organ size and development have been found repeatedly at levels up to 1000 times lower (Colerangle and Roy 1997, Gupta 2000, Howdeshell, et al. 1999, Markey, et al. 2001, Nagel, et al. 1997, Ramos, et al. 2001, Sakaue, et al. 2001, Schonfelder, et al. 2002a, vom Saal, et al. 1998).

- Methylmercury is assumed to cause no harmful effects below a concentration of 11 mg/kg in hair, according to the Environmental Protection Agency (NAS 2000). Yet researchers in the Netherlands found a doubling in the risk of heart attacks and death from coronary heart disease at methylmercury levels of 2 mg/kg in hair, or about one fifth of assumed safe levels (Salonen, et al. 1995). Increased diastolic and systolic blood pressure and decreased heart rate variability in developmentally exposed children have also been observed at doses below the EPA no effect level (NAS 2000, Sorensen, et al. 1999).

- Dibutyl phthalate (DBP) was presumed by the EPA to cause no harmful effects in animals below 125 mg/kg/d based on a 1953 study (IRIS 2003a). More recent studies have shown that DBP causes male reproductive toxicity at 100 mg/kg/d, including delayed puberty, cellular changes in the testis and retained nipples (CERHR 2000, Mylchreest, et al. 1999, Mylchreest, et al. 2000). Decreased numbers of live pups have been observed at an even lower dose of 52 mg/kg/d (CERHR 2000, Wine, et al. 1997).

Many chemicals produce different or even opposite effects at high and low doses – a phenomenon called biphasic dose response.

Chemicals that produce a biphasic dose response are relatively common, and these responses are observed for a variety of effects. The prevalence of these types of effects underscores how wrong one could be by assuming that high dose studies accurately predict low dose toxicity.

- Perchlorate, a component of rocket fuel and drinking water contaminant, causes changes in the size of certain parts of the brain at 0.01 – 1 mg/kg-day, but not at 30 mg/kg-d (Argus 1998). We know that perchlorate causes these effects at lower doses because it is a relatively well-studied chemical by virtue of its use as a pharmaceutical. In contrast, most environmental contaminants would not be assessed for effects on thyroid hormone or brain structure at all.

- Bisphenol A (BPA), an estrogenic endocrine disruptor commonly found in plastics used in dental sealants and as liners in most aluminum and steel cans, can produce opposite effects at low and high doses. BPA increases the developmental rate of embryonic cells at 1 nM (0.229 ppb), while concentrations 100,000 fold higher (100 μM or 22829 ppb) will decrease developmental rate (Takai, et al. 2000a, Takai, et al. 2000b). In prostate cancer cells, BPA will increase cell proliferation at concentrations 100 times less than the levels that inhibit cell growth (1 vs 100 nM or 0.229 vs 22.9 ppb)(Wetherill, et al. 2002).

- Atrazine produced more pronounced hermaphroditism and testicular toxicity in frogs at 0.1 ppb than at 25 ppb (Hayes, et al. in press).

- Pyrethroid insecticides induce hyperactivity in rats at doses up to 0.7 mg/kg but no hyperactivity at a dose 60 times higher (42 mg/kg) (Eriksson, et al. 1991).

- DES, a potent synthetic estrogen, has been shown to cause stimulatory low dose effects on the weights of the prostate (0.02, 0.2, and 2 μg/kg-day) and uterus (0.1 μg/

kg-day), but inhibit growth at higher doses, 200 μg/kg-day and 100 μg/kg-day, respectively (Alworth, et al. 2002, vom Saal, et al. 1997).

Hormesis

While most industry representatives dismiss low dose adverse effects, some embrace a concept called hormesis – a low dose biphasic dose response where low dose effects are beneficial and high doses are toxic. The concept of hormesis is easily conceptualized with vitamins; low doses of many vitamins are beneficial, while high doses can cause adverse effects including kidney toxicity (vitamin D), gastrointestinal upset (vitamins A and D), headaches (vitamin A), increased susceptibility to hemorrhage (vitamin E) and general sense of fatigue (vitamins A and E) (Merck & Co. Inc. 2002).

Although there is considerable scientific support for hormesis with respect to vitamins and minerals, some in the chemical industry are distorting the concept to argue that the low doses of environmental contaminants may also be "beneficial." A recent report on hormesis by the Texas Institute for Advancement of Chemical Technology (TIACT), a "non-profit, charitable organization... dedicated to the advancement of chemical technology through an informed public," contains the most distorted arguments put forth to date. The authors propose hormesis as a rationale for bringing back into commerce long-banned chlorinated chemicals such as PCBs and DDT.

> "The scientific acceptance of hormesis with its possible benefits at low-level exposure could come at no better time than the present when environmentalists and others are calling for bans on more and more chemicals, such as **chlorinated hydrocarbons** (emphasis added) to prevent low-level exposures. Furthermore, the **low-exposure paradigm** (emphasis in original) would make it possible for society to enjoy, safely, the benefits of many chemicals that have been banned in the past or could be banned in the future" (first page of the executive summary) (TIACT 1998). TIACT is supported by donations from Dow, BASF, Bayer, Shell Chemical Company, and Syngenta.

This extreme view of hormesis is not generally accepted. However, hormesis does help explain low dose effects seen in toxicology studies. Scientists have found that while low doses can stimulate a process in the body, high doses can inhibit the

same process. For example, low doses of estrogens will stimulate breast cancer cells to grow (proliferate). High doses of the estrogen can inhibit cell growth – presumably because the high doses can damage the cell to the point of dysfunction or death (Lippman, et al. 1976). Similarly, low doses of pharmacological estrogens stimulate uterine growth in rodents, while high doses – well above therapeutic doses – will cause uterine weight to decrease (Alworth, et al. 2002, Shelby, et al. 1996).

Some people are more sensitive to low dose exposures than others.

People differ in response to the same amount of chemical exposure as a function of their age, differences in metabolic and detoxification pathways, nutritional state, body weight, genetic variability, gender, preexisting conditions, and lifestyle (such as smoking and drinking status). In regulatory toxicology, the default factor used to take these differences into account, referred to as an intraspecies factor, is 10-fold – meaning that the response from one person to another is expected to be no greater than 10 times different.

Chemical response

The assumption of 10-fold variability is not likely realistic when one considers the range of responses in the most sensitive populations of people, rather than simple average differences. For example, recent EPA-funded research found that some people are 10,000 times more sensitive than the average (median) person to certain forms of airborne particles (Hattis, et al. 2001).

Age

In general, fetuses, infants and children are more sensitive to chemical exposure than adults. One reason is age-related differences in metabolism. A comparison of the half-lives (a measure of how fast a chemical leaves the body) for 45 different pharmaceuticals in neonates and adults found that on average it takes neonates 3 to 9 times longer to eliminate 1/2 of the administered dose depending on the primary elimination pathway for that chemical (such as CYP or P450, glucuronidation, renal, other non-CYP elimination pathways) (Ginsberg, et al. 2002a).

But averages can mask significant differences. Approximately seven percent (6/85) of 1-week (< 7 days) to 2-month old babies had an elimination half-life more than 10 times longer than the

adult average level (Hattis, et al. in press). Only one percent (1/85) of the 1-week to 2-month old infants had a faster half-life than the adult average value (Hattis, et al. in press).

The enzyme paraoxonase (PON) is essential to metabolize toxic breakdown products of organophosphate (OP) compounds, including OP insecticides. People with high PON levels metabolize insecticides faster than people with lower PON levels (Hulla, et al. 1999). Human infants do not begin to produce adult-type levels of PON until they are around 2 years of age (Ecobichon and Stephens 1973), making them potentially more vulnerable to OP exposure.

Similarly, the elderly are also more sensitive to chemical effects, which is why the recommended dosage for many drugs is 25 to 50% of that given to younger adults.

Hexachlorobenzene (HCB), an organochlorine pesticide, is more toxic to the young than to adults. In Turkey during the mid to late-1950s, a fungicide containing ten percent HCB was used to make bread, resulting in an extremely high rate of infant mortality (95%) in breast-fed babies born to mothers who ate the bread. There was no detectable change in mortality for exposed adults (ATSDR 2002b). The infants who died had skin lesions, cardio- respiratory failure, weakness and convulsions. HCB also causes neurotoxicity in adulthood following developmental exposure. Symptoms include a jerkiness of movement like that seen in Parkinson's disease (ATSDR 2002b). Other effects observed in adults exposed as children include osteoporosis of hand bones, small hands, swelling and spindling of fingers (ATSDR 2002b).

While HCB exposure has not been definitively linked to impaired immune function in humans, exposure to several organochlorines (including HCB) has been associated with increased risk of otitis media (inflammation of the middle ear) in the first year of life (Dewailly, et al. 2000). A German study found that HCB levels were higher in a group of boys undergoing surgery for undescended testicles compared to boys with no testicular abnormalities (Hosie, et al. 2000). More recently, mothers of men with testicular cancer were found to have higher levels of HCB compared to mothers of men without this disease (Hardell, et al. in press).

Genetic differences

Levels of polycyclic aromatic hydrocarbon (PAH)-DNA adducts,

a biological marker of PAH exposure, vary up to 24-fold in a population of normal adults, reflecting significant differences in PAH exposure and response (Dickey, et al. 1997). However, in people who lack an important detoxification enzyme, glutathione S-transferase M1 (GSTM1), PAH-DNA adducts vary by 52-fold.

Activity of an enzyme used to metabolize alcohol (as well as the industrial chemicals toluene, vinyl chloride and 2-methoxyethanol), aldehyde dehydrogenase-2 (ALDH2), vary up to 26 fold between susceptible people in Asian populations and the US median. Similarly, activity of another enzyme important in OP detoxification, malaoxonase, varies 7-fold within humans – and this number does not begin to include differences between adults and children (Sams and Mason 1999). These numbers exceed the default factor of 3.2 fold used to account for pharmacokinetic variability in risk assessment (Ginsberg, et al. 2002b).

Progress in government's efforts to gather low dose study data.

In 1996 EPA convened an expert committee to develop animal testing protocols for low dose studies, to be conducted for a broad range of industrial chemicals that are suspects for low dose effects. Although the original committee and its successor have met regularly for six years now, they have yet to finalize a single testing protocol. One particular protocol still in draft form is a standard uterine growth test used since the 1930s to flag chemicals that could impair reproduction and development.

The committee's drafts leave out some critical indicators, like tests for brain function in studies of chemicals that suppress thyroid hormones key to brain growth and development. One of the industrial chemicals known to disrupt thyroid function and potentially impair fetal and infant brain development is a rocket fuel ingredient called perchlorate that contaminates an estimated ten percent of the public water supplies in California and that scientists believe crosses the placenta and passes from mother to infant in breast milk (EWG 2000).

CHAPTER 4: TSCA and Reform

Imagine a regulatory system designed in theory to protect hundreds of millions of people from the potential harm of tens of thousands of chemicals in products they use every day. Imagine that this system did not require any health or safety studies prior to the marketing and sale of a chemical; did not require any monitoring of chemicals once they were in use; allowed producers to claim virtually all information related to a chemical as confidential business information and thus forever shield it from public view; and did not allow the public any right to sue or otherwise force testing or monitoring when independent scientists confirmed that significant contamination or hazards may exist.

You have just imagined the Toxic Substances Control Act, the nation's chief regulatory statute for commercial chemicals. TSCA, as it is known, is famous for the lack of authority it provides the Environmental Protection Agency. Under TSCA a chemical company is under no legal obligation to understand how its products might harm human health. And in fact, only after scientists have amassed a body of evidence linking the chemical to human harm can the federal government ban it or leverage a phase out. A string of Congressional hearings and reports from the General Accounting Office have thoroughly documented this fact. With no statutory power to request data on a chemical prior to proving harm, which it typically cannot prove without the data it is seeking, the EPA has essentially given up trying to use TSCA to better understand the potential hazards of the tens of thousands of chemicals in use today.

More than 63,000 chemicals were granted blanket approval for use in consumer and industrial products with the passage of TSCA in 1976. The federal government reviews the safety of chemicals invented since that time through an application process that does not require health and safety test data and that discourages voluntary testing. Companies submit basic toxicity data with fewer than half of all applications to manufacture new chemicals; the government approves 80 percent of these with no restrictions and no requests for tests. Eight of 10 new chemicals win approval in less than three weeks, at an average rate of seven a day.

Companies can volunteer any studies they may have performed to files and dockets maintained by the Environmental Protection Agency, but in the absence of any voluntary submissions, EPA is forced to rely on computer models to estimate if an industrial

THE REGULATORY PRECEDENT OF PESTICIDES

Industrial chemicals are governed by the nearly nonexistent health and safety standards of the Toxic Substances Control Act (TSCA). Pesticides, in contrast, comply with rigorous mandatory testing requirements, proof that the chemical industry can conduct health and safety studies on its products with minimal economic impact.

Pesticides in food are regulated under section 408 of the Food Drug and Cosmetic Act, which requires chemical companies to show that there is a "reasonable certainty of no harm" from exposure to a pesticide, for all exposed individuals, including explicit consideration of the fetus, infant and small child. This standard, which is well defined in case law and regulations, applies to all uses and all routes of exposure to a pesticide (food, air, and water considered together). "Reasonable certainty of no harm" is protective of the public health, particularly where the finding is contingent on fetal and infant exposure, but is not so protective that it cannot be met, or that companies can argue that it is onerous.

Section 408 also requires that pesticides with common mechanisms of toxicity be added together when assessing compliance with the reasonable certainty of no harm standard. This means that groups of pesticides, for example, all organophosphates, are added together when measuring compliance. In contrast, TSCA does not require that regulators assess the additive risks. Many major chemical classes commonly used in consumer products are characterized by common mechanisms of toxicity - phthalates, perfluorinated chemicals, and polybrominated diphenyl ethers, for example - and none are assessed in aggregate by EPA.

When data are not available, legal exposures for infants and children are required to be 10 times lower than for adults, and economic benefits are not allowed as an escape valve, or a means to permit higher risk.

To ensure that these tough standards can be met, the other governing statute,

chemical might be toxic to humans.

In 1998 EPA found that chemical manufacturers had failed to volunteer even the most basic information on chemical properties or toxicity for an estimated 43 percent of the 2800 chemicals produced in the highest quantities in the U.S. (EPA 1998b). A voluntary testing program grew out of this finding. Under this program, called the High Production Volume chemical testing program, or HPV program, participating companies submit their interpretation (but not the data) of eighteen basic screening tests, only one-third of which are directly relevant to human health and none of which include even a standard two-year cancer study, or tests for birth defects linked to low doses.

The group that leads the federal government's efforts to assess testing needs on the health effects of industrial chemicals, the Interagency Testing Committee, or ITC, recently identified through the use of computer models 392 industrial chemicals expected to build up in the human body for which EPA lacks basic data from the manufacturers on chemical properties, uses, and toxicity. Among these are chemicals used in fragrances, dyes and pigments, polyurethane foam, and pesticides. There is no plan to study the presence of these chemicals in humans.

In effect, the nation has no regulatory system for chemicals that are not directly added to food (pesticides and food additives). Instead we have a shell of a program that by law has weak authority to study, much less restrict, the use of chemicals in commerce.

This statutory void has produced:

- Widespread, pervasive contamination of the human population with hundreds of chemicals at low dose mixtures that have never been examined for any of their potential health effects.

- An industry that has no legal obligation to conduct safety tests or monitor for the presence of its chemicals in the environment or the human population – and a significant financial incentive not to do so.

- A federal research establishment that is completely unequipped, both technically and financially, to monitor the human population for commercial chemicals or to study their health effects.

FIFRA (the Federal Insecticide Fungicide and Rodenticide Act), grants the EPA administrator broad (virtually unlimited) authority to request data, and to suspend the sale of the product when data are not generated (section 3, particular 3(c)2(B), and section 6). This is the key reform.

The legislative history of FIFRA is instructive. Beginning in the early 1980's a series of congressional committee investigations and GAO reports documented that basic health studies had not been conducted for most pesticides on the market at that time. In response, Congress amended FIFRA in 1988 to require that all pesticides be "reregistered," which meant that they had to be tested by contemporary standards and re-evaluated for their health risks.

This forced the EPA to deal with the same problem that they face today when considering a comprehensive testing program for toxic chemicals: what to do with all the chemicals already on the market?

EPA's response, which largely was successful, albeit slow, was to impose strict timelines for testing and reevaluation while granting EPA clear authority to require any test for any pesticide, and the authority to suspend the sale of a pesticide if the manufacturer refuses to do the test or fails to submit it on time. Compare this with TSCA where EPA must go through a rulemaking just to get one test on one chemical.

As a result of these amendments, EPA now requires about 120 tests for pesticide registration. These tests range from acute and chronic toxicity, to metabolism, environmental fate and residue chemistry. These tests include toxicity tests that will support regulatory decision making, not the superficial screening tests being conducted under the HPV testing program. EPA has re-evaluated nearly all pesticides of any significance, starting in the early 1990's with more than 100 pesticide active ingredients in about 20,000 different products applied to food crops. There is no reason that these same test requirements could not be applied in a tiered fashion to commercial chemicals regulated under TSCA.

- An ever increasing load of chemical contamination in the human population and global environment that is comprised almost entirely of poorly studied chemicals that have never before been encountered in all of evolutionary history.

In this study, a total of 167 chemicals, pollutants and pesticides were found in the blood and urine of nine individuals in a series of comprehensive tests. On average, analysts found 91 chemicals per person, with a range of from 77 to 106 pollutants and pesticides in the nine individuals studied.

The chemical industry and its supporters argue that 50 or more carcinogens in an individual's bloodstream is safe and accounts for negligible increased cancer risk. The doses, they say, are too low to cause harm.

But there is no science to support this assertion.

The truth is that nobody knows the effects of the low dose mixtures of chemicals identified in this study, and the hundreds of other chemicals that are certain to be present in the body, but for which we could not test. Federal law imposes few health and safety testing requirements on the chemical industry, and sets few public health goals for chemical exposure or use.

Instead, industry decides what tests are done, when they are done, what the results mean, and who gets to see them. Overall, this system has left a void of scientific knowledge on the health and environmental hazards of nearly all chemicals found in consumer products and in people.

Safety margins erode further - new chemicals are invented daily.

The chemical industry gains permission to put more than 2000 new chemicals into the biosphere each year, with no knowledge of the health impact on the exposed human population. People are given no warning of this exposure nor do they have the option not to be exposed.

The predictable outcome of this arrangement is that the dangers of chemicals are discovered only after widespread exposure and harm has occurred. The more recently a chemical has been introduced into commerce, the less scientists understand its toxicity, and the less likely it is that scientists will know how to test for it in people and the environment. New chemicals

TESTING REQUIREMENTS ALONE CAN REMOVE DANGEROUS PRODUCTS FROM THE ENVIRONMENT

By themselves, testing requirements have driven many hazardous compounds off the market. One good example is methoxychlor, a DDT relative, which was banned with little fanfare in 1999 when the manufacturer simply refused to conduct required health studies. Another good example is pesticides used in aircraft cabins. In 1995 EPA asked all manufacturers of pesticides applied inside commercial airplanes to do the exposure studies needed to show the use was safe. Not a single manufacturer of more than 200 products was willing to do the tests (because they knew that the use was not safe), and all uses of pesticides inside aircraft were unceremoniously banned in the United States in 1998.

Another great example of the power of FIFRA's data generation authority involves the toxic byproducts of chlorinating tap water. The Safe Drinking Water Act does not give the EPA authority to require toxicity tests for drinking water contaminants. As a result, the agency is forced to negotiate test programs with polluters or the affected industry, or to pay for the testing from their own research funds. But because chlorine is a pesticide (it kills microbes in water), EPA was able to use the data call-in authority of FIFRA to require the chlorine industry to do a broad range of toxicity tests on chlorination byproducts that they otherwise had not planned to do.

enter the marketplace with no, or only a handful of, toxicity studies. The few chemicals or chemical families that have been well-studied are those for which scientists uncovered, often accidentally, catastrophes or widespread contamination (Figure 2). For instance, the earnest study of DDT toxicity did not start until the discovery that the chemical was driving into extinction a number of bird species, including bald eagles. Intense research on the toxicity of perfluorinated chemicals is beginning only now, after 3M discovered that these Scotchgard ingredients, in use for 50 years, have broadly contaminated humans and are more toxic than previously believed.

And even for the best-studied chemicals, scientists have yet to gain a full understanding of health effects. When setting safety standards for electrical insulators called PCBs, banned in the U.S. since the 1970s, the World Health Organization reviewed 1,200 studies on PCB's harmful effects and properties, but found only 60 that were relevant. In a similar review of PCBs the U.S. government enumerated 14 categories of uncertainty encompassing every step from human exposure to manifestation of health effects (EPA 1996). PCBs are among the best-studied chemicals in the world.

Chemical companies are not required to develop or divulge methods to test for the presence of their chemicals in the environment or the human body. Typically, only after a compound has been on the market for decades and contaminated a significant portion of the environment do independent scientists learn how to detect and quantify it. At that point, the Centers for Disease Control and Prevention (CDC) may choose to test for it in the general population, but even then there is no guarantee that the manufacturer will provide CDC with the methodology to detect it, or that the methods will be reliable. For instance, three years after 3M announced that it was removing the principle perfluorinated compound, PFOS (Scotchgard), from the market, chiefly because it contaminated the blood stream of the entire human race, the CDC still does not have a test method that it considers reliable to find the chemical in human blood.

Ignorance by Design

Detailed analyses by the U.S. EPA (EPA 1998b) and Environmental Defense (ED 1998) make clear how few health effects studies are available even for chemicals produced in the highest volumes. In a review of all publicly available toxicity and environmental fate studies, they found no information – not a single test - for 43 percent of the 2600 chemicals produced in the highest volumes in

the US, with yearly production volumes of more than 1,000,000 pounds. Our study offers stark confirmation: for 55 compounds found in the nine individuals tested (one third of the chemicals identified), there is *no information available* - on chemical uses or health effects - in any of the eight standard industry and government references used for this analysis.

The work by the EPA and ED was important in establishing a baseline measure of data availability. But the tallies in the EPA and ED reports are only as meaningful as the studies they are counting. Both analyses focus on a limited universe of toxicity screens that themselves are not detailed enough to support regulation, and are not targeted toward the most meaningful and relevant health effects. But far worse than the numbers is the policy outcome that these analyses produced: a voluntary program for industry to conduct hundreds more of these same toxicity screens.

Launched with much fanfare in 1999, the so-called high production volume chemical screening, or HPV program, has not yielded data for EPA to review. Instead chemical manufacturers are submitting *summaries* of the screening studies, leaving EPA and the public at the mercy of industry's interpretations of the data, which are not subject to independent peer review. The program is voluntary, and the EPA is powerless to demand any additional information. At the same time the HPV program provides invaluable public relations cover for the chemical manufacturers in the form of thousands of "studies" being conducted "voluntarily" at "great expense."

And even if the actual screening study data were submitted, much of it would be of limited use. Consider the so-called cancer screens. In reality, what industry calls a cancer screen for public relations purposes under the HPV program, is nothing but a mutagenicity assay in a lab dish that both industry and regulators routinely dismiss as inconclusive in the absence of two-year animal studies confirming a carcinogenic effect.

Scientists often study the wrong thing

The nature of our ignorance of chemical exposure is more complicated than tallies of study numbers can convey. There are fundamental problems with even the best regulatory study methodologies when they are applied to the body burden of chemicals identified in this study. The vast majority of toxicity tests required by government regulators have limited relevance to the exposures that are occurring in the human population.

In a typical animal study required by the EPA, scientists test a single chemical in adult animals at high doses. The outcomes analyzed can include increases in the occurrence of tumors, changes in organ weight, or visible birth defects. Scientist don't typically look for functional changes in response, such as brain development, following developmental exposure. Required developmental toxicity studies do not evaluate development after birth and tend to be less sensitive than studies that do assess postnatal function. A 1998 EPA draft report titled "A Retrospective Analysis of Twelve Developmental Neurotoxicity Studies Submitted to the USEPA Office of Prevention, Pesticides and Toxic Substances (OPPTS)" found that the developmental neurotoxicity study resulted in a lower "no observed effect level" for 10 of 12 chemicals compared to the required developmental rat studies that did not look at brain development (Makris, et al. 1998). The developmental neurotoxicity test is not a required test. EPA has requested it for only a small number of chemicals.

In contrast to high dose regulatory studies, people are exposed to multiple chemicals, from conception to death, at relatively low doses. The effects that occur can be subtle, detected across the general population as slight drops in IQ or fertility, or increases in specific types of cancer.

Some scientists, particularly those employed by the chemical industry, argue that "the mere presence" of small amounts of hundreds of chemicals in your bloodstream is biologically insignificant. High dose animal studies are typically offered as proof of this assertion. The truth, however, is that high dose animal studies cannot prove or disprove the safety of chemical exposures at lower doses, particularly when these studies are conducted primarily on adult animals, do not look for health endpoints relevant to low dose exposures, and do not account for interactions with other chemicals to which people are routinely exposed.

Industry's dogmatic allegiance to the high dose theory of toxicology can be traced to the 16th century philosopher Paracelsus, whose philosophy is summarized in the well-known adage "The dose makes the poison." The scientific and regulatory infrastructure in the US is based on studies that feed animals high doses of chemicals in the belief that a high dose will elicit any and all toxic effects that a compound can produce. In practice, if a high dose doesn't elicit a readily measured toxic effect, then industry argues and regulators assume that the substance is not toxic. We now know that this is not true.

Science has advanced in the past 500 years, and outside of regulatory toxicology it is generally accepted that other factors besides dose, most notably the timing of the dose, are equally as important factors in determining the toxic effect.

The most obvious example is fetal exposure, where exposure *in utero* can produce long lasting adverse effects at amounts that produce no observable effects in adults. This outcome is documented in the scientific literature for lead, mercury and PCBs, where exposures in the parts per billion range in the womb or during infancy can lower IQ's or alter behavior, while the same dose produces no observable effects in an adult. Dioxin is another case in point. Men with 80 parts per trillion of dioxin in their blood father nearly twice as many girls as boys. This effect would not have been predicted based on studies of adults.

Many of the compounds detected in this study have been studied and found to cause adverse human effects at low doses. Other chemicals detected in this study have not been tested at all.

Policy Recommendations

TSCA reform

Seven chemicals or chemical classes have been regulated or banned under the Toxic Substances Control Act (TSCA). When compared to the 75,000 chemicals registered for commercial use, the impact of TSCA is nearly imperceptible in the overall context of human chemical exposure. It is little wonder that the chemical industry considers TSCA the only truly workable federal environmental law.

Under TSCA, chemicals are assumed safe until they are proven hazardous. At the same time, the law does not require that manufacturers conduct health and safety studies, nor does it impose a duty on manufacturers to monitor how their products are used or where they end up in the environment.

As a starting point for a major environmental statute, this is problematic.

TSCA puts the burden of proving a chemical's hazards squarely on the shoulders of the EPA (section 4 (1)(A)). The statute then prohibits the EPA from requiring safety tests unless the agency can prove that the chemical presents an unreasonable risk – which it can almost never prove because it cannot require the

studies needed to make that finding. If the agency assembles enough data to require industry to conduct safety studies, it must go through the lengthy process of promulgating a test rule, very similar to a regulatory rule making, to mandate even one test for one chemical. When the data are generated, industry can claim the tests as confidential business information or trade secrets, and thus shield the tests from independent peer review or public scrutiny.

This law is so fundamentally broken that the statute needs to be rewritten. Revisions to the nation's toxic substance laws must include the following provisions:

- For chemicals currently manufactured and used commercially, the chemical industry must submit to EPA all internal studies on the properties, environmental fate, potential human exposure pathways and exposure levels, concentrations in workers and the general population, levels in the environment, worker and community health, measured effects in wildlife, toxicity, mechanisms of action and any other information relevant to human exposures and potential health effects. These studies must be made available to the public.

- Industry must be required to prove the safety of a new chemical before it is put on the market.

- The EPA must have the unencumbered authority to request any and all new data on a chemical that is already on the market.

- The EPA must have the clear authority to suspend a chemical's production and sale if the data requested are not generated, or if they show that the chemical, as used, is not safe for the most sensitive portion of the exposed population.

- Chemicals that persist in the environment or bioaccumulate in the food chain must be banned. Currently EPA cannot demand the data needed to make this determination, and industry is not volunteering it.

- Chemicals found in humans, in products to which children might be exposed, in drinking water, food, or indoor air, must be thoroughly tested for their health effects in low dose, womb-to-tomb, multi-generational studies focused on known target organs, that include sensitive endpoints like organ function and cognitive development. Studies

to define mechanisms of action (how a chemical harms the body) must be conducted.

- The chemical industry must develop and make public analytical methods to detect their chemicals in the human body, and conduct biomonitoring studies to find the levels of their chemicals in the general population.

- Chemical manufacturers must fully disclose the ingredients of their products to the public.

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