

# Body Burden – The Pollution in Newborns

## **A benchmark investigation of industrial chemicals, pollutants and pesticides in umbilical cord blood**

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**Summary.** In the month leading up to a baby's birth, the umbilical cord pulses with the equivalent of at least 300 quarts of blood each day, pumped back and forth from the nutrient- and oxygen-rich placenta to the rapidly growing child cradled in a sac of amniotic fluid. This cord is a lifeline between mother and baby, bearing nutrients that sustain life and propel growth.

Not long ago scientists thought that the placenta shielded cord blood — and the developing baby — from most chemicals and pollutants in the environment. But now we know that at this critical time when organs, vessels, membranes and systems are knit together from single cells to finished form in a span of weeks, the umbilical cord carries not only the building blocks of life, but also a steady stream of industrial chemicals, pollutants and pesticides that cross the placenta as readily as residues from cigarettes and alcohol. This is the human "body burden" — the pollution in people that permeates everyone in the world, including babies in the womb.

In a study spearheaded by the Environmental Working Group (EWG) in collaboration with Commonweal, researchers at two major laboratories found an average of 200 industrial chemicals and pollutants in umbilical cord blood from 10 babies born in August and September of 2004 in U.S. hospitals. Tests revealed a total of 287 chemicals in the group. The umbilical cord blood of these 10 children, collected by Red Cross after the cord was cut, harbored pesticides, consumer product ingredients, and wastes from burning coal, gasoline, and garbage.

This study represents the first reported cord blood tests for 261 of the targeted chemicals and the first reported detections in cord blood for 209 compounds. Among them are eight perfluorochemicals used as stain and oil repellants in fast food packaging, clothes and textiles — including the Teflon chemical PFOA, recently characterized as a likely human carcinogen by the EPA's Science Advisory Board — dozens of widely used brominated flame retardants and their toxic by-products; and numerous pesticides.

Of the 287 chemicals we detected in umbilical cord blood, we know that 180 cause cancer in humans or animals, 217 are toxic to the brain and nervous system, and 208 cause birth defects or abnormal development in animal tests. The dangers of pre- or post-natal exposure to this complex mixture of carcinogens, developmental toxins and neurotoxins have never been studied.

## Chemicals and pollutants detected in human umbilical cord blood



### **Mercury (Hg) - tested for 1, found 1**

Pollutant from coal-fired power plants, mercury-containing products, and certain industrial processes. Accumulates in seafood. Harms brain development and function.



### **Polyaromatic hydrocarbons (PAHs) - tested for 18, found 9**

Pollutants from burning gasoline and garbage. Linked to cancer. Accumulates in food chain.



### **Polybrominated dibenzodioxins and furans (PBDD/F) - tested for 12, found 7**

Contaminants in brominated flame retardants. Pollutants and byproducts from plastic production and incineration. Accumulate in food chain. Toxic to developing endocrine (hormone) system



### **Perfluorinated chemicals (PFCs) - tested for 12, found 9**

Active ingredients or breakdown products of Teflon, Scotchgard, fabric and carpet protectors, food wrap coatings. Global contaminants. Accumulate in the environment and the food chain. Linked to cancer, birth defects, and more.



### **Polychlorinated dibenzodioxins and furans (PBCD/F) - tested for 17, found 11**

Pollutants, by-products of PVC production, industrial bleaching, and incineration. Cause cancer in humans. Persist for decades in the environment. Very toxic to developing endocrine (hormone) system.



### **Organochlorine pesticides (OCs) - tested for 28, found 21**

DDT, chlordane and other pesticides. Largely banned in the U.S. Persist for decades in the environment. Accumulate up the food chain, to man. Cause cancer and numerous reproductive effects.



### **Polybrominated diphenyl ethers (PBDEs) - tested for 46, found 32**

Flame retardant in furniture foam, computers, and televisions. Accumulates in the food chain and human tissues. Adversely affects brain development and the thyroid.



### **Polychlorinated Naphthalenes (PCNs) - tested for 70, found 50**

Wood preservatives, varnishes, machine lubricating oils, waste incineration. Common PCB contaminant. Contaminate the food chain. Cause liver and kidney damage.



### **Polychlorinated biphenyls (PCBs) - tested for 209, found 147**

Industrial insulators and lubricants. Banned in the U.S. in 1976. Persist for decades in the environment. Accumulate up the food chain, to man. Cause cancer and nervous system problems.

Source: Chemical analyses of 10 umbilical cord blood samples were conducted by AXYS Analytical Services (Sydney, BC) and Flett Research Ltd. (Winnipeg, MB).

Chemical exposures in the womb or during infancy can be dramatically more harmful than exposures later in life. Substantial scientific evidence demonstrates that children face amplified risks from their body burden of pollution; the findings are particularly strong for many of the chemicals found in this study, including mercury, PCBs and dioxins. Children's vulnerability derives from both rapid development and incomplete defense systems:

- A developing child's chemical exposures are greater pound-for-pound than those of adults.
- An immature, porous blood-brain barrier allows greater chemical exposures to the developing brain.
- Children have lower levels of some chemical-binding proteins, allowing more of a chemical to reach "target organs."
- A baby's organs and systems are rapidly developing, and thus are often more vulnerable to damage from chemical exposure.
- Systems that detoxify and excrete industrial chemicals are not fully developed.
- The longer future life span of a child compared to an adult allows more time for adverse effects to arise.

The 10 children in this study were chosen randomly, from among 2004's summer season of live births from mothers in Red Cross' volunteer, national cord blood collection program. They were not chosen because their parents work in the chemical industry or because they were known to bear problems from chemical exposures in the womb. Nevertheless, each baby was born polluted with a broad array of contaminants.

U.S. industries manufacture and import approximately 75,000 chemicals, 3,000 of them at over a million pounds per year. Health officials do not know how many of these chemicals pollute fetal blood and what the health consequences of *in utero* exposures may be.

Had we tested for a broader array of chemicals, we would almost certainly have detected far more than 287. But testing umbilical cord blood for industrial chemicals is technically challenging. Chemical manufacturers are not required to divulge to the public or government health officials methods to detect their chemicals in humans. Few labs are equipped with the machines and expertise to run the tests or the funding to develop the methods. Laboratories have yet to develop methods to test human tissues for the vast majority of chemicals on the market, and the few tests that labs are able to conduct are expensive. Laboratory costs for the cord blood analyses reported here were \$10,000 per sample.

A developing baby depends on adults for protection, nutrition, and, ultimately, survival. As a society we have a responsibility to ensure that babies do not enter this world pre-polluted, with 200 industrial chemicals in their blood. Decades-old bans on a handful of chemicals like PCBs, lead gas additives, DDT and other pesticides have led to significant declines in people's blood levels of these pollutants. But good news like this is hard to find for other chemicals.

The Toxic Substances Control Act, the 1976 federal law meant to ensure the safety of commercial chemicals, essentially deemed 63,000 existing chemicals "safe as used" the day the law was passed, through mandated, *en masse* approval for use with no safety scrutiny. It forces the government to approve new chemicals within 90 days of a company's application at an average pace of seven per day. It has not been improved for nearly 30 years — longer than any other major environmental or public health statute — and does nothing to reduce or ensure the safety of exposure to pollution in the womb.

Because the Toxic Substances Control Act fails to mandate safety studies, the government has initiated a number of voluntary programs to gather more information about chemicals, most notably the high production volume (HPV) chemical screening program. But these efforts have been largely ineffective at reducing human exposures to chemicals. They are no substitute for a clear statutory requirement to protect children from the toxic effects of chemical exposure.

In light of the findings in this study and a substantial body of supporting science on the toxicity of early life exposures to industrial chemicals, we strongly urge that federal laws and policies be reformed to ensure that children are protected from chemicals, and that to the maximum extent possible, exposures to industrial chemicals before birth be eliminated. The sooner society takes action, the sooner we can reduce or end pollution in the womb.

### Tests show 287 industrial chemicals in 10 newborn babies

*Pollutants include consumer product ingredients, banned industrial chemicals and pesticides, and waste byproducts*

Sources and uses of chemicals in newborn blood	Chemical family name	Total number of chemicals found in 10 newborns (range in individual babies)
<b>Common consumer product chemicals</b> (and their breakdown products)		<b>47 chemicals</b> (23 - 38)
Pesticides, actively used in U.S.	Organochlorine pesticides (OCs)	7 chemicals (2 - 6)
Stain and grease resistant coatings for food wrap, carpet, furniture (Teflon, Scotchgard, Stainmaster...)	Perfluorochemicals (PFCs)	8 chemicals (4 - 8)
Fire retardants in TVs, computers, furniture	Polybrominated diphenyl ethers (PBDEs)	32 chemicals (13 - 29)
<b>Chemicals banned or severely restricted in the U.S.</b> (and their breakdown products)		<b>212 chemicals</b> (111 - 185)
Pesticides, phased out of use in U.S.	Organochlorine pesticides (OCs)	14 chemicals (7 - 14)
Stain and grease resistant coatings for food wrap, carpet, furniture (pre-2000 Scotchgard)	Perfluorochemicals (PFCs)	1 chemicals (1 - 1)
Electrical insulators	Polychlorinated biphenyls (PCBs)	147 chemicals (65 - 134)
Broad use industrial chemicals	Polychlorinated naphthalenes	50 chemicals

- flame retardants, pesticides, electrical insulators	(PCNs)	(22 - 40)
<b>Waste byproducts</b>		<b>28 chemicals (6 - 21)</b>
Garbage incineration and plastic production wastes	Polychlorinated and Polybrominated dibenzo dioxins and furans (PCDD/F and PBDD/F)	18 chemicals (5 - 13)
Car emissions and other fossil fuel combustion	Polynuclear aromatic hydrocarbons (PAHs)	10 chemicals (1 - 10)
Power plants (coal burning)	Methylmercury	1 chemicals (1 - 1)
<b>All chemicals found</b>		<b>287 chemicals (154 - 231)</b>

Source: Environmental Working Group analysis of tests of 10 umbilical cord blood samples conducted by AXYS Analytical Services (Sydney, BC) and Flett Research Ltd. (Winnipeg, MB).

### **Babies are vulnerable to chemical harm**

Parents know intuitively that babies in the womb are more vulnerable to the effects of industrial chemicals than adults. A pregnant woman may avoid using hair dye and nail polish, pumping gas, or painting the nursery, for example, to protect her baby. This intuition is backed by science that has unfolded primarily over the past two decades. In 1993 the National Academy of Sciences enumerated, in a Congressionally mandated study, the primary factors that contribute to children's unique vulnerability to the harmful effects of chemicals (NAS 1993):

- A developing child's chemical exposures are greater pound-for-pound than those of adults.
- An immature, porous blood-brain barrier allows greater chemical exposures to the developing brain.
- Children have lower levels of some chemical-binding proteins, allowing more of a chemical to reach "target organs."
- A baby's organs and systems are rapidly developing, and thus are often more vulnerable to damage from chemical exposure.
- Systems that detoxify and excrete industrial chemicals are not fully developed.
- The longer future life span of a child compared to an adult allows more time for adverse effects to arise.

The pace and complexity of growth and development in the womb are unmatched later in life. Three weeks after conception, an embryo, still only 1/100th the size of a water droplet, has nevertheless grown at such an explosive rate that were it not to slow down, it would be born literally the size of a million Earths. Over the next five weeks the baby constructs the beginnings of elbows, knees, eyelids, nipples, hair follicles on chin and upper lip, external

genitals, primitive internal organs, a four-chambered heart, working fingers and toes, and even a footprint (Greene 2004). At no other time in life does a person create so much from so little in so short a time. Industrial chemicals that interrupt this intricate process can, at high levels, wreak havoc in the form of severe birth defects, or at lower levels cause subtle but important changes in development that surface later in childhood as learning or behavioral problems, or in adulthood in the form of certain cancers or perhaps neurodegenerative disease.

A recent review by government scientists of the "critical windows" of vulnerability reveals an urgent need for public health policies that recognize childhood sensitivity (Selevan et al. 2000). Many of these windows of vulnerability are found in the early months of human pregnancies, when cells are multiplying and differentiating into specific tissues and organs. Exposures during these times can lead to permanent damage. But a child's vulnerability continues long beyond early pregnancy: the central nervous system, immune, reproductive and endocrine systems, for example, continue to mature even after birth (NAS 1993, Makri et al. 2004). As a whole, these windows facilitate more pronounced risks and effects for chemical exposures in childhood than adulthood. For example, a mother's exposure to dioxins, mercury, or certain pesticides during pregnancy could measurably harm her baby, while affecting her own health perhaps not at all.

In a decades-long mercury poisoning disaster in Minamata, Japan that began in the 1950s, some babies born to women who ate mercury-polluted seafood died within days of birth, while their mothers were free of symptoms. Autopsies revealed that in adults, mercury induced lesions that were concentrated in a few areas of the brain. In the fetus, however, mercury spawned lesions over nearly the entire brain cortex.

In the decades following Minamata, scientists have developed a much fuller understanding of children's vulnerability to chemicals, discovering links between a host of health problems — including asthma, childhood cancer, and brain damage — and such common contaminants as solvents, pesticides, PCBs, and lead (Trasande and Landrigan, 2004). A recent National Academy of Sciences study suggests that environmental factors contribute to at least 28 percent of childhood developmental disabilities (NAS 2000a).

The latest research investigates not only relationships between disease and exposures, but the root causes of chemically-induced disease with *in utero* origins. This research pinpoints traits of a fetus that contribute to vulnerability: low levels of some chemical-binding proteins in the blood, immature excretion pathways, and an immature blood brain barrier, for instance, which combine to increase the transfer of chemicals from the blood to the aptly named "target organs" that may ultimately bear the harm.

The risks to a baby derive not only from his or her physical makeup, but also from the very behaviors and events that prepare the baby for life outside the womb. Beginning in the fifth month of pregnancy, babies regularly swallow and breathe, building muscles essential for survival after birth. Through these actions, the lungs and the gut are filled, again and again, with the same amniotic fluid that collects the baby's urine. Pollutants like plasticizers and pesticides excreted in urine accumulate in this fluid and are cycled right back into the baby's body through the mouth and nose. And in the third trimester the mother's body dissolves stored, maternal fat, shunting it to the baby through the blood, but with this fat the child also receives the persistent pollutants clinging to it, like PCB's, flame retardants, and dioxins. Faced with such diverse exposures and armed with a body ill-equipped to rid itself of

chemicals, it is small wonder that a developing baby so often proves vulnerable to chemical exposures (Makri et al. 2004).

Some studies are beginning to measure the sensitivity of a child relative to an adult for suffering impacts from chemical exposures. For instance, studies of mutagens called polyaromatic hydrocarbons (PAHs) — target chemicals examined in this study and waste products from burning gasoline and garbage — found that even though levels of PAHs are thought to be lower in the fetus than the mother (Srivastava et al. 1986), the fetus bears more cancer-inducing DNA damage from the exposures (Whyatt et al. 2001).

But health and environmental officials have been slow to act on the wealth of studies on childhood vulnerability produced in the past 20 years. After nearly a decade of review, the Environmental Protection Agency updated its cancer risk guidelines in 2003 to explicitly acknowledge the importance of childhood exposures. The agency concluded, after a review of 23 studies of early life exposures to cancer-causing chemicals, that carcinogens average 10 times the potency for babies than adults, and that some chemicals are up to 65 times more powerful (EPA 2005a).

EPA's new policy, though, targets only cancer. It leaves EPA with no formal policy regarding childrens' vulnerability to chemicals that damage the immune system, the brain, or the hormone system, kidney, liver, lungs, thyroid or a host of other potential targets, even though plenty of evidence says that children face higher risks for harm.

## Human health problems on the rise

Over the past 50 years, as infectious childhood diseases like polio, smallpox, rheumatic fever, and diphtheria have largely been controlled, chronic conditions of less obvious origins have taken their place. Asthma, autism, attention deficit and hyperactivity disorders (ADD and ADHD), childhood brain cancer and acute lymphocytic leukemia have all increased over the past 30 years. Five to ten percent of American couples are infertile. Up to half of all pregnancies end in miscarriage. Three to five percent of babies are born with birth defects (CDC 2004, Jahnke et al. 2005, Trasande and Landrigan 2004). Scientists cannot fully explain these increases, but early life exposure to environmental pollutants is a leading suspect.

**Fetal exposures lead to adult disease.** Some chemicals are directly toxic to an exposed child — lead and mercury, for example, which harm a developing brain — while other chemicals induce a chain of events that may culminate in a diagnosed health problem later in life. Hormone-mimicking chemicals like dioxins and furans, for example, could induce delayed cancers in hormone-sensitive tissues like the breast, testicle, or prostate gland. Chemicals like PCBs or DDT can reduce growth rates in the womb, initiating in low birthweight babies lasting, internal survival mechanisms that cascade into cardiovascular disease or diabetes later in life.

<b>AUTISM</b>	<b>10X</b>	<b>increase</b> early 80's-1996
<b>MALE BIRTH DEFECTS</b>	<b>2X</b>	<b>increase</b> hypospadias, 1970-1993
<b>CHILDHOOD ASTHMA</b>	<b>2X</b>	<b>increase</b> 1982-1993
<b>ACUTE LYMPHOCYTIC LEUKEMIA</b>	<b>62%</b>	<b>increase</b> in children, 1973-1999
<b>CHILDHOOD BRAIN CANCER</b>	<b>40%</b>	<b>increase</b> 1973-1994
<b>PRETERM BIRTH</b>	<b>23%</b>	<b>increase</b> mid 80's-2002
<b>INFERTILITY</b>	<b>5-10%</b>	<b>of couples</b>
<b>BIRTH DEFECTS</b>	<b>3-5%</b>	<b>of all babies</b>
<b>SPERM COUNTS</b>	<b>1%</b>	<b>decrease</b> yearly 1934-1996

Sources: Yeargin-Allsopp et al. 2003, CDC 1995, Robison et al. 1995, Schecter 1999, Ananth et al. 2001, Branum and Schoendorf 2002, Swan et al. 1998, Paulozzi et al. 1997, Dunson et al. 2004, Trasande and Landrigan 2004, Jahnke et al. 2005

The fact is, a child can bear a lifelong imprint of risks from the countless molecules of industrial pollutants that find their way through the placenta, down the umbilical cord, and into the baby's body. The consequences — health disorders, subtle or serious — can surface not only in childhood but also in adulthood. Studies now support origins in early life exposures for a startling array of adult diseases, including Alzheimers, mental disorders, heart disease, and diabetes.

Laboratory studies show increased deposits of the Alzheimer-related protein amyloid in the brains of older animals exposed to lead as newborns, but not in animals that were exposed to an equal amount of lead as adults (Basha et al. 2005). And over the past two decades numerous studies have linked low birth weight with adult onset of coronary heart disease, diabetes, stroke, hypertension, depression and other conditions (Barker 1995, Wahlbeck et al. 2001, Thompson et al. 2001, Hales et al. 1991). Low birth weight can arise not only from poor maternal nutrition but also from a host of industrial pollutants, including arsenic, mercury, lead, organic solvents, PCBs, and pesticides, including DDT.

Recent studies shed new light on how early life chemical exposures set adult disease in motion. In laboratory studies scientists from the University of Texas found that fetal exposures to the synthetic hormone (and now-banned drug) DES permanently "reprogrammed" body tissues, dramatically raising rates of uterine cancer, in this case, in later life (Cook et al. 2005). With an estimated 75,000 chemicals registered for use in the U.S., and an average of seven new chemicals approved each day, many not tested for safety and certainly not tested for their ability to "reprogram" body tissues, the ramifications of this study are enormous.

**Fetal exposures cause disease in future generations.** Remarkably, it appears that early life exposures can lead to health problems not only in adulthood, but also down through subsequent generations. For instance, adult diseases linked to newborns' low birth weight, enumerated above, cause adverse effects not only in those babies born small, but also in their children of any birth size, through heritable changes in gene expression that result in a phenomenon known as "epigenetic inheritance." Very different from genetic mutations, which are physical changes in gene structure, epigenetic inheritance is instead characterized by certain genes being turned on or off, but near permanently in ways that can be inherited.

If a genetic mutation is like changing a light fixture, the comparable epigenetic change would involve taping the light switch on or off. Since genes are responsible for making the chemicals that build and repair the body, this unnatural forcing to a permanent on or off position can have far-reaching consequences. In humans, both kinds of genetic changes, mutations as well as epigenetic changes in gene expression, can be passed down to a baby in the womb.

Scientists have recently found heritable epigenetic changes linked to the fungicide vinclozolin and pesticide methoxychlor, which impaired sperm counts and sperm motility not only among animals exposed in utero, but also in three subsequent generations (Anway et al. 2005). In other words, what each of us was exposed to in our mother's womb might affect the health of our great-grandchildren.

Notably, both of these pesticides were recently banned under a federal law that requires pesticides to be safe for newborns and children. The government gives children no explicit protection under the federal law meant to ensure the safety of other commercial chemicals (the Toxic Substances Control Act), even though risks from childhood exposures to industrial chemicals are no lower than those from pesticides.

**Cord blood pollutants in this study, linked to health problems.** Scientific studies implicate some of the chemicals we detected in cord blood with serious, ongoing human health problems:

- **Dioxin** exposures during fetal development have been implicated in endocrine-related cancers in women (breast and uterine, for example) by altering hormone levels, increasing the sensitivity of children and adolescents to other carcinogens (Birnbaum and Fenton 2003). In men, tiny levels of dioxin in the range of 0.02 to 10 parts per billion alter testosterone levels and are linked with diabetes (EPA 2004a). 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. As body burdens increase within and above these ranges, the likelihood, severity, and potential spectrum of non-cancer effects increases (EPA 2004a). Fetal dioxin exposure can harm the immune system, thyroid, and brain (Van Loveren et al. 2003, Faroon et al. 2001, ten Tusscher and Koppe 2004). Dioxin from garbage incinerators is associated with increased incidence of infant death and birth defects (Tango et al. 2004).

- **Methylmercury** exposure in the womb causes measurable declines in brain function in children exposed to levels corresponding to 58 parts per billion in maternal blood (NAS 2000b). Researchers in the Netherlands found a doubling in the risk of heart attacks and death from coronary heart disease at methylmercury hair levels of 2 mg/kg, which corresponds to about one fifth the assumed safe maternal blood level (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 what the EPA considers a safe maternal blood level (NAS 2000b, Sorensen et al. 1999).
- **PCBs** at 9.7 ppb in maternal serum during fetal development can impair brain development, with resultant attention and IQ deficits that appear to be permanent (Jacobson and Jacobson 1996). Notably, IQ deficits are linked to the mother's PCB levels, not the PCB levels in children at 4 and 11 years of age (by which time the children's PCB levels had decreased substantially compared to levels at birth), underscoring the limitations of studies that look for correlations between current body burdens and health effects in the absence of data on *in utero* exposures. Levels of PCBs in the general population are also associated with abnormal menstrual cycles (Cooper et al. 2005).
- **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 the banned, persistent pesticide DDT. Using the associations derived from tests of archived blood samples from a pool of 42,000 women, researchers estimated that DDT exposures in the U.S. population could have accounted for up to 15 percent of infant deaths during the 1960s. Low birth weight is recognized as a risk factor for type II diabetes, high blood pressure, and cardiovascular disease later in life (Prentice and Moore 2005, 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).

### Some facts about human health trends

**Cancer.** Cancer incidence has steadily increased over the decades for many forms of the disease, including breast, prostate, and testicular (NCI 2005). The incidence of childhood cancer increased by 27.1 percent between 1975 and 2002, with the sharpest rise estimated for brain and other nervous system cancers (56.5 percent increase) and acute lymphocytic leukemia (68.7 percent increase). The incidence of testicular cancer also steadily rose 66

percent between 1975 and 2002 (NCI 2005). The probability that a U.S. 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 2004). A broad array of environmental factors plays a pivotal role in the initiation and promotion of cancer. Just 5 to 10 percent of all cancers are directly linked to inherited, genetic factors (ACS 2001).

- **Breast cancer.** Among girls born today, one in seven 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).
- **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). Testicular cancer is now the most common cancer in men age 15 to 35 (NCI 2005).
- **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).

**Major nervous system disorders.** Several recent studies have determined that the reported incidence of autism is increasing, and is now almost 10 times higher than in the mid-1980's (Byrd 2002, Chakrabarti and Fombonne 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 likely contributor. Environmental factors have also been increasingly linked with Parkinson's disease (Checkoway and Nelson 1999, Engel et al. 2001).

**Preterm births and low birth weights.** Preterm births have increased 23 percent over the past 2 decades; low-weight births have become more common (Ananth et al 2001, Branum and Schoendorf 2002). The causes are largely unknown, but environmental factors such as chemical pollutants and nutrition are thought to play a role. Low birth weight has been linked to adult obesity, diabetes, cardiovascular disease, schizophrenia, and other conditions (Barker 1995, Wahlbeck et al. 2001, Thompson et al. 2001, Hales and Ozanne 2003). It has also been linked to lower academic performance, neurosensory impairment, and lower rates of pregnancy in the offspring (Hack et al. 2002).

**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. 2003). 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). Rates of hypospadias, a physical deformity of the penis, have risen in recent years (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, Paulozzi 1999). Several studies have suggested links between developmental exposure to environmental contaminants and cryptorchidism or testicular cancer (Hardell, et al. 2003, Hosie, et al. 2000, Toppari, et al. 1996, Weidner, et al. 1998).

- **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.** 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). Data from the Centers for Disease Control and Prevention show that rates 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.
- **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).

Together with 287 industrial pollutants in 10 newborn babies, this body of science and the litany of serious, continuing human health concerns reveals the critical need for reform of our system of public health protections, which fails to require proof that chemicals are safe for children.

## **Recommendations**

U.S. industries manufacture and import approximately 75,000 chemicals, 3,000 of them at over a million pounds per year. Studies show that hundreds of industrial chemicals circulate in the blood of a baby in the womb, interacting in ways that are not fully understood. Many more pollutants are likely present in the womb, but test methods have yet to be developed that would allow health officials to comprehensively assess prenatal exposure to chemicals, or to ensure that these exposures are safe. From a regulatory perspective, fetal exposure to industrial chemicals is quite literally out of control.

The reason: the Toxic Substances Control Act (TSCA), the nation's notoriously weak chemical safety law. TSCA deprives the EPA of the most basic regulatory tools. The vast majority of chemicals in use today do not have anywhere near sufficient data needed to assess their safety, particularly their safety for the unborn baby or young child. Under TSCA, however, the EPA cannot require this data as a condition of continued chemical use. Instead,

the EPA must negotiate with industry or complete a formal "test rule" for every study that it needs, for every chemical on the market. Consequently, very few high quality toxicity tests are conducted.

When industry submits results of voluntary testing to the agency, huge portions, including key health and safety findings, are routinely redacted as confidential business information, meaning that even state regulatory agencies are not allowed to review them. If risks are identified and action is contemplated, minimizing "unreasonable" costs to industry is the TSCA mandate, no matter how serious the risks and no matter the population that bears them — even unborn babies. And if there is any scientific uncertainty, as there often is, TSCA prohibits precautionary action and requires certainty of harm before actions can be taken to protect the public health. TSCA has not been improved for nearly 30 years — longer than any other major environmental or public health statute.

This study and a strong body of supporting science suggest that fetal exposure to industrial chemicals is contributing to adverse health effects in the human population. This is cause for concern.

But experience also shows us that it is never too late to take action. Blood levels of PCBs and pesticides like DDT are lower today than 30 years ago when they were banned. Since these watershed actions in the 1970s, however, few industrial chemicals have been regulated to any significant degree. The various reasons for this stagnation — the need for data on chemical toxicity and exposure, lack of ambition at the EPA, and chemical industry intransigence — all come back to one central cause: the absence of a strong federal chemical safety law that provides the EPA with unambiguous statutory authority to take the actions needed to ensure that chemicals are safe.

Because TSCA does not mandate safety studies and makes it difficult for EPA to demand them, a number of voluntary initiatives to gather more information about chemicals have been attempted, most notably the high production volume (HPV) chemical screening program. These efforts, however, have been largely ineffective at reducing exposure and are no substitute for a clear statutory requirement to protect children from the toxic effects of chemical exposure.

Federal law must be reformed to ensure that children are protected from chemical exposures, and that to the maximum extent possible exposure to industrial chemicals before birth be eliminated entirely. The nation's pesticide law was amended nearly a decade ago to require explicit protection of infants and children from pesticides. Actions taken under the 1996 Food Quality Protection Act (FQPA) have reduced or eliminated children's exposures to a number of highly hazardous pesticides, with no discernable adverse impact on the availability or price of a wholesome food supply, and without adverse impact on the agricultural or pesticide industry. We recommend a similar standard be applied to commercial chemicals.

This would mean transforming TSCA into a true public health and environmental law, with the following core provisions. A new TSCA would:

- Require chemical manufacturers to demonstrate affirmatively that the chemicals they sell are safe for the entire population exposed, including children in the womb. In the absence of information on the risks of pre-natal exposure, chemicals must be assumed

to present greater risk to the developing baby *in utero*, and extra protections must be required at least as strict as the 10 fold children's safety factor in FQPA.

- Require that the safety of closely related chemicals, such as the perfluorochemicals used to make Teflon and other stain-resistant and water repellant products, be assessed as a group. The presumption would be that these chemicals have additive toxicity unless manufacturers clearly prove otherwise.
- Grant the EPA clear and unencumbered authority to demand all studies needed to make a finding of safety and to enforce clear deadlines for study completion.
- Remove from the market chemicals for which tests demonstrating safety are not conducted.
- Eliminate confidential business protection for all health, safety, and environmental information.
- Require that material safety data sheets provided to workers contain the results of studies conducted under these provisions.
- Provide strong incentives for green, safer chemicals in consumer products and industrial processes.

## Detailed Findings

In a study spearheaded by the Environmental Working Group (EWG), researchers at two major laboratories found an average of 200 industrial compounds, pollutants, and other chemicals in 10 newborn babies, with a total of 287 chemicals found in the group. To our knowledge this work represents the first reported cord blood tests for 261 of the targeted chemicals, and the first reported detections of at least 209 chemicals. Scientists refer to this contamination as a person's body burden.

The study found a broad array of pollutants that collectively are known to present potential risks to nearly every organ and system in the body:

- Of the 287 chemicals found in newborn umbilical cord blood, 180 cause cancer in humans or animals, 217 are toxic to the brain and nervous system, and 208 cause developmental problems. The dangers of exposure to these chemicals in combination has never been studied.
- We detected 287 chemicals of 413 tested (69 percent) in umbilical cord blood samples from 10 newborn babies, with a range of between 154 and 231 for each child. We found 101 chemicals in all babies tested.
- Our tests targeted nine chemical classes; we detected at least half of the analyzed chemicals in each class.

The chemicals we found span organochlorine pesticides (DDT and dieldrin, for example), chemicals currently or formerly used in a wide range of consumer products (perfluorochemicals, brominated fire retardants, PCBs), and chemical pollutants from waste incineration and fossil fuel combustion (polyaromatic hydrocarbons, polychlorinated and polybrominated dioxins and furans, polychlorinated naphthalenes, mercury).

## View results

[Summary of tests by chemical family](#)

## [Summary of tests by chemical family and subclass](#)

### [Summary of tests by potential health effects](#)

**Fetal exposures to mixtures.** The few published biomonitoring studies that measure fetal and newborn exposures among the general population confirm work that the pharmaceutical industry conducted more than 40 years ago establishing that the placenta is permeable not just with respect to oxygen, nutrients and fetal waste materials, but also with respect to xenobiotic chemicals. These chemicals move through the placenta via passive diffusion and, less frequently, active transport mechanisms from maternal to fetal blood (Syme et al. 2004).

The few published cord blood biomonitoring studies of the North American general population target a range of chemical classes, including polybrominated biphenyl ethers, or PBDEs (Mazdai et al. 2003); polychlorinated biphenyls, or PCBs (Stewart 1999,2000; Schechter 1998); organochlorine pesticides (Walker et al. 2003, Rhainds et al. 1999, Lagueux et al. 1999); polyaromatic hydrocarbons, or PAHs (PAH—DNA adducts were analyzed in Bocskay et al. 2005); methylmercury (Rhainds et al. 1999, Belles-Isles et al. 2002, and Bilrha et al. 2003); and polychlorinated dioxins and furans, or PCDD/PCDFs (Schechter 1998). Although these studies each target a fairly limited number of contaminants, collectively they confirm the findings of the current study: babies are exposed to hundreds of industrial chemicals even before birth.

The mixtures comprising a typical baby's body burden create an environment in the body that is drastically different from what is produced in toxicology studies, nearly all of which focus on single chemicals. Studies that target mixtures most often investigate simple mixtures at high doses encompassing only a handful of chemicals, rarely outside the same chemical class. In a few cases, scientists have investigated the toxicity of mixtures designed to mimic chemical combinations found in the environment. The Agency for Toxic Substances and Disease Registry (ATSDR), for instance, has begun to develop "interaction profiles" — assessments of the evidence on joint toxic actions of mixtures — for some common chemical combinations found in the environment (de Rosa et al. 2004, ATSDR 2004). But as a rule, toxicologists have not investigated mixtures that are considered representative of those found in people, much less in sensitive subpopulations such as developing children.

The results of our investigation raise questions with respect to the role of exposures in utero both in a range of children's health problems and in diseases developed in adulthood that may have their origins in early life exposures; the study also reinforces the importance of explicit consideration of fetal and childhood exposures in developing public health policies.

## Test results from 10 newborn babies find 287 chemicals from 9 diverse chemical families



### Mercury (Hg) - tested for 1, found 1

Pollutant from coal-fired power plants, mercury-containing products, and certain industrial processes. Accumulates in seafood. Harms brain development and function.

**Detected in:** 10 of 10 newborns tested

**Average concentration:** 0.947 parts per billion (ppb) (whole blood)

**Range:** 0.07 to 2.3 ppb



### Polyaromatic hydrocarbons (PAHs) - tested for 18, found 9

Pollutants from burning gasoline and garbage. Linked to cancer. Accumulates in food chain.

**Detected in:** 5 of 5 newborns tested

**Average concentration:** 285 parts per trillion (ppt) (blood lipids)

**Range:** 217 to 384 ppt



### Polybrominated dibenzodioxins and furans (PBDD/F) - tested for 12, found 7

Contaminants in brominated flame retardants. Pollutants and byproducts from plastic production and incineration. Accumulate in food chain. Toxic to developing endocrine (hormone) system

**Detected in:** 7 of 10 newborns tested

**Average concentration:** 55.9 parts per trillion (ppt) (blood lipids)

**Range:** below detection limit to 299 ppt



### Perfluorinated chemicals (PFCs) - tested for 12, found 9

Active ingredients or breakdown products of Teflon, Scotchgard, fabric and carpet protectors, food wrap coatings. Global contaminants. Accumulate in the environment and the food chain. Linked to cancer, birth defects, and more.

**Detected in:** 10 of 10 newborns tested

**Average concentration:** 6.17 parts per billion (ppb) (whole blood)

**Range:** 3.37 to 10.7 ppb



### Polychlorinated dibenzodioxins and furans (PBCD/F) - tested for 17, found 11

Pollutants, by-products of PVC production, industrial bleaching, and incineration. Cause cancer in humans. Persist for decades in the environment. Very toxic to developing endocrine (hormone) system.

**Detected in:** 10 of 10 newborns tested  
**Average concentration:** 59.4 parts per trillion (ppt) (blood lipids)  
**Range:** 37.9 to 102 ppt

OC

**Organochlorine pesticides (OCs) - tested for 28, found 21**

DDT, chlordane and other pesticides. Largely banned in the U.S. Persist for decades in the environment. Accumulate up the food chain, to man. Cause cancer and numerous reproductive effects.

**Detected in:** 10 of 10 newborns tested  
**Average concentration:** 18,600 parts per trillion (ppt) (blood lipids)  
**Range:** 8,720 to 35,400 ppt

PBDE

**Polybrominated diphenyl ethers (PBDEs) - tested for 46, found 32**

Flame retardant in furniture foam, computers, and televisions. Accumulates in the food chain and human tissues. Adversely affects brain development and the thyroid.

**Detected in:** 10 of 10 newborns tested  
**Average concentration:** 6,420 parts per trillion (ppt) (blood lipids)  
**Range:** 1,110 to 14,200 ppt

CN

**Polychlorinated Naphthalenes (PCNs) - tested for 70, found 50**

Wood preservatives, varnishes, machine lubricating oils, waste incineration. Common PCB contaminant. Contaminate the food chain. Cause liver and kidney damage.

**Detected in:** 10 of 10 newborns tested  
**Average concentration:** 617 parts per trillion (ppt) (blood lipids)  
**Range:** 295 to 964 ppt

PCB

**Polychlorinated biphenyls (PCBs) - tested for 209, found 147**

Industrial insulators and lubricants. Banned in the U.S. in 1976. Persist for decades in the environment. Accumulate up the food chain, to man. Cause cancer and nervous system problems.

**Detected in:** 10 of 10 newborns tested  
**Average concentration:** 7,880 parts per trillion (ppt) (blood lipids)  
**Range:** 2,990 to 19,700 ppt

Source: Chemical analyses of 10 umbilical cord blood samples conducted by AXYS Analytical Services (Sydney, BC) and Flett Research Ltd. (Winnipeg, MB).

**Test results from 10 newborn babies find 287 chemicals from a diverse range of chemical families and subclasses - table coming soon**

<b>Chemical class and subclass</b>	<b>Concentrations of chemicals in umbilical cord blood from 10 newborns (average and range among individual umbilical cord blood samples)</b>		<b>Number of newborn umbilical blood samples with detections</b>
<b>Metals [parts per billion wet weight]</b>			
Methyl Mercury	0.947	(0.07 - 2.3)	10 of 10
<b>Polybrominated dioxins and furans [parts per trillion lipid weight]</b>			
Brominated dioxins	5.33	(0 - 53.3)	1 of 10
Brominated furans	50.5	(0 - 246)	7 of 10
Tetrabrominated dioxin	0	(0 - 0)	0 of 10
Pentabrominated dioxin	0	(0 - 0)	0 of 10
Hexabrominated dioxin	5.33	(0 - 53.3)	1 of 10
Tetrabrominated furan	1.65	(0 - 11.1)	2 of 10
Pentabrominated furan	10.7	(0 - 48.5)	6 of 10
Hexabrominated furan	12.6	(0 - 73.3)	3 of 10
Heptabrominated furan	25.6	(0 - 118)	6 of 10
Octabrominated furan	0	(0 - 0)	0 of 10
<b>Polychlorinated dioxins and furans [parts per trillion lipid weight]</b>			
Chlorinated dioxins	53.4	(37 - 79.6)	10 of 10
Chlorinated furans	6.04	(0.758 - 35)	10 of 10
Tetrachlorinated dioxin	0	(0 - 0)	0 of 10
Pentachlorinated dioxin	0.291	(0 - 2.910)	1 of 10
Hexachlorinated dioxin	7.1	(3.79 - 12)	10 of 10
Heptachlorinated dioxin	8.92	(5.3 - 12.6)	10 of 10
Octachlorinated dioxin	37.1	(19.9 - 55)	10 of 10

Tetrachlorinated furan	0	(0 - 0)	0 of 10
Pentachlorinated furan	1.62	(0 - 8.660)	4 of 10
Hexachlorinated furan	2.31	(0.379 - 15.4)	10 of 10
Heptachlorinated furan	2.12	(0.379 - 11)	10 of 10
Octachlorinated furan	0	(0 - 0)	0 of 10
<b>Organochlorine Pesticide (OC) [parts per trillion lipid weight]</b>			
Organochlorine Pesticides (OCs)	18600	(8720 - 35400)	10 of 10
<b>Perfluorochemical (PFCs) [parts per billion wet weight]</b>			
Perfluorochemicals (PFCs)	6.17	(3.37 - 10.6)	10 of 10
Perfluorinated sulfonate	4.25	(2.26 - 7.760)	10 of 10
Perfluorinated carboxylic acid	1.92	(1.1 - 2.870)	10 of 10
<b>Polyaromatic hydrocarbon (PAHs) [parts per trillion lipid weight]</b>			
Polyaromatic hydrocarbon (PAHs)	285	(217 - 384)	5 of 5
<b>Polybrominated diphenyl ether (PBDEs) [parts per trillion lipid weight]</b>			
Polybrominated diphenyl ether (PBDEs)	6420	(1110 - 14200)	10 of 10
Dibrominated diphenyl ether	40.4	(0 - 82.7)	7 of 10
Tribrominated diphenyl ether	160	(75.6 - 303)	10 of 10
Tetrabrominated diphenyl ether	1660	(16.6 - 3950)	10 of 10
Pentabrominated diphenyl ether	574	(0 - 1750)	9 of 10
Hexabrominated diphenyl ether	1310	(272 - 7590)	10 of 10
Heptabrominated diphenyl ether	46.6	(12.2 - 117)	10 of 10
Octabrominated diphenyl ether	74.3	(41.2 - 134)	10 of 10
Nonabrominated	859	(0 - 3250)	7 of 10

diphenyl ether			
Decabrominated diphenyl ether	1700	(0 - 9630)	3 of 10
<b>Polychlorinated biphenyl (PCBs) [parts per trillion lipid weight]</b>			
Polychlorinated biphenyls (PCBs)	7880	(2990 - 19700)	10 of 10
Mono-PCB	95.3	(44.1 - 210)	10 of 10
Di-PCB	154	(0 - 304)	9 of 10
Tri-PCB	275	(41.3 - 540)	10 of 10
Tetra-PCB	366	(140 - 873)	10 of 10
Penta-PCB	671	(304 - 1300)	10 of 10
Hexa-PCB	2760	(766 - 6890)	10 of 10
Hepta-PCB	2400	(435 - 6870)	10 of 10
Octa-PCB	889	(172 - 2740)	10 of 10
Nona-PCB	191	(10.2 - 617)	10 of 10
Deca-PCB	75.4	(6.55 - 211)	10 of 10
<b>Polychlorinated naphthalene (PCNs) [parts per trillion lipid weight]</b>			
Polychlorinated naphthalenes (PCNs)	617	(295 - 964)	10 of 10
Monochlorinated naphthalene	65.7	(3.2 - 216)	10 of 10
Dichlorinated naphthalene	27.8	(1.1 - 79.3)	10 of 10
Trichlorinated naphthalene	164	(104 - 315)	10 of 10
Tetrachlorinated naphthalene	292	(127 - 409)	10 of 10
Pentachlorinated naphthalene	30	(2.2 - 64.5)	10 of 10
Hexachlorinated naphthalene	22.9	(2.2 - 111)	10 of 10
Heptachlorinated naphthalene	12.4	(0 - 68.4)	3 of 10
Octachlorinated naphthalene	2.81	(0 - 19.3)	2 of 10

Source: Chemical analyses of 10 umbilical cord blood samples conducted by AXYS Analytical Services (Sydney, BC) and Flett Research Ltd. (Winnipeg, MB).

**The chemicals found in 10 newborns are linked to a number of health problems**

Health Effect or Body System Affected	Number of chemicals found in 10 newborns tested that are linked to the listed health impact		
	Average number found in 10 newborns	Total found in all 10 newborns	Range (lowest and highest number found in individual newborns)
Cancer [1]	133	180 [2]	92 to 155
Birth Defects / Developmental Delays	151	208 [3]	101 to 176
Vision	1	1 [4]	0 to 1
Hormone System	153	211 [5]	104 to 179
Stomach Or Intestines	194	275 [6]	147 to 227
Kidney	128	174 [7]	84 to 149
Brain, Nervous System	157	217 [8]	108 to 183
Reproductive System	185	263 [9]	136 to 219
Lungs/breathing	144	200 [10]	93 to 170
Skin	159	226 [11]	115 to 187
Liver	40	46 [12]	30 to 45
Cardiovascular System Or Blood	162	226 [13]	117 to 190
Hearing	135	187 [14]	85 to 161
Immune System	130	177 [15]	89 to 151
Male Reproductive System	172	245 [16]	122 to 207
Female Reproductive System	142	196 [17]	92 to 168

\* Some chemicals are associated with multiple health impacts, and appear in multiple categories in this table.

[References for Health Effects](#)  
[Footnotes](#)

## **Guide to the chemical families tested in umbilical cord blood**

**Polychlorinated biphenyls (PCBs).** PCBs are toxic, persistent, bioaccumulative, and lipophilic ("fat-loving"). This means that PCBs build up and are stored in fatty tissues and fluids, such as breast milk, and can be passed on to fetuses and infants during pregnancy and lactation. In humans PCBs are linked to increased rates of a number of cancers, including malignant melanoma; non-Hodgkin's lymphoma; and brain, liver, and lung cancer. PCB poisonings in humans have caused fetal and infant death, birth defects, and brain damage in children exposed in the womb. PCBs are known to interfere with hormonal processes. In 1976, the manufacture of PCBs was banned in the United States because of concern for human health impacts, but PCBs are still widely found in the general population of the U.S.

In humans, PCBs are associated with skin lesions, thyroid disruption, and altered menstrual cycling, as well as damage to the nervous, immune, and cardiovascular systems. PCB exposure in the womb or during lactation is also associated with decreased IQ and impaired psychomotor development, decreased immune function and skin disease (chloracne) (ATSDR 2000a). The National Toxicology Program considers several PCB mixtures to be "reasonably anticipated" human carcinogens (NTP 2004). Likewise, EPA considers PCBs to be "probable" human carcinogens (EPA 2000a).

In laboratory animals, PCBs are known to cause cancer and damage to the reproductive, endocrine, immune, and nervous systems. In addition, PCBs damage the kidney and gastrointestinal tract, and cause birth defects.

PCBs do not occur naturally. Through their manufacture, use and disposal PCBs were released into the air, water, and soil. They were used primarily in transformers and other electrical equipment. Some consumer products still in use today may contain electrical components containing PCBs. PCBs continue to enter the environment through leaks at hazardous waste sites, during trash incineration, and through illegal dumping. People are exposed primarily through eating high fat meat and dairy products and PCB-contaminated seafood (ATSDR 2004).

**Organochlorine Pesticides (OCs).** As a class, the organochlorine (OC) pesticides are toxic, persistent, bioaccumulative, and lipophilic ("fat-loving"). They build up in the body, are stored in fatty tissues and fluids, such as breast milk, and can be passed on to fetuses and infants during pregnancy and lactation. OC pesticides can harm the brain of humans and laboratory animals, which is not surprising since they were designed to attack the nervous system of insects. In addition, many OC pesticides disrupt the hormone system. This family of chemicals includes many pesticides banned in the U.S., including DDT and dieldrin.

**Polychlorinated dibenzodioxins and dibenzofurans (PCDD/Fs, or chlorinated dioxins and furans).** Chlorinated dioxins and furans are unwanted byproducts of the manufacture and burning of products that contain chlorine. They cause cancer in humans, and they are generally considered to be among the most toxic environmental contaminants known to man. As a class, these chemicals are extremely toxic, persistent, bioaccumulative, and lipophilic ("fat-loving"). They build up in the body, are stored in fatty tissues and fluids, such as breast

milk, and can be passed on to fetuses and infants during pregnancy and lactation. Most people are exposed to dioxin through the food they eat, primarily from meat, dairy, fish and eggs.

In humans, chlorinated dioxins and furans are associated with cancer, skin lesions, damage to the nervous system and immune system, altered carbohydrate and lipid metabolism, thyroid disruption, altered menstrual cycling, and cardiovascular effects.

In laboratory animals, the chemicals are known to cause a variety of effects including cancer and impaired reproductive, endocrine, cardiovascular, immune, respiratory, neurological and metabolic function. In addition, dioxins cause skin disease and birth defects (ATSDR 1994, 1998).

**Methylmercury.** Methylmercury is toxic to the developing fetal brain, and exposure in the womb can cause learning deficiencies and can delay mental development in children. The U.S. Centers for Disease Control (CDC) recently reported data showing that one of every six American women of childbearing age already has mercury in her blood at levels that the National Academy of Sciences considers potentially unsafe for the developing fetus. Most women are exposed to methylmercury through seafood, which accumulates the metal, much of which is released to the environment from the burning of coal at coal fired power plants.

High dose methylmercury poisoning during development causes severe neurotoxicity, including mental retardation in humans (NAS 2000b). Methylmercury also causes developmental malformations and altered immune, reproductive, cardiovascular and kidney function (NAS 2000b).

**Polynuclear aromatic hydrocarbons (PAHs).** PAHs are a group of chemicals formed during the incomplete burning of coal, oil, gas, wood, garbage, or other organic substances, such as tobacco and charbroiled meat. Other sources of PAHs include asphalt and roofing tar. PAHs are found throughout the environment in air, water, and soil. There are more than 100 PAH compounds, and although the toxicity of individual PAHs is not identical, there are some similarities.

PAHs are linked to cancer in both animals and humans. In humans, PAH exposure by inhalation or skin contact has been linked to cancer. Laboratory studies show that PAHs cause tumors in laboratory animals when inhaled, ingested, or in contact with the skin. PAHs cause birth defects, are toxic to the skin, blood, reproductive and immune systems in animals. Although robust information exists for only some of the PAHs investigated in this study, studies show that toxicity profiles are likely similar across all chemicals in this family. EPA has determined that seven PAH chemicals are "probable" human carcinogens: benz[a]anthracene, benzo[a]pyrene, benzo[b]fluoranthene, benzo[k]fluoranthene, chrysene, dibenz[a,h]anthracene, and indeno[1,2,3-c,d]pyrene. (ATSDR 1995).

**Polybrominated dibenzodioxins and dibenzofurans (PBDD/Fs, or brominated dioxins and furans).** Brominated dioxins and furans are toxic, persistent, bioaccumulative and

lipophilic ('fat-loving'). They build up in human tissues, are stored in fatty tissues and fluid, such as breast milk, and can be passed on to fetuses and infants during pregnancy and lactation. Brominated dioxins and furans are formed unintentionally, either from incineration of wastes that include consumer products infused with brominated flame retardants like PBDEs, or as trace contaminants in mixtures of bromine-containing chemicals.

Brominated dioxins and furans have dioxin-like activity, meaning that they cause birth defects in animals and otherwise disrupt the reproductive development, immune and hormone systems. They add to the total dioxin body burden, which are near levels where effects may be occurring in the general population (Birnbaum 2003, EPA 2000a, WHO 1998).

**Perfluorochemicals (PFCs).** PFCs are industrial chemicals widely used as water, stain and grease repellants for food wrap, carpet, furniture, and clothing. The family includes such well known name brands as Scotchgard and Teflon. PFCs are also released to the environment in air and water emissions at numerous manufacturing and processing facilities worldwide, including primary production sites such as DuPont's Washington Works facility, WV; 3M's Cottage Grove, MN site, and Daikin's Decatur, AL plant. PFCs are likely also released to the environment at countless secondary manufacturing facilities, including sites where consumer products are coated for water, stain, and grease repellency.

But the dominant source of PFCs to the environment are likely fluorotelomer chemicals, the active ingredients in coatings of furniture, clothing, food packaging, and other products. Fluorotelomers break down in the environment and in the body to PFCs differing only in the carbon chain length and end group (Dinglasan et al. 2004; Ellis et al. 2004; Hagen et al. 1981). Most PFCs are fairly mobile in water, but due to low volatility of the persistent carboxy acids and sulfonates many do not have the potential to migrate in air far from locations of its release as a manufacturing pollutant. In contrast, studies indicate that PFC telomers are relatively volatile and could migrate long distances through the atmosphere (Ellis et al. 2004; Martin et al. 2004). Fluorotelomers are a likely source of the persistent perfluorochemicals found in newborns in this study, and in wildlife and water in areas remote from manufacturing sites and human populations.

Available scientific findings to date show that PFCs widely contaminate human blood (Kannan et al. 2004; Olsen 2002a; Olsen 2002b; Olsen 2002c), that they persist in the body for decades (Burris et al. 2002), that they act through a broad range of toxic mechanisms of action to present potential harm to a wide range of organs (ovaries, liver, kidney, spleen, thymus, thyroid, pituitary, testis), and that they persist indefinitely in the environment with no known biological or environmental breakdown mechanism (3M 2000, 3M 2001a, 3M 2001b, NAS 1972). The U.S. Environmental Protection Agency has described PFCs as combining "persistence, bioaccumulation, and toxicity properties to an extraordinary degree" (Auer 2000). Two individual PFCs that are associated with Teflon and Scotchard products are described below.

- **Perfluorooctanoic acid (PFOA).** PFOA is a synthetically produced chemical used in the manufacture of Teflon and other non-stick cookware. It is also used to make fluorinated chemicals used as fire retardants and for oil, stain, grease and water repellency for furniture, carpet, clothing, food packaging, and countless other applications (Kissa 2001). Importantly, PFOA is also a breakdown product and

metabolite of many of these chemicals (Dinglasan et al. 2004, Ellis et al. 2004). PFOA causes testicular, breast, and pancreatic tumors in animals. PFOA has been linked with increased cholesterol, stroke, and prostate cancer in exposed workers. PFOA also suppresses the immune system, and affects the pituitary, spleen, ovaries, thymus, thyroid, testicles, liver, kidney, and reproductive system in laboratory animals.

- Recently, the human health implications of widespread PFOA exposures has become a concern (EPA 2002a, 2003b), and in 2003 the Environmental Protection Agency (EPA) launched a major review of PFOA that Agency's Assistant Administrator called "the most extensive scientific assessment ever undertaken on this type of chemical" (EPA 2003d). Currently there is considerable data on PFOA that is not yet publicly available. Court documents from a lawsuit filed by EPA over DuPont's alleged suppression of PFOA health studies (EPA 2004b) indicate that the Agency has recently received at least 15 boxes of additional data from DuPont, and potentially in excess of one million pages, comprising company studies and other documents relevant to human health and exposure (EPA 2004c). EPA is only now processing these documents.
- **Perfluorooctane sulfonate (PFOS).** PFOS is a synthetically-produced chemical used for grease and water repellency for furniture, carpet, clothing and other applications. For decades it was the active ingredient in 3M's Scotchgard. 3M removed PFOS from the US market in 2001 under pressure from the EPA due its widespread pollution of people and the environment combined with its toxicity. In humans, PFOS has been linked with bladder, digestive tract, and male reproductive organ cancers. Other effects in humans have not been adequately studied. In animals, PFOS causes cancer, birth defects and other reproductive effects in animals (OECD 2002).

**Polybrominated diphenyl ethers (PBDEs).** PBDEs are brominated fire retardants, intentionally added to computers, TVs, foam furniture, and hundreds of other consumer products. They are toxic, persistent, bioaccumulative and lipophilic ('fat-loving'). They build up in the body, are stored in fatty tissues and fluid, such as breast milk, and can be passed on to fetuses and infants during pregnancy and lactation. People are exposed through the food they eat, primarily meat, dairy, fish and eggs. They are also exposed through PBDE-containing products in their homes, offices and cars. Commercial uses and human exposure sources for three commercial mixtures of PBDEs are described below.

- **Penta commercial PBDE mixture.** Penta is the common name for one of the three commercial PBDE mixtures. Penta was commonly added to foam products (mattresses, upholstered furniture, automobile seats, and carpet padding) manufactured before 2005. It was voluntarily phased out of production by 2005 in the wake of concerns over its toxicity and ubiquity in human breast milk, but will persist in the environment and people for decades to come. Single exposures to Penta in laboratory animals cause permanent impacts to learning, memory and behavior. These effects appear to grow worse with age. The period of greatest sensitivity in laboratory animals correlates with the third trimester of human pregnancy. Penta PBDEs are also know to cause hearing deficits, delayed puberty, decreased sperm count, fetal malformations, and possibly cancer (NIEHS 2001, deWit 2002).
- **Octa Commercial PBDE mixture.** Octa is the common name for one of the three commercial PBDE mixtures. The vast majority of all Octa production was added to ABS plastics to slow the spread of fire. Octa made up about 15 percent of the weight

of computer casings, until it was phased-out by 2005 due to concerns about its accumulation in people and the environment. People may be exposed to Octa through their diet or when the chemical is slowly released from products in their home, office or vehicle. Octa PBDEs have not been subject to the same level of scientific scrutiny as other PBDEs. Decades old studies have found reduced increased enzyme activity, fetal weights and fetal malformation at relatively high doses (NIEHS 2001, deWit 2002).

- **Deca Commercial PBDE mixture.** Deca is the common name for one of the three commercial PBDE mixtures. Deca is the most widely used brominated fire retardant in the world. It is added to plastics in electronic products and sprayed on industrial fabrics to slow the spread of fire. Computer monitors, televisions, copiers and home appliances often contain Deca. People are exposed to Deca in foods and through Deca-containing products in their homes and workplace. Single exposures to Deca in laboratory animals cause permanent impacts to learning, memory and behavior. These effects appear to grow worse with age. The period of greatest sensitivity in laboratory animals correlates with the third trimester of human pregnancy. Deca is also known to cause hearing deficits, delayed puberty, decreased sperm count, fetal malformations, and possibly cancer (Viberg et al. 2003, de Wit 2002). Recent studies indicate that Deca breaks down into other forms of PBDEs, and may contribute to levels of penta and octa PBDE compounds in human tissues.

**Polychlorinated Naphthalenes (PCNs).** There are 75 possible chemical variations of PCNs. They have been used as cable insulation, wood preservatives, engine oil additives, electroplating masking compounds, capacitors, and in dye production (EPA 1983). Products are generally mixtures of several different PCNs. The largest source of PCNs believed to be waste incineration and disposal of items containing PCNs, although other potential sources of PCNs to the environment include sewage discharge from municipal and industrial sites, leaching from hazardous waste sites. PCNs are also unwanted byproducts formed after the chlorination of drinking water (Kuehl et al. 1984b, Vogelgesang 1986, Furlong et al. 1988, Lin et al. 1984, Shiraishi et al. 1985). They have not been used commercially in significant quantities since the 1980s.

PCNs are toxic and persistent. They bioaccumulate in people and are stored in fatty tissues. PCNs have not been tested for their ability to induce cancer. The toxic effects of many PCNs are thought to be similar to dioxin. In humans, severe skin reactions (chloracne) and liver disease have both been reported after occupational exposure to PCNs. Other symptoms found in workers include cirrhosis of the liver, irritation of the eyes, fatigue, headache, anaemia, haematuria, impotentia, anorexia, and nausea. At least 10 deaths were reported from liver toxicity. Workers exposed to PCNs also have a slightly higher risk of all cancers combined. (WHO 2001).

## FOOTNOTES - HEALTH EFFECTS SUMMARY

[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:** 1 Polyaromatic hydrocarbons (PAH), 7 Brominated Dioxins and Furans (BD/F), 2 Perfluorinated Chemicals (PFC), 11 Chlorinated Dioxins and Furans (D/F), 12 Organochlorine Pesticides (OC), and 147 Polychlorinated Biphenyls (PCB)

[3] **Birth Defects / Developmental Delays:** Mercury, 1 Polyaromatic hydrocarbons (PAH), 7 Brominated Dioxins and Furans (BD/F), 2 Perfluorinated Chemicals (PFC), 11 Chlorinated Dioxins and Furans (D/F), 7 Organochlorine Pesticides (OC), 32 Polybrominated Diphenyl Ethers (PBDE), and 147 Polychlorinated Biphenyls (PCB)

[4] **Vision:** 1 Organochlorine Pesticides (OC)

[5] **Hormone System:** Mercury, 1 Polyaromatic hydrocarbons (PAH), 7 Brominated Dioxins and Furans (BD/F), 2 Perfluorinated Chemicals (PFC), 11 Chlorinated Dioxins and Furans (D/F), 10 Organochlorine Pesticides (OC), 32 Polybrominated Diphenyl Ethers (PBDE), and 147 Polychlorinated Biphenyls (PCB)

[6] **Stomach Or Intestines:** Mercury, 5 Polyaromatic hydrocarbons (PAH), 7 Brominated Dioxins and Furans (BD/F), 2 Perfluorinated Chemicals (PFC), 11 Chlorinated Dioxins and Furans (D/F), 20 Organochlorine Pesticides (OC), 32 Polybrominated Diphenyl Ethers (PBDE), 50 Polychlorinated Naphthalenes (CN), and 147 Polychlorinated Biphenyls (PCB)

[7] **Kidney:** Mercury, 7 Brominated Dioxins and Furans (BD/F), 2 Perfluorinated Chemicals (PFC), 11 Chlorinated Dioxins and Furans (D/F), 6 Organochlorine Pesticides (OC), and 147 Polychlorinated Biphenyls (PCB)

[8] **Brain, Nervous System:** Mercury, 2 Polyaromatic hydrocarbons (PAH), 7 Brominated Dioxins and Furans (BD/F), 11 Chlorinated Dioxins and Furans (D/F), 17 Organochlorine Pesticides (OC), 32 Polybrominated Diphenyl Ethers (PBDE), and 147 Polychlorinated Biphenyls (PCB)

[9] **Reproductive System:** Mercury, 3 Polyaromatic hydrocarbons (PAH), 7 Brominated Dioxins and Furans (BD/F), 2 Perfluorinated Chemicals (PFC), 11 Chlorinated Dioxins and Furans (D/F), 10 Organochlorine Pesticides (OC), 32 Polybrominated Diphenyl Ethers (PBDE), 50 Polychlorinated Naphthalenes (CN), and 147 Polychlorinated Biphenyls (PCB)

[10] **Lungs/breathing:** Mercury, 7 Brominated Dioxins and Furans (BD/F), 11 Chlorinated Dioxins and Furans (D/F), 2 Organochlorine Pesticides (OC), 32 Polybrominated Diphenyl Ethers (PBDE), and 147 Polychlorinated Biphenyls (PCB)

[11] **Skin:** Mercury, 4 Polyaromatic hydrocarbons (PAH), 7 Brominated Dioxins and Furans (BD/F), 11 Chlorinated Dioxins and Furans (D/F), 6 Organochlorine Pesticides (OC), 50 Polychlorinated Naphthalenes (CN), and 147 Polychlorinated Biphenyls (PCB)

[12] **Liver:** Mercury, 2 Organochlorine Pesticides (OC), and 43 Polychlorinated Biphenyls (PCB)

[13] **Cardiovascular System Or Blood:** Mercury, 1 Polyaromatic hydrocarbons

(PAH), 7 Brominated Dioxins and Furans (BD/F), 2 Perfluorinated Chemicals (PFC), 11 Chlorinated Dioxins and Furans (D/F), 7 Organochlorine Pesticides (OC), 50 Polychlorinated Naphthalenes (CN), and 147 Polychlorinated Biphenyls (PCB)

[14] **Hearing:** 7 Brominated Dioxins and Furans (BD/F), 1 Chlorinated Dioxins and Furans (D/F), 32 Polybrominated Diphenyl Ethers (PBDE), and 147 Polychlorinated Biphenyls (PCB)

[15] **Immune System:** Mercury, 7 Brominated Dioxins and Furans (BD/F), 2 Perfluorinated Chemicals (PFC), 11 Chlorinated Dioxins and Furans (D/F), 9 Organochlorine Pesticides (OC), and 147 Polychlorinated Biphenyls (PCB)

[16] **Male Reproductive System:** Mercury, 7 Brominated Dioxins and Furans (BD/F), 6 Chlorinated Dioxins and Furans (D/F), 2 Organochlorine Pesticides (OC), 32 Polybrominated Diphenyl Ethers (PBDE), 50 Polychlorinated Naphthalenes (CN), and 147 Polychlorinated Biphenyls (PCB)

[17] **Female Reproductive System:** 7 Brominated Dioxins and Furans (BD/F), 2 Perfluorinated Chemicals (PFC), 6 Chlorinated Dioxins and Furans (D/F), 2 Organochlorine Pesticides (OC), 32 Polybrominated Diphenyl Ethers (PBDE), and 147 Polychlorinated Biphenyls (PCB)

## Study methodology

**Introduction.** For 10 children born in U.S. hospitals between August 11th and September 8th, 2004, the moment of birth was marked not only by a first cradling in parents' arms, but also by a blood draw integral to a benchmark study of industrial pollutants in newborns. In the most comprehensive tests yet conducted on human umbilical cord blood, we analyzed each child's cord blood for a broad battery of industrial chemicals, pollutants, and pesticides — 413 chemicals in total, from nine chemical classes. To our knowledge this work includes the first reported cord blood tests for 261 of the targeted chemicals. Information below describes the components of this new study, detailing the blood collection procedures, sample preparation and analysis methods, and the quality assurance and quality control provisions included in the study design.

**Cord blood sample acquisition and storage.** The American National Red Cross obtained ten umbilical cord blood samples from live births in U.S. hospitals in August and September 2004. Besides each child's birthday, the Environmental Working Group obtained no identifying information, either personal or geographic, regarding the samples. Samples consisted of between 79 and 121 milliliters (mL) of umbilical cord blood and 35 mL citrate-phosphate-dextrose (CPD) anticoagulant in a 250 mL Baxter Fenwal Blood-Pack unit (Baxter Healthcare Corporation, Deerfield, IL). The 35 mL of CPD anticoagulant consisted of 921 mg sodium citrate, 893 mg dextrose, 105 mg citric acid, 78 mg monobasic sodium phosphate. Samples were shipped to AXYS Analytical Services (Sydney, BC) within 24 hrs of collection in coolers with gel ice packs. Samples were stored at 4 degrees C for up to four weeks until the entire set of 10 samples was received.

**Sample preparation.** Cord blood samples were transferred from the blood collection bags into measuring cylinders to determine the total sample volume. About 5 mL of the sample was then transferred into a polypropylene tube for perfluorochemical analysis. The remainder

was transferred to a glass container. Both portions were stored at -20 degrees C. Concentrations of chemicals in blood samples were computed based on the total sample weight less the weight of the anticoagulant.

**Analysis of PCDD/PCDFs, PBDD/PBDFs, PCBs, PBDEs, PCNs.** Analyses for the following groups of compounds were achieved on a single 50 gram portion of the blood-anticoagulant mixture: polychlorinated dioxins and furans (PCDD/PCDFs), polybrominated dibenzodioxins and dibenzofurans (PBDD/PBDFs), polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs) and polychlorinated naphthalenes (PCNs). The sample was first spiked with an extensive suite of <sup>13</sup>C labeled surrogate standards including compounds from all of the target analyte groups. The sample was extracted by shaking with 40 mL of ethanol and 40 mL of saturated ammonium sulfate solution followed by liquid-liquid extraction into 150 mL of hexane. The extract was cleaned up and fractionated by a series of adsorption chromatographic columns (silica, alumina, florisil and carbon) and analyzed by gas chromatography with high resolution mass spectrometric detection (GC/HRMS). Five separate analyses were conducted: PCBs following the protocols of EPA Method 1668A; PBDEs following the protocols for EPA Method 1614; PCDD/PCDFs following the protocols for EPA Method 1613B; and, separately, PCNs and PBDD/PBDFs following in-house methods patterned after the EPA 1600 series methods.

GC/HRMS analyses were performed using a Micromass Autospec Ultima magnetic sector high resolution mass spectrometer equipped with a Hewlett-Packard 6890 gas chromatograph. Quantification of target analytes was achieved by isotope dilution quantification using the <sup>13</sup>C labeled surrogate standards.

**Analysis of organochlorine pesticides.** Another 40 gram aliquot of blood-anticoagulant mixture was used for analysis of organochlorine pesticides. The sample was first spiked with multiple <sup>13</sup>C labeled surrogate pesticide standards. The sample was extracted by the procedure described above, cleaned up by gel permeation chromatography on BioBeads SX-3 and split into 2 fractions on Florisil. Each fraction (non-polar compounds and polar compounds) was analyzed by GC/HRMS for pesticides. Organochlorine pesticides were analyzed on a Micromass VG70 magnetic sector high resolution mass spectrometer equipped with a Hewlett-Packard 5890 gas chromatograph.

**Analysis of Polyaromatic Hydrocarbons (PAHs).** PAH analysis was conducted on a 20-gram aliquot of blood anticoagulant mixture. A suite of <sup>2</sup>D labeled surrogate standards was added to the sample which was then extracted as described above. The extract was cleaned up by gel permeation chromatography on BioBeads SX-3 and adsorption chromatography on silica. It was then analyzed by gas chromatography with a mass selective detector (GC/MSD) using an Agilent 6890 gas chromatograph coupled to an Agilent 5973N mass selective detector operated at unit resolution in the electron impact ionization mode using multiple ion detection. Quantification of target analytes was achieved by isotope dilution quantification using the <sup>2</sup>D labeled surrogate standards.

**Analysis of Perfluorochemicals (PFCs).** Analysis for perfluorochemicals was conducted on a 2 gram aliquot of sample. The sample was first spiked with two <sup>13</sup>C labeled perfluorochemical surrogate standards, extracted with acetonitrile and cleaned up on a C-18 solid phase extraction cartridge. The extract was analyzed by LC/MS/MS using a Micromass Quattro Ultima MS/MS coupled with a Waters 2690 liquid chromatographic system.

Quantification of target analytes was achieved by isotope dilution quantification using the  $^{13}\text{C}$  labeled surrogate standards.

**Analysis for Methylmercury.** Analysis for methylmercury was conducted by Flett Research Ltd. (Winnipeg, MB). Approximately 0.3 g of blood-anticoagulant mixture was analyzed by KBr extraction, followed by ethylation, purge and trap and cold vapor atomic fluorescence spectroscopy (CVAFS). The analysis batch included a procedural blank and a reference sample (DORM-2, National Research Council of Canada).

**Procedures for quality assurance and quality control (QA/QC).** All organic analyses were conducted in accordance with AXYS' accredited QA/QC program. Regular participation in international inter-laboratory calibration programs is a component of this program. Each analysis batch also included a procedural blank, a laboratory blank, blood bag blanks (extractions from ethanol and from q water-corn oil water mixture added to the standardized cord blood container), and an analysis duplicate. The sample results were reviewed and evaluated in relation to the QA/QC samples worked up at the same time. The sample surrogate standard recoveries and detection limits, procedural blank data and the laboratory control sample data were evaluated against method criteria to ensure data quality. A positive finding was determined as three times the minimum quantifiable area. Subsequently, to correct for possible procedural or equipment contamination, the blank sample analyses were subtracted from the respective determined analyte values.

## References

- 3M. 2000. Biodegradation study of PFOS. AR226-0057. Washington, DC: U.S. Environmental Protection Agency.
- 3M. 2001a. Screening Studies in the Aqueous Photolytic Degradation of Perfluorooctanoic Acid (PFOA). AR226-1030 Photolysis E00-2192. Washington, DC: U.S. Environmental Protection Agency.
- 3M. 2001b. Hydrolysis Reactions of Perfluorooctanoic Acid (PFOA). AR2261030a090. Washington, DC: U.S. Environmental Protection Agency.
- ACS (American Cancer Society). 2001. Cancer Facts & Figures 2001. Available online at [http://www.cancer.org/docroot/STT/stt\\_0\\_2001.asp?sitearea=STT&level=1](http://www.cancer.org/docroot/STT/stt_0_2001.asp?sitearea=STT&level=1).
- ACS (American Cancer Society). 2004. Cancer Facts & Figures 2004. Available online at [http://www.cancer.org/docroot/STT/stt\\_0\\_2004.asp?sitearea=STT&level=1](http://www.cancer.org/docroot/STT/stt_0_2004.asp?sitearea=STT&level=1).
- Ananth CV, Misra DP, Demissie K, Smulian JC. 2001. Rates of preterm delivery among Black women and White women in the United States over two decades: an age-period-cohort analysis. *Am J Epidemiol*. 154:657-65.
- Anway MD, Cupp AS, Uzumcu M, Skinner MK. Epigenetic transgenerational actions of endocrine disruptors and male fertility. *Science*. 2005 Jun 3;308(5727):1466-9.
- ATSDR (Agency for Toxic Substances and Disease Registry). 1994. Toxicological profile for chlorodibenzofurans.
- ATSDR (Agency for Toxic Substances and Disease Registry). 1995. Toxicological profile for mirex and chlordecone.
- ATSDR (Agency for Toxic Substances and Disease Registry). 1995. Toxicological profile for polycyclic aromatic hydrocarbons.
- ATSDR (Agency for Toxic Substances and Disease Registry). 1998. Toxicological profile for dibenzo-p-dioxins.
- ATSDR (Agency for Toxic Substances and Disease Registry). 2000a. Toxicological profile for polychlorinated biphenyls (PCBs).
- ATSDR (Agency for Toxic Substances and Disease Registry). 2004. Guidance manual for the assessment of joint toxic actions of chemical mixtures. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.
- Auer, C. 2000. Phaseout of PFOS. Internal memorandum from Charles Auer, Environmental Protection Agency (EPA). EPA Office of Pollution Prevention and Toxics Docket Number AR226-0629. May 16 2000.
- Barker DJP. 1995. Fetal origins of coronary heart disease. *BMJ* 1995;311:171-174.

Basha MR, Wei W, Bakheet SA, Benitez N, Siddiqi HK, Ge YW, Lahiri DK, Zawia NH. The fetal basis of amyloidogenesis: exposure to lead and latent overexpression of amyloid precursor protein and beta-amyloid in the aging brain. *J Neurosci*. 2005 Jan 26;25(4):823-9.

Belles-Isles M, Ayotte P, Dewailly E, Weber J-P, Roy R. 2002. Cord Blood Lymphocyte functions in newborns from a remote maritime population exposed to organochlorines and methylmercury *Journal of Toxicology and Environmental Health, Part A*, 65:165-182.

Bergstrom R, Adami HO, Mohner M, Zatonski W, Storm H, Ekbom A, Tretli S, Teppo L, Akre O, Hakulinen T. 1996. Increase in testicular cancer incidence in six European countries: a birth cohort phenomenon. *J Natl Cancer Inst* 88:727-33.

Bilrha H, Roy R, Moreau B, Belles-Isles M, Dewailly E, Ayotte P. 2003. In Vitro Activation of Cord Blood Mononuclear Cells and Cytokine Production in a Remote Coastal Population Exposed to Organochlorines and Methyl Mercury. *Environmental Health Perspectives*. 111: 1952-1957.

Birnbaum LS, Staskal DF, Diliberto JJ. 2003. Health effects of polybrominated dibenzo-p-dioxins (PBDDs) and dibenzofurans (PBDFs). *Environ Int*. Sep;29(6):855-60.

Bocskay KA, Tang D, Orjuela MA, Liu X, Warburton DP, Perera FP. 2005. Chromosomal aberrations in cord blood are associated with prenatal exposure to carcinogenic polycyclic aromatic hydrocarbons. *Cancer Epidemiol Biomarkers Prev*. 2005 Feb;14(2):506-11.

Branum AM, Schoendorf KC. 2002. Changing patterns of low birthweight and preterm birth in the United States, 1981-98. *Paediatr Perinat Epidemiol*. 2002 Jan;16(1):8-15.

BSEF (Bromine Science and Environmental Forum). 2002. An introduction to brominated flame retardants. Brussels, Belgium, 1-28.

Burriss JM, Lundberg JK, Olsen GW, Simpson D, Mandel JH. 2002. Interim report: Determination of serum half-lives of several fluorochemicals. AR226-1086. Washington, DC: U.S. Environmental Protection.

Byrd RS. 2002. The Epidemiology of Autism in California: A Comprehensive Pilot Study. Available online at [http://mindinstitute.ucdmc.ucdavis.edu/news/study\\_final.pdf](http://mindinstitute.ucdmc.ucdavis.edu/news/study_final.pdf).

Carrington CD, Montwill B, Bolger PM. 2004. An intervention analysis for the reduction of exposure to methylmercury from the consumption of seafood by women of child-bearing age. *Regul Toxicol Pharmacol*. 2004 Dec;40(3):272-80.

CDC (Centers for Disease Control and Prevention). 1995. Asthma — United States, 1982-1993. *MMWR Morb Mortal Wkly Rep*. 43:952-955.

CDC (Centers for Disease Control and Prevention). 2003. Second national report on human exposure to environmental chemicals. NCEH Pub. No. 03-0022. Available at: <http://www.cdc.gov/exposurereport/2nd/pdf/secondner.pdf>.

CDC (Centers for Disease Control and Prevention). 2004. Chronic Disease Overview. Available online at <http://www.cdc.gov/nccdphp/overview.htm>.

CDC (Centers for Disease Control and Prevention). 2005. Chemicals for inclusion in the third national exposure report. Available at: <http://www.cdc.gov/exposurereport/>.

Chakrabarti S, Fombonne E. 2001. Pervasive developmental disorders in preschool children. *JAMA* 285:3093-9.

Checkoway H, Nelson LM. 1999. Epidemiologic approaches to the study of Parkinson's disease etiology. *Epidemiology* 10:327-36.

Cook JD, Davis BJ, Cai SL, Barrett JC, Conti CJ, Walker CL. 2005. Interaction between genetic susceptibility and early-life environmental exposure determines tumor-suppressor-gene penetrance. *Proc Natl Acad Sci U S A*. 2005 Jun 14;102(24):8644-9. Epub 2005 Jun 3.

Cooper GS, Klebanoff MA, Promislow J, Brock JW, Longnecker MP. 2005. Polychlorinated biphenyls and menstrual cycle characteristics. *Epidemiology*. 2005 Mar;16(2):191-200.

de Rosa CT, El-Masri HA, Pohl H, Cibulas W, Mumtaz MM. 2004. Implications of chemical mixtures in public health practice. *J Toxicol Environ Health B Crit Rev*. 7, 339-50.

de Wit, C. 2002. An overview of brominated flame retardants in the environment. *Chemosphere*. (46):583-624.

DHHS (U.S. Department of Health and Human Services). 2004. The National Children's Study. Background information available online at <http://www.nationalchildrensstudy.gov/>.

Dinglasan MJ, Ye Y, Edwards EA, Mabury SA. 2004. Fluorotelomer alcohol biodegradation yields poly- and perfluorinated acids. *Environ Sci Technol*. 38: 2857-2864.

Dunson DB, Baird DD, Colombo B. 2004. Increased infertility with age in men and women. *Obstet Gynecol*. 103:51-56.

Ellis DA, Martin JW, De Silva AO, Mabury SA, Hurley MD, Sulbaek Andersen MP, Wallington TJ. 2004. Degradation of fluorotelomer alcohols: a likely atmospheric source of perfluorinated carboxylic acids. *Environ Sci Technol*. 38: 3316-3321.

Engel LS, Checkoway H, Keifer MC, Seixas NS, Longstreth WT, Jr., Scott KC, Hudnell K, Anger WK, Camicioli R. 2001. Parkinsonism and occupational exposure to pesticides. *Occup Environ Med* 58:582-9.

EPA (U.S. Environmental Protection Agency). 1983. Category of chemical substances known as chlorinated naphthalenes: proposed determination of significant new uses. *Federal register*, 48(89):20668-20679.

EPA (U.S. Environmental Protection Agency). 1996. PCBs: Cancer Dose-Response Assessment and Application to Environmental Mixtures. EPA/600/P-96/001F.

EPA (U.S. Environmental Protection Agency). 1997. Chemistry assistance manual for premanufacture notification submitters. EPA 744-R-97-003. Available online at <http://www.epa.gov/oppt/newchems/chem-pmn/>.

EPA (U.S. Environmental Protection Agency). 2000a. Dioxin Reassessment. Online: <http://cfpub.epa.gov/ncea/cfm/dioxreass.cfm?ActType = default>.

EPA (U.S. Environmental Protection Agency). 2000b. EPA and 3M Announce Phase Out of PFOS. News Release. May 16 2000. Available online at <http://yosemite.epa.gov/opa/admpress.nsf/0/33aa946e6cb11f35852568e1005246b4?OpenDocument>.

EPA (U.S. Environmental Protection Agency). 2002a. Pesticide industry sales and usage 1994 and 1995 market estimates. Available online at <http://www.epa.gov/oppbead1/pestsales/95pestsales/>.

EPA (U.S. Environmental Protection Agency). 2002b. Revised draft hazard assessment of perfluorooctanoic acid and its salts. US EPA Office of Pollution Prevention and Toxics. 4 November, 2002. AR226-1136. Washington, DC: U.S. Environmental Protection Agency.

EPA (U.S. Environmental Protection Agency). 2003a. America's children and the environment. Measures of contaminants, body burdens, and illnesses. Available online at <http://www.epa.gov/envirohealth/children>.

EPA (U.S. Environmental Protection Agency). 2003b. Dioxin Reassessment. Online: <http://cfpub.epa.gov/ncea/cfm/dioxreass.cfm?ActType = default>

EPA (U.S. Environmental Protection Agency). 2003c. Preliminary risk assessment of the developmental toxicity associated with exposure to perfluorooctanoic acid and its salts. 10 April 2003. OPPT-2003-0012-0002. Washington, DC: U.S. Environmental Protection Agency Office of Pollution Prevention and Toxics.

EPA (U.S. Environmental Protection Agency). 2003d. EPA intensifies scientific investigation of a chemical processing aid. Environmental News. 14 April 2003. Washington, DC: U.S. Environmental Protection Agency Office of Public Affairs.

EPA (U.S. Environmental Protection Agency). 2004a. NAS Review Draft of EPA's Exposure and Human Health Reassessment of 2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TCDD) and Related Compounds.

EPA (U.S. Environmental Protection Agency). 2004b. USEPA complaint against E.I. du Pont de Nemours and Co. Docket # TSCA-HQ-2004-0016, RCRA-HQ-2004-0016, and TSCA-HQ-2005-5001.

EPA (U.S. Environmental Protection Agency). 2004c. Request for a Motion for Temporary Stay of Proceeding. Exhibit 7. Docket # TSCA-HQ-2004-0016, TSCA-HQ-2005-5001.

EPA (U.S. Environmental Protection Agency). 2005a. Supplemental guidance for assessing susceptibility from early-life exposures to carcinogens. EPA Risk Assessment Forum. EPA/630/R-03/003F. March 2005. [Final version of 2003 Draft].

EPA (U.S. Environmental Protection Agency). 2005b. Fact sheets on new active ingredients. Available online at <http://www.epa.gov/opprd001/factsheets/>.

EPA (U.S. Environmental Protection Agency). 2005c. What is the TSCA Chemical Substance Inventory? EPA Office of Prevention, Pesticides and Toxic Substances. Available online at <http://www.epa.gov/opptintr/newchems/invntory.htm>. Accessed May 15, 2005.

EPA (U.S. Environmental Protection Agency). 2005d. Draft Risk Assessment of the potential human health effects associated with exposure to perfluorooctanoic acid and its salts. January 4, 2005. (Released January 12, 2005). Available online at <http://www.epa.gov/oppt/pfoa>.

Eriksson JG, Forsen T, Tuomilehto J, Winter PD, Osmond C, Barker DJ. 1999. Catch-up growth in childhood and death from coronary heart disease: longitudinal study. *Bmj* 318:427-31.

Eriksson J, Forsen T, Tuomilehto J, Osmond C, Barker D. 2000a. Fetal and childhood growth and hypertension in adult life. *Hypertension* 36:790-4.

Eriksson JG, Forsen T, Tuomilehto J, Osmond C, Barker DJ. 2000b. Early growth, adult income, and risk of stroke. *Stroke* 31:869-74.

Eriksson JG, Forsen T, Tuomilehto J, Jaddoe VW, Osmond C, Barker DJ. 2002. Effects of size at birth and childhood growth on the insulin resistance syndrome in elderly individuals. *Diabetologia* 45:342-8.

Eriksson JG, Forsen TJ. 2002. Childhood growth and coronary heart disease in later life. *Ann Med* 34:157-61.

EWG (Environmental Working Group). 2003. Mothers Milk: Record levels of toxic fire retardants found in American mothers' breast milk. Washington, DC. Available online at <http://www.ewg.org/reports/mothersmilk/>

EWG (Environmental Working Group). 2003. Body Burden: The Pollution in People. Washington, DC. Available online at <http://www.ewg.org/reports/bodyburden/>

Faroon O, Jones D, de Rosa C. 2001. Effects of polychlorinated biphenyls on the nervous system. *Toxicol Ind Health*. 2001 Sep;16(7-8):305-33. Review.

FDA (U.S. Food and Drug Administration). 2000. Cosmetics Compliance Program. Domestic Cosmetics Program. July 31, 2000. Available online at <http://www.cfsan.fda.gov/~comm/cp29001.html>.

FDA (U.S. Food and Drug Administration). 2004. Backgrounder for the 2004 FDA/EPA Consumer Advisory: What You Need to Know About Mercury in Fish and Shellfish. Available online at <http://www.fda.gov/oc/opacom/hottopics/mercury/backgrounder.html>.

FDA (U.S. Food and Drug Administration). 2005. EAFUS: A Food Additive Database. (Everything Added to Food in the U.S.). FDA Center for Food Safety and Applied Nutrition. Available online at <http://www.cfsan.fda.gov/~dms/eafus.html>.

Forsen T, Eriksson J, Tuomilehto J, Reunanen A, Osmond C, Barker D. 2000. The fetal and childhood growth of persons who develop type 2 diabetes. *Ann Intern Med* 133:176-82.

Furlong ET, Carter DS, Hites RA. 1988. Organic contaminants in sediments from the Trenton Channel of the Detroit River, Michigan. *Journal of Great Lakes research*. 14:489-501.

Godfrey KM, Barker DJ. 2001. Fetal programming and adult health. *Public Health Nutr* 4:611-24.

Grandjean P, Weihe P, White RF, Debes F, Araki S, Yokoyama K, Murata K, Sorensen N, Dahl R, Jorgensen PJ. 1997. Cognitive deficit in 7-year-old children with prenatal exposure to methylmercury. *Neurotoxicol Teratol*. 1997 Nov-Dec;19(6):417-28.

Greene, Alan. 2004. *From First Kicks to First Steps: Nurturing Your Baby's Development from Pregnancy Through the First Year of Life*. McGraw-Hill Companies. New York.

Hack M, Flannery DJ, Schluchter M, Cartar L, Borawski E, Klein N. 2002. Outcomes in young adulthood for very-low-birth-weight infants. *N Engl J Med*. 2002 Jan 17;346(3):149-57.

Hagen, Donald F.; Belisle, John; Johnson, James D.; and Venkateswarlu, P. 1981. Characterization of Fluorinated Metabolites by a Gas Chromatographic- Helium Microwave Plasma Detector; The Biotransformation of 1H, 1H, 2H, 2H-Perfluorodecanol to Perfluorooctanoate. *Analytical Biochemistry*. 118, 336-343.

Hale. 2001. Polybrominated Diphenyl Ether Flame Retardants in Virginia Freshwater Fishes (USA). *Environmental Science and Technology*. 35(23):4585-4591.

Hales CN, Barker DJ. 2001. The thrifty phenotype hypothesis. *Br Med Bull* 60:5-20.

Hales CN, Barker DJP, Clark PMS, Cox LJ, Fall C, Winter PD. 1991. Fetal and infant growth and impaired glucose tolerance at age 64 years. *BMJ* 303:1019-1022.

Hales CN, Ozanne SE. 2003. For debate: Fetal and early postnatal growth restriction lead to diabetes, the metabolic syndrome and renal failure. *Diabetologia*. 2003 Jul;46(7):1013-9. Epub 2003 Jun 21. Review.

Hardell L, van Bavel B, Lindstrom G, Carlberg M, Dreifaldt AC, Wijkström H, Starkhammar H, Eriksson M, Hallquist A, Kolmert T. in press. Increased Concentrations of Polychlorinated Biphenyls, Hexachlorobenzene and Chlordanes in Mothers to Men with Testicular Cancer. *Environ Health Perspect* [Online 19 December 2002].

Herman-Giddens ME, Slora EJ, Wasserman RC, Bourdony CJ, Bhapkar MV, Koch GG, Hasemeier CM. 1997. Secondary sexual characteristics and menses in young girls seen in office practice: a study from the Pediatric Research in Office Settings network. *Pediatrics* 99:505-12.

Hooper K, McDonald TA. 2000. The PBDEs: an emerging environmental challenge and another reason for breast-milk monitoring programs. *Environ Health Perspect*. May;108(5):387-92.

Hosie S, Loff S, Witt K, Niessen K, Waag KL. 2000. Is there a correlation between organochlorine compounds and undescended testes? *Eur J Pediatr Surg* 10:304-9.

- Jacobson JL, Jacobson SW. 1996. Intellectual impairment in children exposed to polychlorinated biphenyls in utero. *N Engl J Med* 335:783-9.
- Jahnke GD, Iannucci AR, Scialli AR, Shelby MD. 2005. Center for the evaluation of risks to human reproduction--the first five years. *Birth Defects Res B Dev Reprod Toxicol*. 2005 Feb;74(1):1-8. Review.
- Kannan K, Corsolini S, Falandysz J, Fillmann G, Kumar KS, Loganathan BG, Mohd MA, Olivero J, Van Wouwe N, Yang JH, Aldoust KM. 2004. Perfluorooctanesulfonate and related fluorochemicals in human blood from several countries. *Environ Sci Technol* 38(17): 4489-95.
- Kissa E. 2001. *Fluorinated Surfactants and Repellents*. Marcel Dekker, Inc., New York.
- Kuehl DW, Durhan E, Butterworth BC, Linn D. 1984. Tetrachloro-9H-carbazole, a previously unrecognized contaminant in sediments of the Buffalo River. *Journal of Great Lakes research*, 10:210-214.
- Lagueux J, Pereg D, Ayotte P, Dewailly E, Poirer GG. 1999. Cytochrome P450 CYP1A1 Enzyme Activity and DNA Adducts in Placenta of Women Environmentally Exposed to Organochlorines. *Environmental Research Section A* 80:369-382.
- Longnecker MP, Klebanoff MA, Zhou H, Brock JW. 2001. Association between maternal serum concentration of the DDT metabolite DDE and preterm and small-for-gestational-age babies at birth. *Lancet* 358:110-4.
- Makri A, Goveia M, Balbus J, Parkin R. 2004. Children's susceptibility to chemicals: a review by developmental stage. *J Toxicol Environ Health B Crit Rev*. 2004 Nov-Dec;7(6):417-35. Review.
- Martin JW, Smithwick MM, Braune BM, Hoekstra PF, Muir DC, Mabury SA. 2004. Identification of long-chain perfluorinated acids in biota from the Canadian Arctic. *Environ Sci Technol*. 38:373-380.
- Mazdai A, Dodder NG, Abernathy MP, Hites RA, Bigsby RM. 2003. Polybrominated diphenyl ethers in maternal and fetal blood samples. *Environ Health Perspect*. 2003 Jul;111(9):1249-52.
- McKiernan JM, Goluboff ET, Liberson GL, Golden R, Fisch H. 1999. Rising risk of testicular cancer by birth cohort in the United States from 1973 to 1995. *J Urol* 162:361-3.
- Mocarelli P, Brambilla P, Gerthoux PM, Patterson DG, Jr., Needham LL. 1996. Change in sex ratio with exposure to dioxin. *Lancet* 348:409.
- Mocarelli P, Gerthoux PM, Ferrari E, Patterson DG, Jr., Kieszak SM, Brambilla P, Vincoli N, Signorini S, Tramacere P, Carreri V, Sampson EJ, Turner WE, Needham LL. 2000. Paternal concentrations of dioxin and sex ratio of offspring. *Lancet* 355:1858-63.
- NAS (National Academies of Science). 1972. *Degradation of Synthetic Organic Molecules in the Biosphere*. Washington, DC.

NAS (National Academy of Sciences). 1993. Pesticides in the Diets of Infants and Children. National Academy Press. Washington, DC.

NAS (National Academy of Sciences). 2000a. Scientific Frontiers in Developmental Toxicology and Risk Assessment. Committee on Developmental Toxicology. Washington, DC: National Academies Press.

NAS (National Academy of Sciences). 2000b. Toxicological Effects of Methylmercury. National Research Council. National Academy Press, Washington, DC.

NCI (National Cancer Institute). 1996. SEER Cancer Statistics Review. 1973-1996. Available online at [http://www.seer.ims.nci.nih.gov/Publications/CSR1973\\_1996/](http://www.seer.ims.nci.nih.gov/Publications/CSR1973_1996/).

NCI (National Cancer Institute). 1997. SEER Cancer Statistics Review. 1973-1997. Available online at [http://www.seer.ims.nci.nih.gov/Publications/CSR1973\\_1997/](http://www.seer.ims.nci.nih.gov/Publications/CSR1973_1997/).

NCI (National Cancer Institute). 2005. Surveillance, Epidemiology, and End Results (SEER) Program ([www.seer.cancer.gov](http://www.seer.cancer.gov)) SEER\*Stat Database: Nov 2004 Sub (1973-2002), NCI, DCCPS, Surveillance Research Program, Cancer Statistics Branch, released April 2005.

NIEHS (National Institute for Environmental Health Sciences). 2001. Toxicological Summary for Selected Polybrominated Diphenyl Ethers. Submitted by Bonnie Carson, Integrated Laboratory Systems, Research Triangle Park, North Carolina. March, 2001.

Noren K, Meironyte D. 2000. Certain organochlorine and organobromine contaminants in Swedish human milk in perspective of past 20-30 years. *Chemosphere*. 2000 May-Jun;40(9-11):1111-23.

NTP (National Toxicology Program). 2004. Report on Carcinogens, Eleventh Edition; U.S. Department of Health and Human Services, Public Health Service, National Toxicology Program.

OECD (Organisation for Economic Co-operation and Development). 2002. Hazard assessment of perfluorooctane sulfonate (PFOS) and its salts. ENV/JM/RD(2002)17/FINAL.

Olsen GW, Burris JM, Lundberg JK, Hansen KJ, Mandel JH, Zobel LR. 2002a. Final Report: Identification of fluorochemicals in human sera. III. Pediatric participants in a group A streptococci clinical trial investigation. AR2261085. Washington, DC: U.S. Environmental Protection Agency.

Olsen GW, Burris JM, Lundberg JK, Hansen KJ, Mandel JH, Zobel LR. 2002b. Final Report: Identification of fluorochemicals in human sera. I. American Red Cross Adult Blood Donors. AR226-1083. Washington, DC: U.S. Environmental Protection Agency.

Olsen GW, Burris JM, Lundberg JK, Hansen KJ, Mandel JH, Zobel LR. 2002c. Final Report: Identification of fluorochemicals in human sera. II. Elderly participants of the adult changes in thought study, Seattle, WA. AR2261084. Washington, DC: U.S. Environmental Protection Agency.

Ong KK, Dunger DB. 2002. Perinatal growth failure: the road to obesity, insulin resistance and cardiovascular disease in adults. *Best Pract Res Clin Endocrinol Metab* 16:191-207.

Paulozzi LJ, Erickson JD, Jackson RJ. 1997. Hypospadias trends in two US surveillance systems. *Pediatrics* 100:831-4.

Paulozzi LJ. 1999. International trends in rates of hypospadias and cryptorchidism. *Environ Health Perspect*. 1999 Apr;107(4):297-302.

Pirkle JL, Brody DJ, Gunter EW, Kramer RA, Paschal DC, Flegal KM, Matte TD. 1994. The decline in blood lead levels in the United States. The National Health and Nutrition Examination Surveys (NHANES). *JAMA* 272, 284-291.

Prentice AM, Moore SE. 2005. Early programming of adult diseases in resource poor countries. *Arch Dis Child*. 90:429-432.

Rhainds M, Levallois P, Dewailly E, Pierre A. 1999. Lead, Mercury, and Organochlorine Compound Levels in Cord Blood in Quebec, Canada. *Archives of Environmental Health*. 54:40-47.

Robison LL, Buckley JD, Bunin G. 1995. Assessment of environmental and genetic factors in the etiology of childhood cancers: the Childrens Cancer Group epidemiology program. *Environ Health Perspect* 111:201-206.

Robison LM, Sclar DA, Skaer TL, Galin RS. 1999. National trends in the prevalence of attention-deficit/hyperactivity disorder and the prescribing of methylphenidate among school-age children: 1990-1995. *Clin Pediatr (Phila)* 38:209-17.

Robison LM, Skaer TL, Sclar DA, Galin RS. 2002. Is attention deficit hyperactivity disorder increasing among girls in the US? Trends in diagnosis and the prescribing of stimulants. *CNS Drugs* 16:129-37.

Salonen, JT, K Seppanen, et al. 1995. Intake of mercury from fish, lipid peroxidation, and the risk of myocardial infarction and coronary, cardiovascular, and any death in eastern Finnish men. *Circulation*. 91(3): 645-655.

Schade G, Heinzow B. 1998. Organochlorine pesticides and polychlorinated biphenyls in human milk of mothers living in northern Germany: current extent of contamination, time trend from 1986 to 1997 and factors that influence the levels of contamination. *Sci Total Environ* 215(1-2):31-39.

Schechter A, Kassis I, Papke O. 1998. Partitioning of dioxins, dibenzofurans, and coplanar PCBS in blood, milk, adipose tissue, placenta and cord blood from five American women. *Chemosphere*. 1998 Oct-Nov;37(9-12):1817-23.

Schechter CB. 1999. Re: Brain and other central nervous system cancers: recent trends in incidence and mortality. *J Natl Cancer Inst*. 91:2050-2051.

Selevan SG, Kimmel CA, Mendola P. 2000. Identifying critical windows of exposure for children's health. *Environ Health Perspect*. 2000 Jun;108 Suppl 3:451-5.

Sexton K, Needham LL, Pirkle JL. 2004. Measuring chemicals in human tissues is the "gold standard" for assessing people's exposure to pollution. *American Scientist*. 92, 38-45.

Sorensen N, Murata K, Budtz-Jorgensen E, Weihe P, Grandjean P. 1999. Prenatal methylmercury exposure as a cardiovascular risk factor at seven years of age. *Epidemiology*. 10:370-375.

Srivastava VK, Chauhan SS, Srivastava PK, Kumar V and Misra UK. 1986. Fetal translocation and metabolism of PAH obtained from coal fly ash given intratracheally to pregnant rats. *J Toxicol Environ Health*. 18, 459-469.

Stettler N, Bovet P, Shamlaye H, Zemel BS, Stallings VA, Paccaud F. 2002. Prevalence and risk factors for overweight and obesity in children from Seychelles, a country in rapid transition: the importance of early growth. *Int J Obes Relat Metab Disord* 26:214-9.

Stewart P, Darvill T, Lonky E, Reihman J, Pagano J, Brush B. 1999. Assessment of prenatal exposure to PCBs from maternal consumption of Great Lakes fish: An analysis of PCB pattern and concentration. *Environmental Research Section A* 80, S87-S96.

Stewart P, Reihman J, Lonky E, Darvill T, Pagano J. 2000. Prenatal PCB exposure and neonatal behavioral assessment scale (NBAS) performance. *Neurotoxicology and Teratology* 22:21-29.

Stock NL, Lau FK, Ellis DA, Martin JW, Muir DC, Mabury SA. 2004. Polyfluorinated telomer alcohols and sulfonamides in the North American troposphere. *Environ Sci Technol* 38: 991-996.

Swan SH, Elkin EP, Fenster L. 2000. The question of declining sperm density revisited: an analysis of 101 studies published 1934-1996. *Environ Health Perspect* 108:961-6.

Swan SH, Brazil C, Drobnis EZ, Liu F, Kruse RL, Hatch M, Redmon JB, Wang C, Overstreet JW; Study For Future Families Research Group. 2003. Geographic differences in semen quality of fertile U.S. males. *Environ Health Perspect*. 2003 Apr;111(4):414-20.

Syme MR, Paxton JW, Keelan JA. 2004. Drug transfer and metabolism by the human placenta. *Clin Pharmacokinet* 2004;43(8):487-514.

Tango T, Fujita T, Tanihata T, Minowa M, Doi Y, Kato N, Kunikane S, Uchiyama I, Tanaka M, Uehata T. 2004. Risk of adverse reproductive outcomes associated with proximity to municipal solid waste incinerators with high dioxin emission levels in Japan. *J Epidemiol*. 2004 May;14(3):83-93.

ten Tusscher GW, Koppe JG. 2004. Perinatal dioxin exposure and later effects — a review. *Chemosphere*. 54:1329-1336.

Thompson C, Syddall H, Rodin I, Somond C, Barker DJ. 2001. Birth weight and the risk of depressive disorder in late life. *Br J Psychiatry*. 2001 Nov;179:450-5.

- Thornton JW, McCally M, Houlihan J. 2002. Biomonitoring of industrial pollutants: Health and policy implications of the chemical body burden. *Public Health Reports*. Vol 117, 315-323.
- Toppari J, Larsen JC, Christiansen P, Giwercman A, Grandjean P, Guillette LJ, Jr., Jegou B, Jensen TK, Jouannet P, Keiding N, Leffers H, McLachlan JA, Meyer O, Muller J, Rajpert-De Meyts E, Scheike T, Sharpe R, Sumpter J, Skakkebaek NE. 1996. Male reproductive health and environmental xenoestrogens. *Environ Health Perspect* 104 Suppl 4:741-803.
- Trasande L, Landrigan PJ. 2004. The National Children's Study: a critical national investment. *Environ Health Perspect*. 2004 Oct;112(14):A789-90.
- Van Loveren H, Vos J, Putman E, Piersma A. 2003. Immunotoxicological consequences of perinatal chemical exposures: a plea for inclusion of immune parameters in reproduction studies. *Toxicology*. 2003 Apr 1;185(3):185-91. Review.
- Viberg H, Fredriksson A, Jakobsson E, Orn U, Eriksson P. 2003. Neurobehavioural Derangements in Adult Mice Receiving Decabrominated Diphenyl Ether (PBDE 209) During a Defined Period of Neonatal Brain Development. *Toxicol Sci*. 76:112-20.
- WA DOH (Washington State Department of Health). 2005. PBDEs: What they are and what you can do. Available online at <http://www.doh.wa.gov/ehp/oehas/pbde/pbdeuse.htm>.
- Wahlbeck K, Forsen T, Osmond C, Barker DJ, Eriksson JG. 2001. Association of schizophrenia with low maternal body mass index, small size at birth, and thinness during childhood. *Arch Gen Psychiatry*. 2001 Jan;58(1):48-52.
- Walker JB, Seddon L, McMullen E, Houseman J, Tofflemire K, Corriveau A, Weber J-P, Mills C, Smith S, Van Oostdam J. 2003. Organochlorine levels in maternal and umbilical cord blood plasma in Arctic Canada *The Science of the Total Environment* 302:27-52.
- Weidner IS, Moller H, Jensen TK, Skakkebaek NE. 1998. Cryptorchidism and hypospadias in sons of gardeners and farmers. *Environ Health Perspect* 106:793-6.
- WHO (World Health Organization). 1998. Polybrominated dibenzo-p-dioxins and dibenzofurans. *Environ Health Criteria* 205.
- WHO (World Health Organization). 2001. Chlorinated naphthalenes. *Concise International Chemical Assessment Document* 34. Available online at <http://www.inchem.org/documents/cicads/cicads/cicad34.htm>.
- Whyatt RM, Jedrychowski W, Hemminki K, Santella RM, Tsai KY, and Perera FP. 2001. Biomarkers of polycyclic aromatic hydrocarbon-DNA damage and cigarette smoke exposures in paired maternal and newborn blood samples as a measure of differential susceptibility. *Cancer Epidemiology, Biomarkers & Prevention*. 10, 581-588.
- Yang JZ, Agarwal SK, Foster WG. 2000. Subchronic exposure to 2,3,7,8-tetrachlorodibenzo-p-dioxin modulates the pathophysiology of endometriosis in the cynomolgus monkey. *Toxicol Sci* 56:374-81.

Yeargin-Allsopp M, Rice C, Karapurkar T, Doernberg N, Boyle C, Murphy C. 2003. Prevalence of Autism in a US Metropolitan Area. *JAMA*. 289:49-55.

Zito JM, Safer DJ, dosReis S, Gardner JF, Boles M, Lynch F. 2000. Trends in the prescribing of psychotropic medications to preschoolers. *JAMA* 283:1025-30.