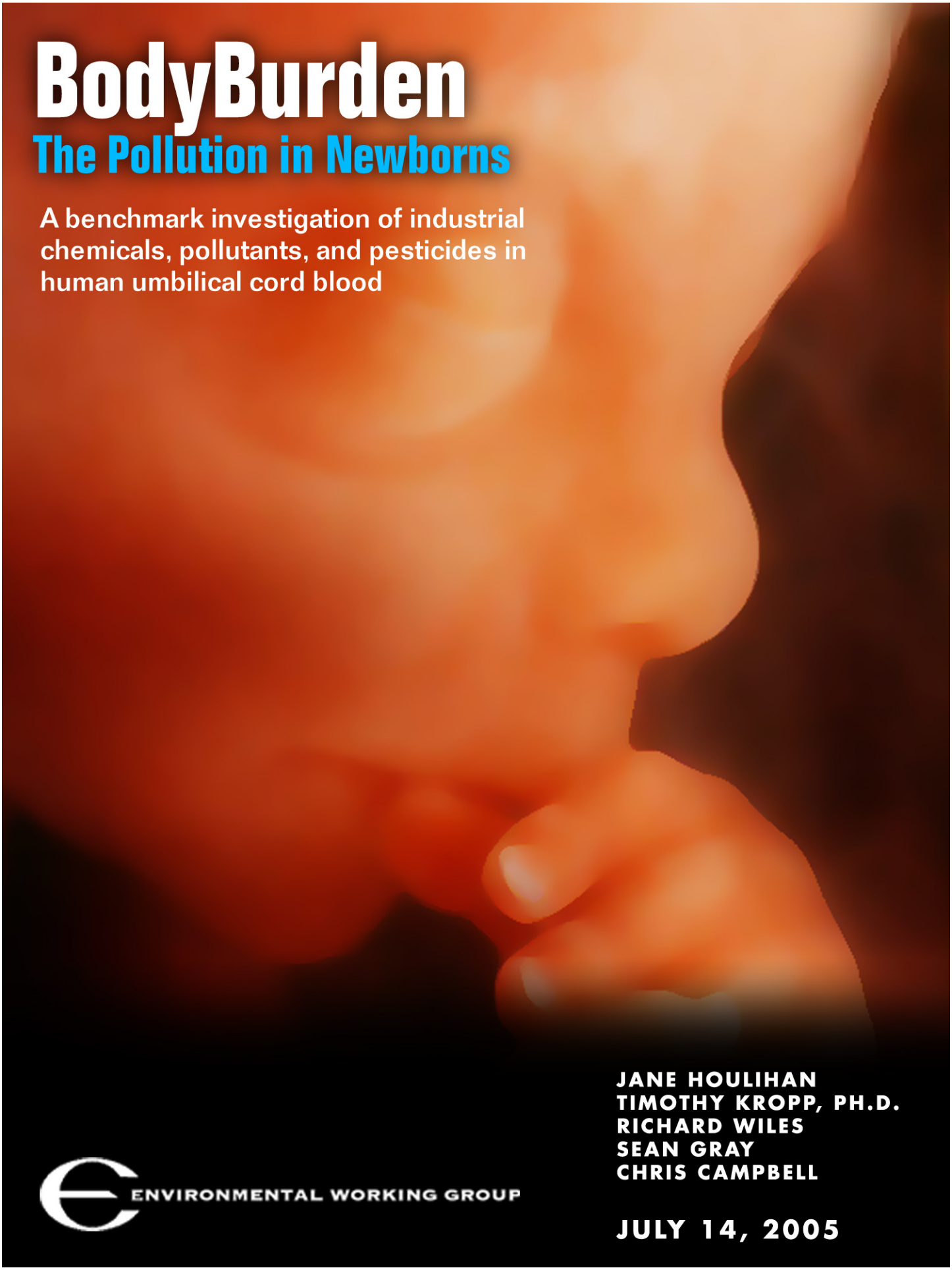
BodyBurden

The Pollution in Newborns

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



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EWG is a nonprofit research organization with offices in Washington, DC and Oakland, CA. EWG uses the power of information to educate the public and decision-makers about a wide range of environmental issues, especially those affecting public health.

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Environmental Working Group
July 14, 2005

Peer Statement

Scientists' and Pediatricians' Statement on EWG Study of Industrial Chemicals in Umbilical Cord Blood

July 8, 2005

Over the past decade, scientists and medical experts have become increasingly concerned about the adverse effects of chemicals in the environment on children. This awareness has been fueled by a growing understanding of the potential for small amounts of chemicals to produce profound changes in development when exposures occur at critical periods of development. It is further increased by concerns about the vast numbers of potentially toxic chemicals to which the developing child is exposed, both before and after birth.

A recent study by the Environmental Working Group detected 287 commercial chemicals, pesticides, and pollutants in the umbilical cord blood from 10 newborn infants, randomly selected by the Red Cross from U.S. hospitals. The finding of these chemicals in the bloodstreams of the youngest and most vulnerable members of our society raises issues of substantial importance to public health and points to the need for major reforms to the nation's laws that aim to protect the public from chemical exposures.

The study confirms that even before birth, a child is exposed to hundreds of chemical compounds, many of which could harm that child's health and development. This is disturbing because scientific studies and empirical evidence have repeatedly shown that pre-natal and early childhood chemical exposures can be substantially more harmful than exposures that occur later in life.

The immature blood brain barrier may allow greater chemical exposures to the developing brain. A diminished ability to excrete and detoxify many chemicals can produce higher levels of chemicals circulating in the blood of the child than the mother. The occurrence of complex processes of cell growth and differentiation may provide the opportunity for irreversible effects to occur during critical windows of development. And the longer

life span of the child compared to an adult allows more time for adverse effects to arise.

These health concerns are largely the results of gaping holes in the government safety net that allows this largely uncontrolled exposure. There are 75,000 chemicals in commerce, and at least 3,000 produced in quantities greater than 1,000,000 pounds per year. Yet we do not know how many of these chemicals end up in fetal blood and what the effects of these exposures are. Presumably, if EWG had tested for more compounds, more would have been detected, perhaps many more.

The federal law that ensures the safety of these chemicals has not been improved for nearly 30 years - longer than any other major environmental or public health statute. Because this law, the Toxic Substances Control Act, is so weak, a number of voluntary initiatives to gather health information about chemicals have been attempted. These efforts, however, have been largely ineffective at reducing exposure and do not substitute for a clear statutory requirement to protect children from the toxic effects of chemical exposure.

In light of the findings in the EWG study and a substantial body of supporting science, we strongly urge that federal laws and policies 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, the 1996 Food Quality Protection Act, was amended nearly a decade ago to require the explicit protection of infants and children from pesticides. Actions taken under 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. We recommend a similar standard be applied to commercial chemicals.

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For links to more biographical information, please visit:
http://www.ewg.org/reports/bodyburden2/statement.php

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Interactive Umbilical Cord Blood Test Results

Production Note:

The print version of this report was updated on August 18, 2005 to include the scientific peer statement. Please note that the page numbers in this document are different than the earlier version of the print report.

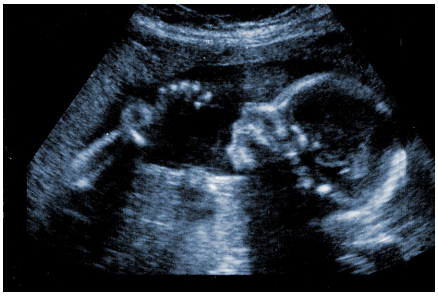
Part 1

Executive Summary

Summary. In the month leading up to a baby's birth, the umbilical cord pulses with the equivalent of 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.



A DEVELOPING CHILD'S CHEMICAL EXPOSURES ARE GREATER POUND-FOR-POUND THAN THOSE OF ADULTS.

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.

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

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).

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 number of chemicals found in each newborn
Common consumer product chemicals *(and their breakdown products)*			**47 Found:**	**(23 - 48)**
Pesticides, actively used in U.S.	OC	Organochlorine pesticides (OCs)	7	(2 - 6)
Stain and grease resistant coatings for food wrap, carpet, furniture (Teflon, Scotchgard, Stainmaster...)	PFC	Perfluorochemicals (PFCs)	8	(4 - 8)
Fire retardants in TVs, computers, furniture	PBDE	Polybrominated diphenyl ethers (PBDEs)	32	(13 - 29)
Chemicals banned or severely restricted in the U.S. *(and their breakdown products)*			**212 Found:**	**(111 - 185)**
Pesticides, phased out of use in U.S.	OC	Organochlorine pesticides (OCs)	14	(7 - 14)
Stain and grease resistant coatings for food wrap, carpet, furniture (pre-2000 Scotchgard)	PFC	Perfluorochemicals (PFCs)	1	(1 - 1)
Electrical insulators	PCB	Polychlorinated biphenyls (PCBs)	147	(65 - 114)
Broad use industrial chemicals - flame retardants, pesticides, electrical insultators	CN	Polychlorinated naphthalenes (PCNs)	50	(22 - 40)
Waste byproducts			**28 Found:**	**(6 - 21)**
Garbage incineration and plastic production wastes	BD/F	Polychlorinated and Polybrominated dibenzo dioxins and furans (PCDD/F and PBDD/F)	18	(5 - 13)
Car emissions and other fossil fuel combustion	PAH	Polynuclear aromatic hydrocarbons (PAHs)	9	(1 - 10)
Power plants (coal burning)	Hg	Methylmercury	1	(1 - 1)
All chemicals found			**TOTAL = 287 chemicals**	**(154 - 231)**

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).

Part 2

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.

CHILDREN HAVE LOWER LEVELS OF SOME CHEMICAL-BINDING PROTEINS, ALLOWING MORE OF A CHEMICAL TO REACH "TARGET ORGANS."

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.

Guest Commentary

Umbilical cord blood

Dr. Alan Greene, July 14 2005
http://www.drgreene.com/

No hunger is more intense than the hunger for oxygen. For babies before birth, their entire oxygen supply comes not from their fluid-filled lungs, but through a life-and-death channel to their mothers called the umbilical cord. It starts smaller than a human hair, but by the time of birth, the umbilical cord is a sturdy lifeline is as big around as an adult finger and 20 to 24 inches long.

Very early in pregnancy, the fertilized egg floats independently, conservatively managing its own resources. Then, during a process called implantation, it burrows into the welcoming lining of the mother's uterus. Enzymes melt away protective layers, and the two fiercely latch on to each other. This powerful connection ushers in an unequaled time of change and growth for the baby. The taps are wide open. Suddenly there is a luxurious amount of nutrition available. By Day 19 or 20 after conception, the embryo is floating, tethered to the placenta by a narrow stalk that will become the umbilical cord. The quiet, economic rearrangement of the early cells, the careful management of limited resources, gives way to overflowing surplus. By 4 months gestation, at least 75 quarts a day will flow through the umbilical cord. A typical blood cell will make a complete round trip every 30 seconds. Before it is finally cut, more than 300 quarts of blood a day will flow through the umbilical cord.

The umbilical cord is the living link through which a mother feeds her baby and removes its waste. The cord also becomes the conduit of an ongoing exchange, a silent conversation, where hormones from the mother and the baby signal changes in each other's bodies.

The umbilical cord consists of three blood vessels — two umbilical arteries and one umbilical vein — embedded in slippery connective tissue called Wharton's jelly. The arteries spiral around the vein, giving the cord the toughness of a cable. At one end of the cord is the baby; at the other is the placenta.

The baby's heart pumps depleted blood out of its body through the umbilical arteries to the placenta. In the placenta, the arteries divide into smaller and smaller branches, finally breaking up into a network of tiny capillaries. These capillaries intertwine

deeply with the mother's blood, while staying separate. It is here that the exchange of materials — oxygen, hormone signals, nutrients, and waste — occurs. The baby's capillaries then flow and combine into larger and larger venous blood vessels, finally joining in the large single umbilical vein. The replenished blood returns like a steady, unhindered river bringing the stuff of life to the fetus.

In contrast, the mother's blood in the placenta forms a free-flowing, living lake that bathes the fetal capillaries. Unlike the fetal blood in the placenta that is completely contained in blood vessels, maternal blood flows into about 80 to 100 small spiral arteries of the uterus that empty wide-open into this five-ounce lake of blood. The blood in the lake is refreshed completely three or four times each minute to supply the baby's needs.

Today, this most primal of lakes has become polluted with industrial contaminants. And developing babies are nourished exclusively from this polluted pool. They mainline the contaminants through their umbilical cord, injecting them into their veins more potently than any IV drug administration.

At the time of birth, after the umbilical cord is clamped and cut, the blood remaining in the cord is often collected and stored because it is a valuable source of stem cells. The potency of stem cells comes from their ability to transform into other tissues, organs, and systems in the body. Stem cells are "young" in the best sense of the word, and full of potential. Each stem cell is like being dealt a valuable wildcard in a game of cards.

Today, we use stem cells to regenerate people's blood and immune system after they have been treated with chemotherapy or radiation to destroy cancer cells. Already, more than 45 disorders can be treated with stem cells from umbilical cord blood. Preliminary research suggests that stem cells hold great promise for treating important common conditions such as heart disease, stroke, and Alzheimer's. Work is also underway to use stem cells to treat diabetes, muscular dystrophy, Parkinson's disease, and spinal cord injury, among others.

This is the same valuable blood that was analyzed in this study, and found to contain a startling array of industrial contaminants. It is the blood supply that bathed and nourished every cell of the baby while her organs and systems formed. It satisfied her hunger. The cord blood is an echo of the polluted lake within. It is tangible evidence that, after the cord is cut, the industrial chemicals that the mother was exposed to are now coursing through her baby's veins as the little one first greets the world.

Part 3

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.

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

A BABY'S ORGANS AND SYSTEMS ARE RAPIDLY DEVELOPING, AND THUS ARE OFTEN MORE VULNERABLE TO DAMAGE FROM CHEMICAL EXPOSURE.

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. 2000, Paulozzi et al. 1997, Dunson et al. 2004, Trasande and Landrigan 2004, Jahnke et al. 2005

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-mimicing 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.

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 certaintly 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 epigenitic 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 (lipid weight, serum) alter testosterone levels and are linked with diabetes (EPA 2004a). Dioxin at 80 parts per trillion (lipid weight) 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 2005).

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 also 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.

Part 4

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 thoroughly, 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 individual 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.

IN A CHILD, SYSTEMS THAT DETOXIFY AND EXCRETE INDUSTRIAL CHEMICALS ARE NOT FULLY DEVELOPED.

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.

Supplemental Materials

Detailed Findings

In a study spearheaded by the Environmental Working Group (EWG), researchers at two major laboratories found an average of 204 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).

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; Schecter 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 (Schecter 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.

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

Hg	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
PAH	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
BD/F	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
PFC	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
D/F	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).

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.

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.

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 still widely pollute 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

Test results from 10 newborn babies find 287 chemicals from a diverse range of chemical families and subclasses

Chemical class and subclass	Concentrations of chemicals in umbilical cord blood from 10 newborns (average and range among individual umbilical cord blood samples)		Number of newborn umbilical blood samples with detections
Metals [parts per billion wet weight]			
Methyl Mercury	0.947	(0.07 - 2.3)	10 of 10
Polybrominated dioxins and furans [parts per trillion lipid weight]			
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
Octabrominated dioxin	0	(0 - 0)	0 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
Polychlorinated dioxins and furans [parts per trillion lipid weight]			
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
Organochlorine Pesticide (OC) [parts per trillion lipid weight]			
Organochlorine Pesticides (OCs)	18600	(8720 - 35400)	10 of 10
Perfluorochemical (PFCs) [parts per billion wet weight]			
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
Polyaromatic hydrocarbon (PAHs) [parts per trillion lipid weight]			
Polyaromatic hydrocarbon (PAHs)	285	(217 - 384)	5 of 5
Polybrominated diphenyl ether (PBDEs) [parts per trillion lipid weight]			
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 diphenyl ether	859	(0 - 3250)	7 of 10
Decabrominated diphenyl ether	1700	(0 - 9630)	3 of 10
Polychlorinated biphenyl (PCBs) [parts per trillion lipid weight]			
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
Polychlorinated naphthalene (PCNs) [parts per trillion lipid weight]			
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).

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 primarily used as coolants and lubricants 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 from 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 their blood at levels that the National Academy of Sciences considers potentially unsafe for the developing fetus (CDC 2003, NAS 2000). 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 the 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, WV facility; 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 packacking, 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 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 2003a, 2005d), 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 from meat, dairy, fish and eggs. They are also exposed through the 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 likely persist in the environment and people for decades to come. Single exposures to Penta in laboratory animals causes 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, the time of most rapid fetal brain growth. 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 produced 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 by ingesting small particles of the chemical that are released from products in their homes and workplace. As with Penta mixtures, 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 know 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 and leaching from hazardous waste sites. PCNs are also formed during the chlorination process of drinking water (Kuehl et al. 1984b, Furlong et al. 1988, WHO 2001). PCNs have not been used commercially in significant quantities since the 1980s.

CN

PCNs are toxic and persistent. They bioaccumulate in people and are stored in fatty tissue. 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)

Supplemental Materials

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.

THE LONGER FUTURE LIFE SPAN OF A CHILD COMPARED TO AN ADULT ALLOWS MORE TIME FOR ADVERSE EFFECTS TO ARISE.

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 13C 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 13C 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 13C 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 2D 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 2D 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 13C 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 13C 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 water-corn oil 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.

Supplemental Materials

Answers to Frequently Asked Questions

Question #1: How does this study compare to the government's National Exposure Report?

In late July 2005 the Centers for Disease Control and Prevention (CDC) plans to release its third in a series of National Exposure Reports, a study that "provides an ongoing assessment of the U.S. population's exposure to chemicals," including many of the industrial chemicals EWG tested in umbilical cord blood.

Our study compares and contrasts with CDC's in the following ways:

- The CDC studies primarily adults, and tests for just a handful of chemicals in children ages one and older. EWG studied children at the moment of birth. By testing umbilical cord blood, our study defines the mixtures of chemicals that pollute a child in the womb, during the time in life of the highest sensitivity to harm from chemical exposures. CDC has not tested newborns in any of its National Exposure Report studies.

- The CDC studies individual chemicals in a multitude of people. Our study examined individual people, in this case newborns, for a multitude of chemicals.

- The CDC's work helps us assess exposure levels for each targeted contamination across the U.S. population. Our study documents instead the complex reality of the mixtures of chemicals in individual people — the human "body burden."

- Although CDC's results from the Third National Exposure Report are not public as of this writing, they have published the list of chemicals that will be included in their report (CDC 2005). Our tests compare to CDC's tests in the following ways:

    - EWG and CDC have tested for 62 chemicals in common (polychlorinated dibenzodioxins

A CHILD'S IMMATURE, POROUS BLOOD-BRAIN BARRIER ALLOWS GREATER CHEMICAL EXPOSURES TO THE DEVELOPING BRAIN.

and dibenzofurans, mercury, organochlorine pesticides, and polychlorinated biphenyls).

- EWG has tested for 351 chemicals not included in CDC's study (polybrominated dibenzodioxins and dibenzofurans, polyaromatic hydrocarbons, perfluorochemicals, polybrominated diphenyl ethers, polychlorinated biphenyls, and polychlorinated naphthalenes).

- CDC has tested for 88 chemicals not included in EWG's study (metals, organochlorine pesticides, organophosphate insecticides, pyrethroid pesticides, herbicides, phytoestrogens, polyaromatic hydrocarbons, and tobacco smoke).

Both studies reveal disturbing gaps in our system of public health safeguards, which allows uncontrolled exposures to complex mixtures of industrial chemicals beginning even before birth.

Question #2: Why test for chemicals in people?

Applications of body burden (biomonitoring) data for human health risk assessment and public health policy

Scientists and regulators use body burden data (biomonitoring studies) to estimate human health risks from exposures to industrial chemicals, to set public health policies that protect against these risks, and to track the success of these policies in reducing exposures. The applications of biomonitoring are rapidly expanding beyond its traditional use in occupational medicine and poisoning cases to new applications in measuring exposures and estimating health risks among the general population (Thornton et al. 2002, EWG 2003, Sexton et al. 2004, CDC 2003). Public health officials have recently used body burden data in assessing health risks for chemicals described below, all of we found in this study in newborn umbilical cord blood:

- **Mercury.** When CDC body burden studies showed high blood levels of mercury in women of childbearing age, government scientists assessed the data to show that one of every six women is exposed to mercury in excess of safe levels, through their consumption of mercury-contaminated seafood. These analyses were benchmarked back to seminal umbilical cord blood studies linking mercury to brain damage among children exposed in the womb (Grandjean et al. 1997). FDA then designed and publicized seafood consumer advisories that are intended

to lower women's blood mercury levels (Carrington et al. 2004, FDA 2004). EWG's investigation identified mercury (as the form in seafood, methylmercury) in all 10 newborns tested.

• **Scotchgard.** Beginning in 1997 3M found the active ingredient in Scotchgard (PFOS) not only in blood from U.S. blood banks, but also in the blood of 600 children tested. Concurrently, 3M was learning that Scotchgard induces serious birth defects in laboratory studies, results that government scientists called "disturbing." EPA officials pressured 3M to take Scotchgard off the market. According to government officials, Scotchgard "combine[s] persistence, bioaccumulation, and toxicity properties to an extraordinary degree" (Auer 2000). In the past three years 3M has completely reformulated the product, although the persistent PFOS chemical will continue to pollute people, including babies in the womb, for generations to come. EWG's investigation identified PFOS in all 10 newborns tested, and represents the first reported detections of PFOS in U.S. cord blood.

• **Teflon chemical PFOA.** In the wake of the Scotchgard phaseout, EPA turned their attention to a closely related chemical, the Teflon ingredient PFOA. EPA conducted an assessment of human health risks benchmarked on measured levels of PFOA in the blood of the general population (EPA 2005d). This assessment, currently under review by EPA's independent Science Advisory Panel, was conducted to guide EPA in designing policies necessary to lower human exposures to PFOA. The Agency's priority review and assessment of PFOA is driven by its ubiquity in human blood — it pollutes the blood of more than 95 percent of Americans — combined with the chemicals' broad toxicity and the fact that, among all human blood pollutants, PFOA belongs to a chemical family (perfluorochemicals) that is uniquely persistent in the environment: PFOA never breaks down. EWG's investigation identified PFOS in all 10 newborns tested, the first reported detections of the chemical in cord blood from the general population.

• **Dioxin.** In a politically controversial series of exposure and human health risk assessments, EPA has consistently relied on body burden measurements of dioxin — in breast milk and other human tissues — to estimate exposures and health risks for the notirious family of dioxin-like chemicals (EPA 2004a). EWG's investigation identified dioxin-like chemicals in all 10 newborns tested.

Biomonitoring can fill data gaps and reduce uncertainties inherent in traditional exposure and risk assessment, leading to more fully informed public health policies. As measures of "internal dose," biomonitoring data comprise exposure estimates more direct, and with lower uncertainty, than those that scientists derive from traditional algorithms — methods that compound uncertainty by combining estimates of behavior patterns, pharmacokinetics, and external doses. When compared against measurements or estimates of internal dose from toxicology studies, biomonitoring data also providing a more direct estimate of potential hazards by reducing the need to compensate for differences in pharmacokinetics between humans and laboratory animals in exposure and risk assessments. Government scientists used this technique most recently in their risk assessment for the Teflon chemical PFOA, in which they compared measured human serum levels of PFOA to animal serum PFOA levels from laboratory studies (EPA 2005d).

In addition to the clear benefits of its use in exposure and risk assessments that shape public health policy, body burden studies are also a powerful tool for tracking the success of programs that aim to mitigate exposures. Body burden studies show, for example, that blood lead levels in children have dropped steadily since the mandatory reduction of lead in gasoline and house paint of the 1970s; the median concentration fell 85 percent between 1976 and 2000 (Pirkle et al. 2004, EPA 2003a).

Body burden data also has the capacity to uncover sensitive or highly exposed subpopulations, and the potential to elucidate distributions of exposure for individuals and across populations, including exposures to mixtures. Consideration of both of these factors — sensitive subpopulations and the nature of mixtures that comprise the human body burden — are critical components in developing effective public health policies. It is with a goal of exploring these two factors that we conducted our cord blood pollution investigation. Our study seeks specifically to measure the human body burden in an inherently sensitive in utero population, and to define in part the chemical mixtures present among the study samples.

The scientific community also uses biomonitoring such as that performed in this cord blood study to track exposure reductions that can stem from public health interventions. Biomonitoring studies have documented the success of public health interventions in dramatically reducing children's blood lead levels in the U.S. (Pirkle et al. 1994); in lowering PCB and organochlorine pesticide levels in breast milk from mothers in Germany and Sweden (Schade and Heinzow 1998, Noren and Meironyte 2000); and even in reducing exposures to second-hand smoke in the U.S. (CDC 2003).

In future biomonitoring efforts (CDC 2005) scientists from the Centers for Disease Control and Prevention plan to collect exposure data that can document the efficacy of recent public health interventions restricting the use of the Scotchgard chemical PFOS (EPA 2000b) and the popular home insecticide chlorpyrifos, or Dursban. And in the Children's Health Act of 2000 (Public Law 106-310 Sec. 1004), Congress authorized "a national longitudinal study of environmental influences (including physical, chemical, biological and psychosocial) on children's health and development." The study, as planned, aims to track exposure and health outcomes for 100,000 American children from early pregnancy to age 21 (DHHS 2004).

Question #3: Why did you test just 10 newborns?

Studies of chemicals in human tissues are expensive — in this study, laboratory costs alone were $10,000 per sample. The methods are highly specialized, few laboratories are equipped with the machines and technical expertise to run the analyses, and costs are high. Because of these constraints, a high fraction of umbilical cord blood pollution studies have tested a small number of babies. We identified 41 studies in the peer-reviewed literature that have reported on cord blood levels for some of the same pollutants we tested. Of these, 15 percent (6 studies) tested 15 or fewer babies:

- 15 subjects — Inoue K, Okada F, Ito R, Kato S, Sasaki S, Nakajima S, Uno A, Saijo Y, Sata F, Yoshimura Y, Kishi R, Nakazawa H. 2004. Perfluorooctane sulfonate (PFOS) and related perfluorinated compounds in human maternal and cord blood samples: assessment of PFOS exposure in a susceptible population during pregnancy. Environ Health Perspect. 2004 Aug;112(11):1204-7.

- 15 subjects — Guvenius DM, Aronsson A, Ekman-Ordeberg G, Bergman A, Noren K. 2003. Human prenatal and postnatal exposure to polybrominated diphenyl ethers, polychlorinated biphenyls, polychlorobiphenylols, and pentachlorophenol. Environ Health Perspect. 2003 Jul;111(9):1235-41.

- 12 subjects — 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.

- 10 subjects — Sarcinelli PN, Pereira AC, Mesquita SA, Oliveira-Silva JJ, Meyer A, Menezes MA, Alves SR, Mattos

RC, Moreira JC, Wolff M. 2003. Dietary and reproductive determinants of plasma organochlorine levels in pregnant women in Rio de Janeiro. Environ Res. 2003 Mar;91(3):143-50.

• 9 subjects — Cooper SP, Burau K, Sweeney A, Robison T, Smith MA, Symanski E, Colt JS, Laseter J, Zahm SH. Prenatal exposure to pesticides: a feasibility study among migrant and seasonal farmworkers. Am J Ind Med. 2001 Nov;40(5):578-85.

• 5 subjects — Schecter 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.

Question #4: How do industrial chemicals get in my body?

More than 75,000 commercial chemicals are currently approved for use in the U.S. (EPA 2005c), a number that grows by 2,500 new chemicals yearly (EPA 1997). U.S. industries produce or import 3,000 of these in quantities of greater than one million pounds per year (EPA 2005c). Many pesticides banned in the U.S. for decades (PCBs and DDT, for example) persist in the environment, build up in the food chain, and continue to contribute to daily exposures. Government sources detail more than 3,000 chemicals used as food additives (FDA 2005), an estimated 10,500 ingredients in personal care products (FDA 2000), and more than 500 chemicals approved as active ingredients in pesticides (EPA 2002a,2005b). Many of these chemicals, whether used purposefully or found as unwanted impurities, can contribute to a person's body burden through exposures from food, air, water, dust and soil, and consumer products. And for many chemicals in our bodies, the health consequences are unknown. The studies aren't required under federal law, and in most cases simply haven't been done.

Question #5: How can I reduce my chemical exposures?

Some exposures to pesticides and industrial chemicals are unavoidable. Persistent pollutants, some banned for decades, still contaminate the environment and end up in the food we eat, the water we drink, and the air we breathe.

Yet even exposures to persistent pollutants can be reduced through a varied diet that contains fewer meat and high fat dairy products. Other chemical exposures, like toxic substances in household cleaners, can be avoided altogether.

Some simple tips for reducing exposures to industrial chemicals are:

- Eat fewer processed foods, which often contain chemical additives.
- Eat organic produce. It's free of pesticides and preservative chemicals.
- Don't microwave food in plastic containers, use glass or ceramics.
- Run your tap water through a home filter before drinking. Filters can reduce levels of common tap water pollutants.
- Eat fewer meat and high fat dairy products, which contain higher levels of some pollutants.
- Reduce the number of cosmetics and other personal care products you use, which can contain harmful chemicals and can be sold with no safety testing.
- Avoid artificial fragrances.
- Don't use stain repellants on clothing, bedding or upholstery.
- Reduce the number of household cleaners you use. Try soap and water first.
- Avoid using gasoline-powered yard tools — use manual or electric tools instead.
- Avoid breathing gasoline fumes when you're filling your car.
- Eat seafood known to be low in PCB and mercury contamination, including wild Alaska salmon and canned salmon. Avoid canned tuna — it contains mercury.

Particularly if you're pregnant, try to follow the tips listed above. Is there someone in your household who can take over using household cleaners and pumping gas while you're pregnant? Eat canned salmon instead of canned tuna. Paint the baby room well before you conceive. Don't use nail polish, which contains chemicals linked to birth defects in laboratory studies.

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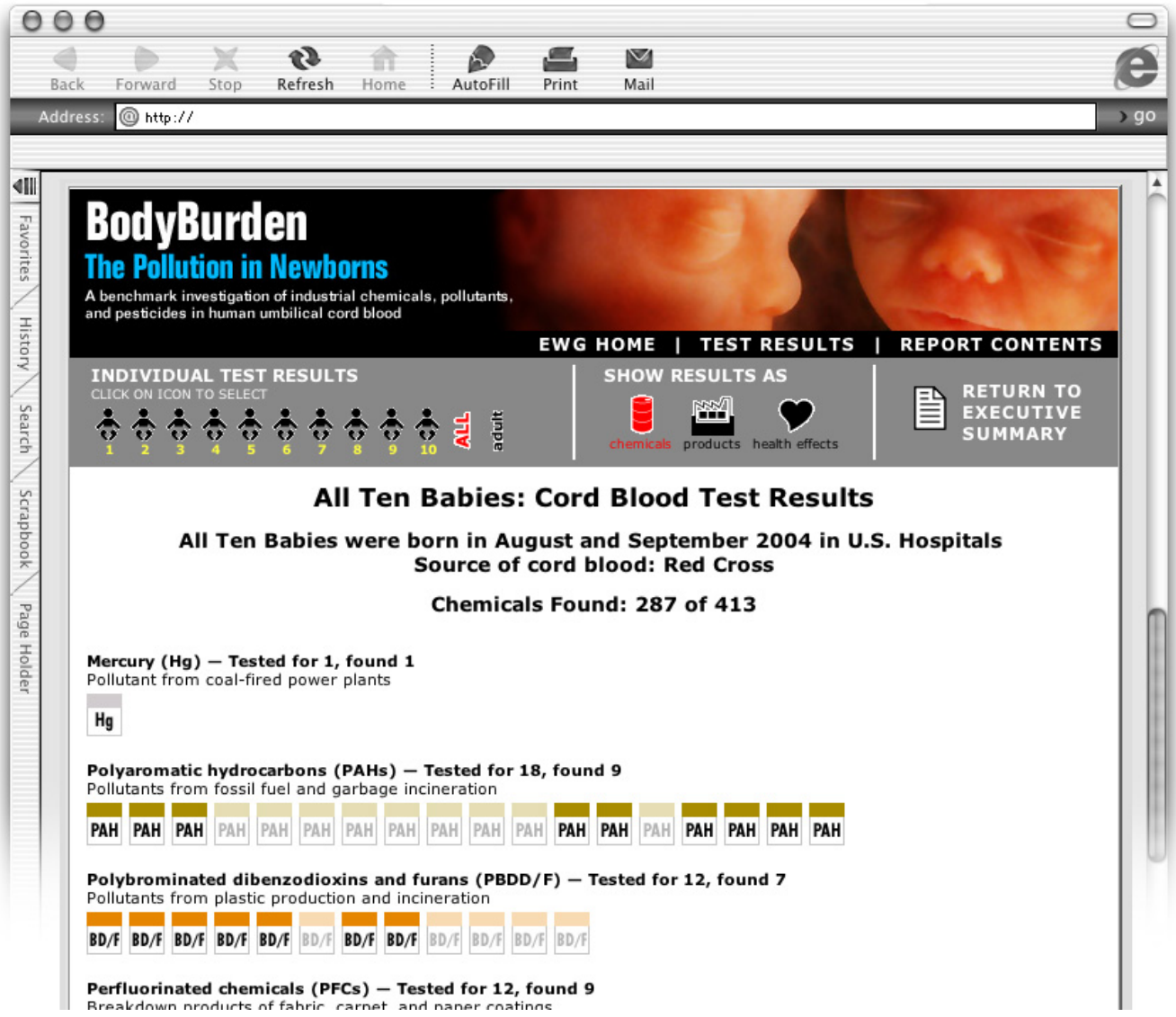
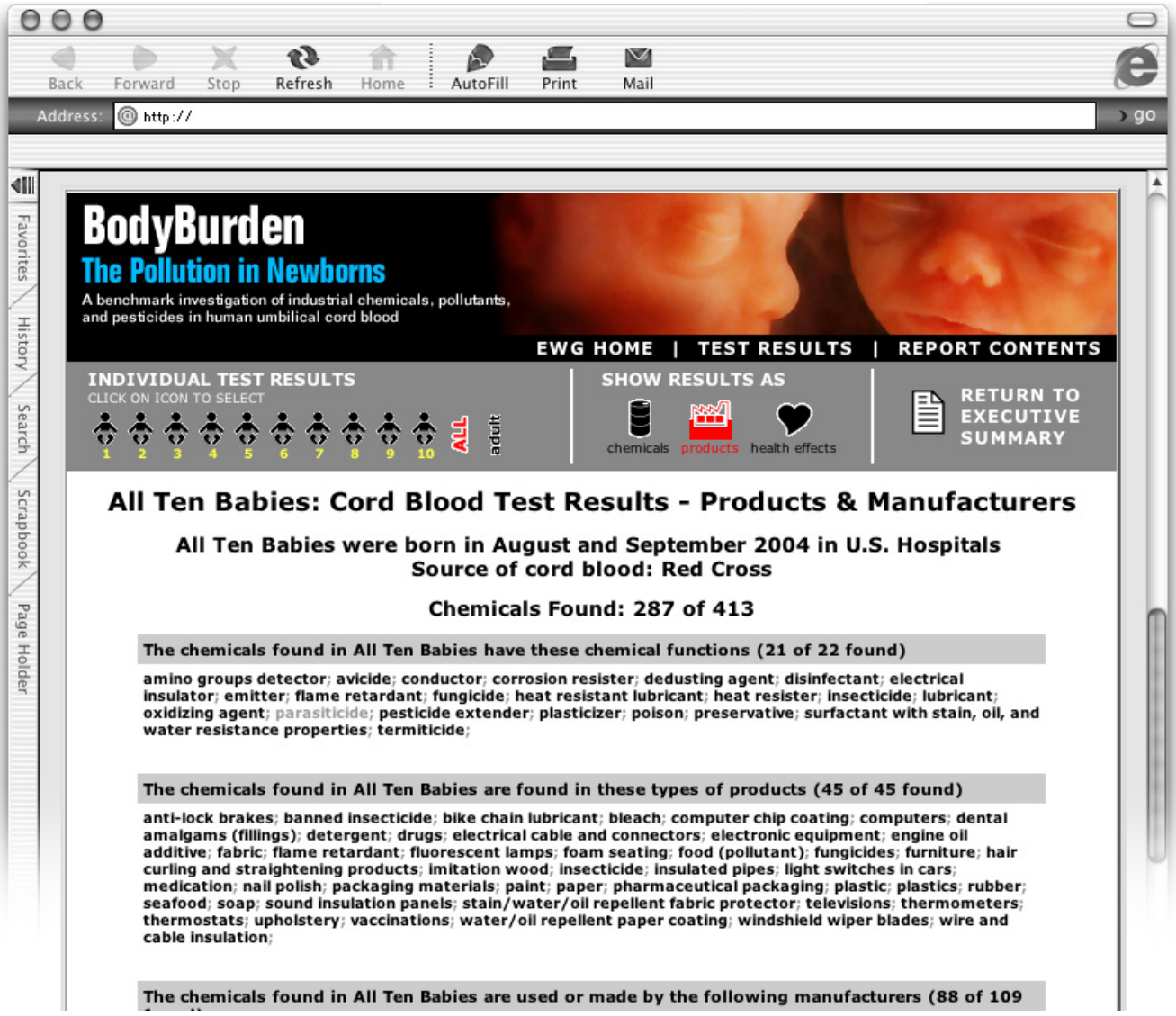
Interactive Umbilical Cord Blood Test Results

Pollution in 10 babies. A graphical testing summary shows the 287 chemical pollutants in the 10 newborns tested, including Teflon chemicals, fire retardants, and pesticides.



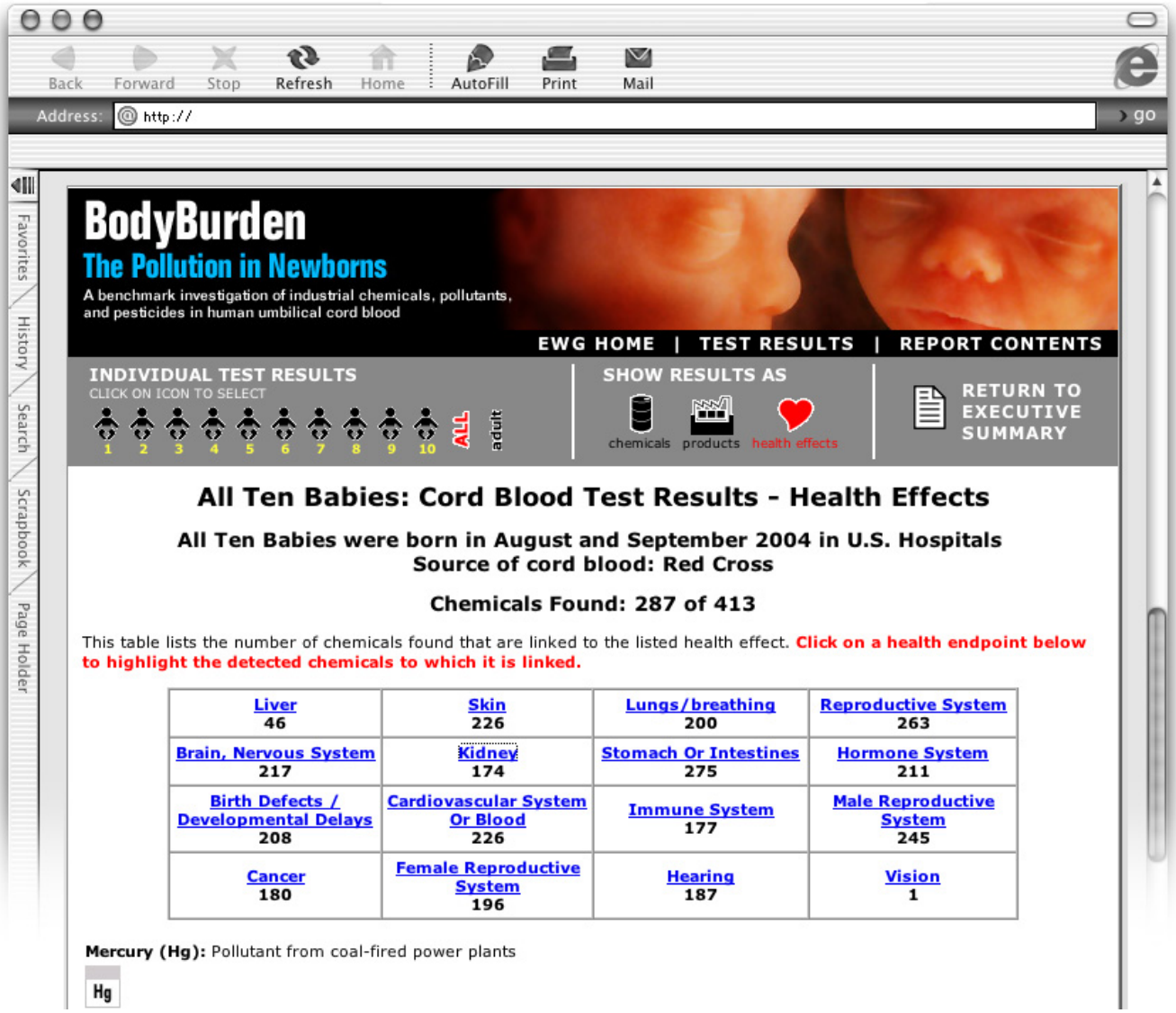
Available at:
http://www.ewg.org/reports/bodyburden2/testresults.php

Products/manufacturers for pollutants in 10 babies. Tests show chemicals used as plasticizers, fungicides and surfactants in newborn umbilical cord blood.



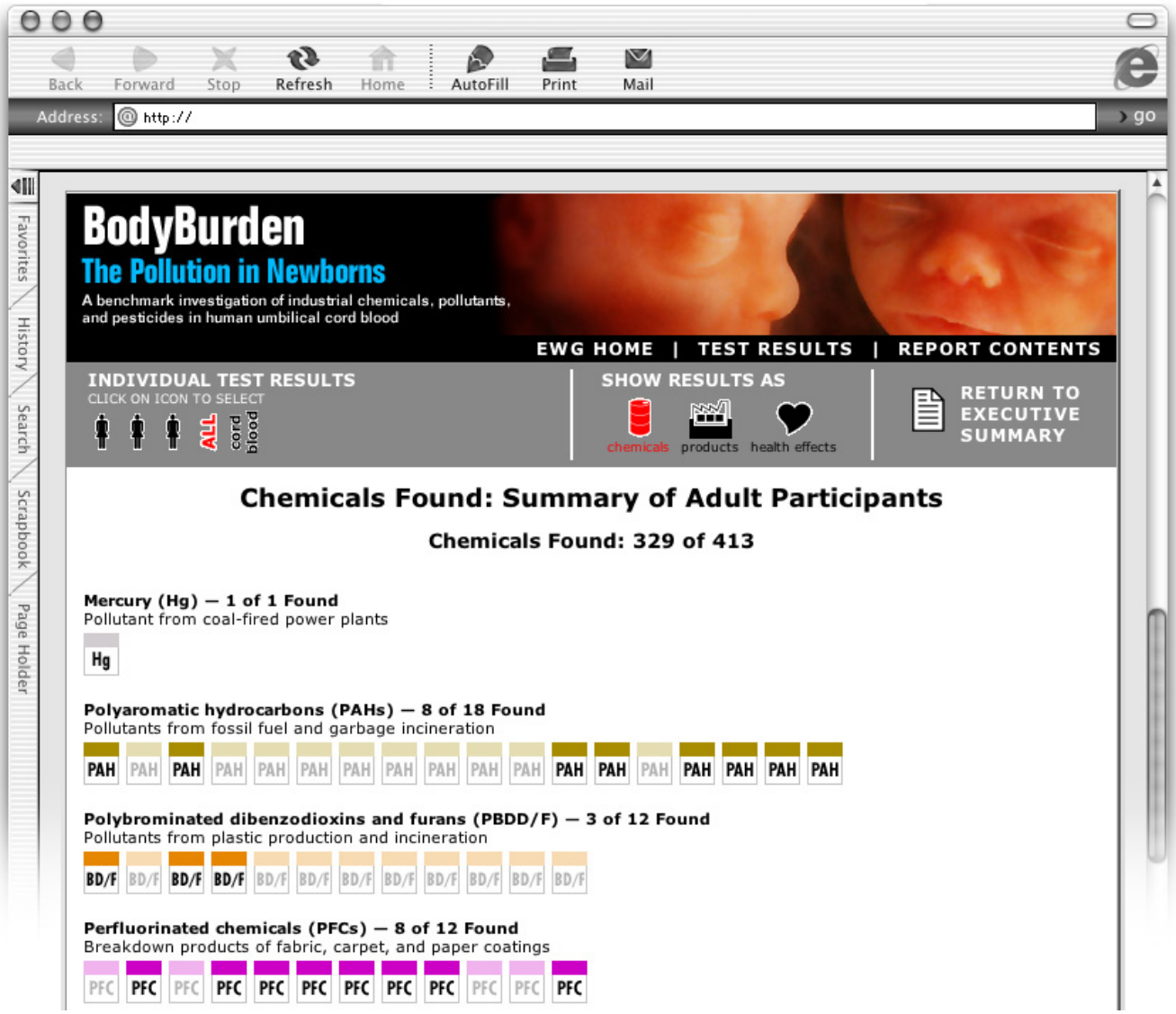
Available at:
http://www.ewg.org/reports/bodyburden2/testresults.php?&view=mfg

Health effects linked to pollutants in 10 babies. Of the 287 chemicals we found in newborns, 180 can 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.



Available at:
http://www.ewg.org/reports/bodyburden2/testresults.php?&view=health

Pollution in 3 adults. We tested three adults, including a U.S. Representative, for the same suite of 413 industrial chemicals, pollutants and pesticides tested in newborns, and found 329 chemicals altogether.



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http://www.ewg.org/reports/bodyburden2/testresults_adults.php

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