A GUIDE TO BIOMONITORING OF INDUSTRIAL CHEMICALS

by Christopher Oleskey BA; Michael McCally, MD, PhD

Center for Children's Health and the Environment
Department of Community and Preventive Medicine Box 1043
Mount Sinai School of Medicine
New York, NY 10029

Contact Information:
Email: christopher.oleskey@mssm.edu
Tel: 212-241-8806
Fax: 212-360-6965

Acknowledgements: Many thoughtful colleagues advised us in the preparation of this guide. Some reviewed the manuscript, others critiqued specific sections. We are indebted to: Bill Moyers, Michael Lerner, Phil Landrigan, MD, MSc; Audrey Their, Larry Needham, PhD; Lynn Goldman, MD, MPH; Paul Donally, PhD; Andrew Todd, PhD; and Anjali Garg, MS.

A. INTRODUCTION

We live in an environment contaminated with large amounts of industrial chemicals. The majority of these chemicals have been produced and released into the environment during the past 50 years, and large amounts are dispersed each year. The majority are not currently tested for their risk to human health. Approximately 70,000 industrial chemicals are registered with the Environmental Protection Agency (EPA) for commercial use, and each year around 1,500 new chemicals are introduced into the marketplace. Humans are potentially exposed to the 3,000 high-production volume (HPV) chemicals, those produced annually in quantities of 1 million tons or more. Once exposed, humans may absorb these chemicals into their bodies and face potential health risks. However, less than half of these highly prevalent chemicals have been tested for their ability to cause toxic health effects and fewer than 20% of industrial chemicals have been tested for their capacity to interfere with human development. We know very little regarding the relationship between exposure and health risk for most of these chemicals.

On the other hand, the health effects for some of these chemicals are well known. The heavy metals lead, mercury, and manganese are known to be toxic to the nervous system (and are associated with learning disabilities in children). Other chemicals, such as 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (commonly known as dioxin or TCDD), the heavy metal chromium, and the volatile organic compound benzene, are known to have carcinogenic properties. Phthalates, the most abundant man-made chemical in the environment, cause reproductive and developmental effects in animals. The organochlorines, a class of chlorine-containing compounds including dioxins, furans, polychlorinated biphenyls (PCB's), and certain pesticides such as DDT, tend to persist in the environment and become concentrated in animal tissues. Many organochlorines have the ability to disrupt the endocrine system, the body's hormonal signaling system, which is crucially important for regulating reproduction and development.

The developing fetus, infants and children are particularly vulnerable to many of these compounds. Birth defects and developmental disabilities are increasingly common, and chemical toxicants are known to play a role in causing some of these conditions. Exposure to lead, mercury, PCB's, dioxins, certain pesticides, and other neurotoxicants are suspected by some researchers to play a role in the development of developmental disorders: attention deficit/hyperactivity disorder (ADHD), dyslexia, and mental retardation.

Humans are exposed to industrial chemicals in many different ways. Workers involved in manufacturing may be exposed to toxic chemicals while on the job or may bring the chemicals on their clothes to their residences, thereby possibly exposing their families. Community exposure may occur after chemicals are released directly into the environment from industrial facilities, agriculture or other sources of environmental pollution, such as automobile and diesel exhaust, incinerators, and tobacco smoke. We also become exposed to these chemicals through the air we breathe, food we eat, and water we drink. Finally, commercial products manufactured by industry may contain potentially toxic chemicals. Many products used in or around the home contain chemicals that may pose an exposure risk for humans. It should also be mentioned that some toxins originate from naturally occurring mechanisms. Aflatoxin is formed from a fungus

on products such as corn. Other chemicals, such as arsenic, may originate from industrial sources or naturally from the earth's crust.

It is now possible to measure the amounts of these chemicals in food, air, soil and water, as well as the actual amounts of these chemicals in human tissue. Biomonitoring is the measurement of exogenous chemicals, their metabolites, or their reaction products in blood, urine, breast milk, fat, hair or other tissue. Biomonitoring is the preferred and most direct estimate of the amount of an exogenous chemical that is absorbed into the body. Scientists now know the approximate amount of hundreds of exogenous chemicals stored or circulating in the body. The total amount present in the body is termed the body burden. Continued improvement in laboratory technology now makes it possible to measure the body burdens for many classes of industrial chemicals in low (parts per trillion) concentrations. Unfortunately, these tests are technically difficult and expensive. The relationship of chemical body burden to human health is largely unknown, but research in this area is expanding rapidly.

National studies are now underway to determine the chemical body burden of ordinary citizens in the United States population, persons not known to be exposed. The Center for Environmental Health of the Centers for Disease Control and Prevention (CDC) recently released the results of its first annual biomonitoring survey of the U.S. population. This study, termed the **National Report on Human Exposure to Environmental Chemicals,** measured the blood and urine levels in the U.S. population of 27 industrial chemicals. The report includes first-time information about body burdens in the U.S. population for certain chemicals such as phthalates. Additionally, the report also has begun the process of establishing reference range, or "normal" values to be used by physicians and health researchers in examining exposure trends over time.

The release of the CDC's national exposure report and the recent Bill Moyers PBS special television program "Trade Secrets" effectively announced to the public the availability of these powerful techniques. Many persons are interested in such testing of their own blood or urine. Some believe themselves to be exposed, some have obscure and often debilitating symptoms. Others believe themselves chemically injured and may be in conflict with employers. Some want to reduce their family's exposure. Some are just curious and are seeking information and counseling on human biomonitoring. This guide is intended to help citizens in their search for information about biomonitoring and body burdens of industrial chemicals.

B. ORGANIZATION OF THE GUIDE

B.1. PURPOSE OF THE GUIDE

The focus of this guidebook is human biomonitoring: the measurement of chemicals in human tissue. There are many sources of information about human biomonitoring on the World Wide Web, in medical magazines and textbooks, and in health advocacy organization resources. This guide brings together these information resources, organizes them by topic area, and provides a

brief annotated description of each. The goal is to help you select resources relevant to your concern.

This guide is intended to be an information resource about human exposure to environmental chemicals. It is not intended to serve as a comprehensive resource on the health effects of exposure to toxic chemicals, nor is it to be used as a means for self-diagnosing chemical illness from observed health conditions, signs, or symptoms. Even if you have been exposed to a potentially toxic chemical, it is important to remember that the presence of the chemical in your blood or urine does not necessarily mean it has caused or will cause disease. No guidebook should substitute for seeing a physician if you think you may have been exposed to toxic chemicals, or if you have experienced illness that you believe may be related to such exposure.

B.2. INTENDED AUDIENCE

This guide has two intended audiences: the general public and health professionals. Both groups have interest and concern about human exposure to chemicals. Most resources in this guide are accessible to general reader with little scientific training. The more technical resources may be helpful to health care providers. Some resources, particularly journal articles and textbooks, presume but do not require some scientific training.

B.3. CONTENTS

The contents of this guide are divided into several sections. The first section contains information resources on the science of biomonitoring, the CDC's **National Report on Human Exposure to Environmental Chemicals** and other biomonitoring studies. Next, the question of how to get tested for chemical exposure is addressed. Getting tested for industrial chemical exposure is not a simple process. Rules and regulations exist on the federal, state, and individual laboratory level that limit an individual's ability to have his/her own tissues tested. The guide seeks to identify opportunities for individuals to be tested for industrial chemical exposure.

The next section presents resources that enable the reader to investigate basic chemical information databases, as well as resources for general toxicological information (including Internet-accessible toxicology databases). The main body of this guide is modeled on the classes of toxic chemicals analyzed for exposure in humans in the CDC's national exposure report. These include heavy metals, pesticides, and phthalates. Dioxins, furans, PCB's, and some volatile organic compounds are covered in this guide but are not covered in the initial CDC report. Each individual section is divided into three components: Web sites, Books/Texts, and Journal Articles. The guidebook does not cover each chemical in a specific class. The guide instead covers information resources for selected specific chemicals, to be used as a model for studying other chemicals in a class. Also, many of the resources covered in this guide contain information about similar chemicals in addition to information about the specific chemical referenced.

Next, some specific populations of people at particular risk from industrial chemical exposure are covered. The guide also contains information on specific exposure pathways, and organizations that provide information on environmental health. The appendices include a

sample ATSDR Toxicological Profile, a table of clinical laboratory regulations for ordering tests and receiving test results (organized by state), and a section on environmental health resources and relevant federal regulation. Finally, the guide concludes with an essay on body burdens of industrial chemicals in the general population.

B.4. HOW TO USE THE GUIDE

This guide contains a table of contents which allows the user to advance directly to the specific topic of interest. When in the table of contents, simply click on the page number corresponding to the section in the guide you wish to see and the text will automatically forward to that section.

B.4.a. Books

Most of the texts listed in this guide are written at intermediate to advanced levels of technicality. Those interested in particular areas are first encouraged to look at the Web sites listed under the area of interest, and then turn to the book if the information provided on the internet is not sufficient. Books will cover the material in a more comprehensive way but will often not contain the most up-to-date information in the field. Many of these books will be available at larger libraries, and others might only be available at medical or scientific libraries. Books are also valuable for the extensive references to articles published in medical journals. These references may be used as a resource for exploring more specific topic areas in greater detail.

B.4.b. Journals

The best source for medical and scientific journals is a medical library. Specific articles can be found directly through the library's reference system, or indirectly through Medline on the web. Abstracts of articles may be printed from Medline. Journal articles tend to be more technical than other information sources such as web sites and information from citizen's groups. Journals are targeted towards health professionals in a specific discipline and represent current research. Journal articles are recommended mainly for those with a deeper interest in a specific issue.

Medline can be accessed through Pubmed of the National Library of Medicine. The address is:
http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?db=PubMed
If you do not have access to Medline at home, a local public library, university, or medical library should be able to provide access for you.

B.4.c. Searching the World Wide Web

The web sites listed in this guide will either take you directly to information about a chemical of interest, or it will take you to a site or database that will enable you to find the specific information you are looking for.

There is a tremendous amount of information directly viewable on the Web sites listed in the guide. However, large stores of information are frequently available on Web sites in the form of

compressed data files known as PDF files. These files, often large texts or charts, can be downloaded and viewed by using the Adobe Acrobat Reader, an application on most home computers. If your computer does not have the Adobe Acrobat Reader, you may download it for free at: **http://www.adobe.com/products/acrobat/readstep.html**

Search engines are another method for locating information on the World Wide Web. Commonly used search engines include:

Go.com	**http://www.go.com/**	Vivisimo	**http://www.vivisimo.com**
Yahoo	**http://www.yahoo.com/**	Wisenet	**http://www.wisenet.com**
Google	**http://www.google.com/**	Teoma	**http://www.teoma.com**
Alta Vista	**http://www.altavista.com/**		

Search engines are commonly used tools to identify relevant sites on the Internet. They are useful when beginning your research, particularly if you do not have specific web site addresses or databases of web site addresses organized by topic area. Search engines allow you to look up Internet sites based on key words typed into their search boxes. The more general the term, the greater number of sites found. If more specific words and/or combinations of words are used, the search will be more refined. For example, a search for "pesticides" will produce thousands of Web site addresses, many not particularly useful. But a search with "organophosphate and exposure" will produce a smaller list with more specific and useful web sites. In addition, search engines often include their own links to collections of resources. These are organized by category, and by following their sequence you may zero in on a small list of sites that are most useful for finding the information you are seeking. For example, through Google, you can follow the link from "Science" to "Chemistry" to "Clinical and Medicinal Chemistry". This will give you a list of links to 22 clinical chemistry sites including the NIH Chemical Information Page, American Association for Clinical Chemistry, American Society for Clinical Laboratory Science, International Federation of Clinical Chemistry and Laboratory Medicine, Organophosphorus Medicinal Chemistry and other useful sites.

Google's Directions for Using Search Engines:
http://www.google.com/help/basics.html
This Web site explains the basics of using search engines to find specific information.

B.5. TIPS ON GETTING TESTED

Having one's blood or urine tested for exogenous or industrial chemicals can be both easy and difficult. For example, your physician can send your blood to a local clinical chemistry laboratory or public health laboratory and get a blood lead level, and in some area's, pesticide residues. On the other hand, to get a broad panel of chemicals measured including PCBs, dioxins, and/or phthalates, one may have to join a research study or with a group make a private arrangement with a specialized research laboratory.

There are many issues involved in having oneself tested and these matters are discussed in detail in Section D. Names and contact information for specific laboratories are presented as well as clinical laboratory regulations by state.

1) Start with your own physician. He or she knows your particular case and can be helpful. In most states only a physician or other licensed health professional can order clinical laboratory tests and receive test results.
2) Contact an occupational/environmental physician at a medical school or teaching hospital or through the Association of Occupational and Environmental Clinics (contact information in Section D). Your physician may not be helpful or may not know how you can be tested.
3) Contact Quest Diagnostic Laboratories or Pacific Toxicology Laboratories. These large nationwide clinical laboratories will in some cases consider testing individuals or groups. Their contact information is in Section D below.
4) Remember that we all have some body burden of industrial chemicals. The presence of a chemical does not necessarily indicate illness. Consultation with a sympathetic physician is useful. Discuss your possible exposures to industrial chemicals.
5) Consider reducing your and your family's exposure to industrial chemicals by changing your diet to use only organic produce. Consider limiting your intake of meat and dairy products. Make sure your house or apartment do not contain lead exposure hazards. Limit or abandon the use of household chemical pesticides, and in particular, stop smoking.

C. BIOMONITORING

Biomonitoring is the measurement of an exogenous agent in a biological medium (blood, urine, etc.) or the measurement of "markers" that indicate the presence of an exogenous agent in a biological medium. Exogenous agents in this case are chemicals manufactured by humans and released to the environment. These agents may pose exposure and health risks for humans. Human biomonitoring includes the measurement of industrial chemicals in blood, urine, breast milk, fat, hair, or other tissues. Clinical laboratory technology now allows for the measurement of heavy metals, pesticide residues, dioxins, furans, PCB's, phthalates, volatile organic compounds, polyaromatic hydrocarbons, and cotinine, a marker of environmental tobacco smoke exposure. The tests are often complex and costly. Research into the consequences of human exposure to these chemicals is rapidly expanding.

C.1. GENERAL BIOMONITORING INFORMATION

C.1.a. Web Sites

Biomonitoring Program: Background
Division of Laboratory Sciences (DLS)
U.S. Centers for Disease Control (CDC)

http://www.cdc.gov/nceh/dls/biomonitoring.htm
This Web site describes the CDC's biomonitoring program in detail. It includes the goals of the program and the chemicals capable of being measured by the CDC. Many of these chemicals are not included in the CDC's *National Report on Human Exposure to Environmental Chemicals*.

Models, Monitoring and Biological Markers
International Program for Chemical Safety (IPCS)
World Health Organization
http://www.who.int/pcs/training_material/module4/annex3.htm
This site provides an extensive bibliography of articles on biomonitoring, biomonitoring models, and biological markers. These are professional articles useful for those interested in the concepts of dose-response, multicompartmental models, biomarker determination, determining exposure standards, and risk assessment.

C.1.b. Books/Texts

Ashford, Nicholas A.; Spadafor, Christine J.; and Hattis, Dale B. **Monitoring the Worker for Exposure and Disease: Scientific, Legal, and Ethical Considerations in the Use of Biomarkers**. Baltimore: The Johns Hopkins University Press, 1990.

This book explains the science of human biomonitoring, which is increasingly being used as a supplement or replacement for environmental monitoring of toxic substances in the workplace. It also examines the medical, legal, and ethical issues of such testing and develops policy recommendations. This book is suitable for a general audience.

Kneip, TJ; and Crable, JV (editors). **Methods for Biological Monitoring: a Manual for Assessing Human Exposure to Hazardous Substances.** Washington: American Public Health Association, 1988.

This book address biomonitoring testing procedures in detail. It is technical in scope, and geared towards toxicology laboratory professionals.

Baselt, Randall C. **Biological Monitoring Methods for Industrial Chemicals,** (Third Edition). Foster City: Chemical Toxicology Institute, 1997.

This text compiles information on industrial and environmental chemicals subject to biological monitoring, and describes analytical methods determining their presence in human tissue. This work is comprehensive, technical, and intended for those in the field of occupational medicine.

C.1.c. Journals/Specific Articles

General Information About Biomonitoring

Heinzow BG, McLean A. Critical evaluation of current concepts in exposure assessment. *Clinical Chemistry.* 1994; 40(7 pt 2):1368-75.

This article provides a good introduction to biomonitoring. As is the case with most journal articles, it is intended for a professional audience, but it is not overly technical. It reviews the connection between environmental pollution and human health risks.

Suk W, Collman G, Damstra T. Human Biomonitoring: Research Goals and Needs. *Environmental Health Perspectives.* 1996; 104(suppl 3):479-483.

This journal article is a good starting point for a general survey of the current state of biomonitoring science and its goals for the future.

Wise SA, Koster BJ. Considerations in the design of an environmental specimen bank: experiences of the National Biomonitoring Specimen Bank Program. *Environmental Health Perspectives*. 1995; 103(suppl 3):61-7.

This article describes the activities of the NIST (National Institute of Standards and Technology) biomonitoring specimen bank since 1979. It addresses the biomonitoring of both human and animal tissue.

Goldman LR, Anton-Culver H, Kharrazi M, Blake E. Banking of human tissue for biomonitoring and exposure assessment: utility for environmental epidemiology and surveillance. *Environmental Health Perspectives*. 1995; 103(suppl 3):31-34.

This journal article discusses opportunities to establish human tissue banks in connection with pre-existing public health surveillance programs for cancer and reproductive disease. It also discusses ethical issues of biomonitoring, risk communication, environmental justice, and community involvement.

Ashford NA. Monitoring the worker and the community for chemical exposure and disease: legal and ethical considerations in the US. *Clinical Chemistry*. 1994; 40(7 pt 2):1426-37.

This article provides an overview of ethical issues involved in the biomonitoring of workers (by employers) and the biomonitoring of the community (by public health officials). It suggests mechanisms for positive relations in employer-worker and community-public health communities.

Technical Information About Biomonitoring Science

Aitio A. Reference limits in Occupational Toxicology. *Clinical Chemistry*. 1994; 40(7 Pt 2):1385-6.

This technical article discusses the concept of reference limits in biomonitoring.

Aldridge WN. Defining thresholds in occupational and environmental toxicology. *Toxicology Letters*. 1995; 77(1-3):109-18.

This technical article discusses the concept of a threshold as a maximum exposure level when toxicity does not occur. It also examines biological parameters that influence exposure-response relationships.

Aitio, A, and Kallio A. Exposure and effect monitoring: a critical appraisal of their practical application. *Toxicology Letters*. 1999; 108(2-3):137-47.

This article discusses biomarkers of exposure as indicators of health risk. This requires that the relationship between biomarker and health effect. The article illustrates some of the complexities in using biomonitoring to assess health risks.

C.2. CDC EXPOSURE REPORT

In 2001, the U.S. Centers for Disease Control and Prevention (CDC) issued its first report in what will be an annual series, the **National Report on Human Exposure to Environmental Chemicals.** This report contains information about levels of 27 environmental chemicals in the U.S. population. These chemicals include thirteen heavy metals, six metabolites of organophosphate pesticides (from the breakdown of 28 individual commercial pesticides), cotinine, and metabolites of seven phthalates. Measurements were made on blood and urine collected from up to 3000 persons in the United States during 1999-2000.

The CDC Exposure Report reported levels of the following chemicals:

METALS
• Lead • Mercury • Cadmium • Cobalt
• Uranium • Antimony • Barium • Beryllium
• Cesium • Molybdenum • Platinum • Thallium
• Tungsten

TOBACCO SMOKE
• Cotinine (a metabolite of nicotine)

ORGANOPHOPHATE PESTICIDES
Urine metabolites of 28 pesticides, including chlorpyrifos,
diazinon, fenthion, malathion, parathion, disulfoton, phosmet, phorate, temephos, and methyl parathion:
• Dimethylphosphate
• Dimethylthiophosphate
• Dimethyldithiophosphate
• Diethylphosphate
• Diethylthiophosphate
• Diethyldithiophosphate

PHTHALATES
Urine metabolites of seven phthalates:
• Mono-ethyl phthalate • Mono-isononyl phthalate
• Mono-butyl phthalate • Mono-cyclohexyl phthalate
• Mono-2-ethylhexyl phthalate • Mono-benzyl phthalate
• Mono-n-octyl phthalate

By comparing the results with future yearly reports, public health officials will be able to describe trends in exposure to environmental chemicals in U.S. citizens. Data will be reported according to the age, sex, race/ethnicity, geographic area, and income level of the people tested.

Future reports will be expanded to include approximately 100 priority environmental chemicals. Chemicals under consideration include volatile organic compounds, polyaromatic hydrocarbons, dioxins, furans, polychlorinated biphenyls, trihalomethanes, haloacetic acids, carbamate pesticides, and organochlorine pesticides.

Centers for Disease Control Web sites

Homepage for the Report

http://www.cdc.gov/nceh/dls/report/ This Web site contains direct links to the major findings, overview, results, and summary (a PDF file) of the report. Through this site you may also download the complete report in PDF format.

Overview of the Report:

http://www.cdc.gov/nceh/dls/report/overview.htm#public This site provides a definition of biomonitoring and describes the seven major uses of the report: to determine if chemicals are getting into the blood of Americans and what these levels are in blood and urine, to determine the prevalence of people with elevated levels, to assess the effectiveness of U.S. public health efforts to reduce exposure, to establish reference ranges, to track exposure trends over time, and to determine what levels of chemicals are higher among minorities, children, people of low income, elderly, women of childbearing age, and other groups. The final goal of the report is to set research priorities for human health effects of environmental chemicals.

Other Web Sites on CDC Report

Background of CDC Exposure Report

CDC Report Analysis Physicians for Social Responsibility (PSR)

http://www.psrus.org/expreport/ This PSR site is a summary of important findings and concerns from the CDC National Exposure Report.

C.3. OTHER BIOMONITORING STUDIES

Cumulative Exposure Report
Environmental Protection Agency (EPA)
http://www.epa.gov/cumulativeexposure/
The EPA's Cumulative Exposure Project (CEP) is an ongoing study examining how much toxic contamination Americans are exposed to cumulatively through air, food, soil and drinking water. The study will estimate exposure levels for different communities and demographic groups nationwide, and will help identify important pollutants and pollutant sources for further analysis. Click "resources" for links to the literature on exposure and health risks from air pollution.

National Health and Nutrition Examination Survey
(NHANES I Epidemiologic Study)
CDC
http://www.cdc.gov/nchs/nhanes.htm
NHANES is an ongoing survey conducted by the National Center for Health Statistics (NCHS) and the CDC. This survey has been designed to collect information about the health and diet of people in the United States. NHANES includes a biomonitoring component that preceded the CDC national exposure report.

Urban Soil Lead Abatement Demonstration Project
EPA
http://www.epa.gov/ncea/lead.htm
This site includes a description of the EPA's Urban Soil Lead Abatement Demonstration Project for monitoring urban soil lead concentrations and blood lead levels in humans.

C.4. TRADE SECRETS: A MOYER'S REPORT

Trade Secrets: A Moyer's Report
Public Broadcasting System (PBS)
http://www.pbs.org/tradesecrets/
This is the Web site homepage for **Trade Secrets**, an April 2001 television report by PBS journalist Bill Moyers. This program was an investigation of chemical manufacturing corporations whose workers were exposed to vinyl chloride. Some companies withheld information about the health risks from workers who had been exposed to this dangerous chemical. This program also covered the subject of a chemical body burden, and what this reservoir of toxic chemicals in human tissue may imply for human health. This Web site contains a description of the television program, chemical industry archives, and information on Bill Moyer's personal chemical body burden and where he might have been exposed to these chemicals.
To buy the Trade Secrets video call 1-800-257-5126 or see:
http://www.pbs.org/tradesecrets/buy.html

D. GETTING TESTED FOR CHEMICAL EXPOSURE

D.1. CONSIDERATIONS IN HUMAN BIOMONITORING

A citizen may decide to have him or herself tested for exogenous chemicals for reasons including, most typically, health concerns. Such testing is usually arranged by a physician as part of a medical evaluation. In some circumstances a person may wish to be tested without the intercession of a physician. A number of issues ought to be kept in mind when considering biomonitoring tests.

First, we all have small amounts of metals and industrial chemicals in our tissues. The health significance of this body burden of chemicals is known for a few agents, like lead, and unknown for many others. For the fetus and infants, chemical levels in tissues are high enough to cause health effects in animals and may be dangerous in humans. We discuss these issues in detail in the essay at the end of this guide.

Second, the presence of a potentially toxic chemical in blood or urine does not automatically indicate illness. While no one likes the fact of uninvited chemicals in our tissues, such exposures do not establish the likelihood of future illness. Unfortunately, although scientists have known of the chemical body burden, there are relatively few well-done studies of human health outcomes related to these exposures.

Third, biomonitoring tests are expensive. An inclusive panel of tests that might include heavy metals, organochlorines, phthalates and other classes of chemicals can cost $1000 to $5000 per person, depending on the panel of chemicals and the numbers of persons tested.

A fourth concern is quality. Clinical laboratories that report to doctors are highly regulated for their quality and very conscientious about the reliability of their results, as patients' lives are at stake. But some laboratories slack on quality control, particularly laboratories that market directly to consumers. Analysis of human hair for heavy metals, through the procedures of hair mineral analysis, is now offered directly to consumers by several commercial labs in the United States. In a recent study, the same hair in several samples was sent to 6 U.S. laboratories, which together analyze 90% of samples submitted for mineral analysis in the nation. The study reported wide variations in mineral concentrations reported by the various labs. It also found discrepancies in sample preparation methods, calibration standards, and laboratory designations of normal reference range values. The study concluded that "hair mineral analysis from these laboratories was unreliable", and recommended that "health care practitioners refrain from using such analyses to assess individual nutritional status or suspected environmental exposures". **See: Seidel, Sharon; Kreutzer, Richard; Smith, Daniel; McNeel, Sandra; Gilliss, Debra. Assessment of Commercial Laboratories Performing Hair Mineral Analysis. *JAMA*. 2001; 285:67-71.**

An additional problem in biomonitoring is the interpretations of results. To say that an observed level of a chemical is safe or normal requires comparison values from a large group of normal persons, determined with the same laboratory methods. Laboratory technology also changes over time and improvements allow for detection of smaller chemical concentrations in tissue. In addition, human health effects research results accumulate over time leading to the lowering of standards for safe levels of exposure. Safe exposure standards for lead and for nuclear radiation have come down steadily over the last 80 years as better health effects science becomes available. A physician or health professional's advice is very important to avoid misinterpretations of biomonitoring results.

D.2. BARRIERS TO GETTING TESTED

While a number of clinical laboratories perform tests for the presence of toxic chemicals, there are many barriers to self-testing for industrial chemical exposure, that is barriers to individuals approaching a laboratory directly. There are barriers in government regulatory law and customary practice.

First, all clinical laboratories that deal with human tissues, with the possible exception of hair, must follow federal and state guidelines. These regulations – required by law – discourage individuals from ordering and receiving tests directly from clinical chemistry laboratories.

The federal laws regulating clinical laboratories are the Clinical Laboratory Act (CLIA) of 1967, and the Clinical Laboratory Improvement Amendments Act of 1988. CLIA is administered by the Centers for Medicare and Medicaid Studies (CMS), formerly the Health Care Finance Administration (HCFA), the federal agency that pays for health services. CLIA specifies that all testing of human biological methods must be performed according to state law. CLIA mandates, among others, are that states establish requirements for who can order clinical laboratory tests and who can receive test results. ***To learn more about CLIA see Appendix N.4, "Federal Regulation".***

Guidelines vary state to state. In the majority of states only "authorized health professionals" may order tests and receive test results. In New York authorized health professionals include physicians, dentists, podiatrists, chiropractors, physician assistants, certified nurse midwives, and nurse practitioners. Patients in New York are not allowed to order tests but may directly receive test results. California allows physicians, osteopaths, nurse practitioners (under physician supervision), and physician assistants (under physician supervision) to order tests. Physicians in California may authorize the release of results to patients. Some states (New Hampshire, Vermont, Arkansas, Louisiana, Texas and some western states) do not prohibit lay persons from ordering and receiving test results or do not have specific guidelines. ***To learn more about state regulations for ordering tests and receiving test results see Appendix N.2, "Clinical Lab State Guidelines".***

In those states where the law allows the individual to order tests, he or she must negotiate the internal guidelines of the private laboratory corporations that perform the testing. Typically these corporate guidelines prohibit individual consumers from ordering and receiving tests

without a physician referral. In our survey we identified no clinical laboratory which allows a concerned individual to order clinical or toxicological test without a physician referral.

Another barrier is the complexity of certain tests. For example, there are two or possibly three commercial laboratories that can perform dioxin tests. Tests for dioxins and other organochlorine chemicals are technically complex. The labs do not want to set up the equipment for one or two tests. The EPA does not recommend routine testing for dioxins and PCBs, and the CDC, which conducts the national exposure study, will also not accept testing requests from individuals.

Because of these barriers, it is not possible today to offer a comprehensive consumer's guide to personal clinical testing identifying the available tests, costs, quality and contact information. Despite these considerations, biomonitoring of human tissues is still the most direct and preferable method of determining one's exposure to industrial chemicals. Knowledge of one's body burden of industrial chemicals is important health information, information that individuals have a right to know. Barriers to individual's access to this information need to be systematically addressed by health professionals and policy makers.

Physician practice is also a barrier to biomonitoring. Physicians are typically not well informed about environmental health and industrial chemical exposure and biomonitoring. Some are dismissive of patients' concerns and not helpful in arranging testing. In addition, unless the test relates to a specific diagnosis, testing is unlikely to be reimbursed by health plans. Finally, much remains to be known about chemical sensitivity and physicians may distrust chemical injury complaints.

Two decades ago physicians and hospitals kept personal health records from patients. Today the patient "owns" and has free access to his or her medical records, rights established by the courts. A similar right to know initiative may be appropriate in toxics biomonitoring.

D.3. GETTING TESTED

Consult a physician. Working with you, a physician can discuss your health concerns, evaluate your possible exposures, and arrange for and interpret test results. Physicians routinely order and interpret laboratory tests in the management of disease. In some cases, physicians request laboratory testing for toxics like lead, mercury or pesticides. If an exposure is established, a physician can work with you to identify the source of the chemical and ways to reduce exposure, and treat illness that might result.

If your physician is not knowledgeable or helpful, you may ask for a referral or seek out an occupation and/or environmental health physician. A local medical school or teaching hospital will have an occupational medicine group. The Association of Occupational and Environmental Clinics (**http://www.aoec.org**) is also a useful resource.

D.3.a. Private Laboratories

There are many private commercial laboratories that offer a wide range of biomonitoring services. These laboratories follow state and federal regulations, which, in the majority of states, require a referral from a physician or other licensed health professional. Some of the larger, reputable clinical laboratory corporations are listed below.

Quest Diagnostics (includes SmithKline Beecham Clinical Labs, Corning Clinical Labs, Metpath)
http://www.questdiagnostics.com
Tel: 201-393-5597
Quest Diagnostics is a large clinical laboratory corporation with numerous branches throughout the United States. Quest does not perform testing directly from patient request.

QuestDirect
http://www.questest.com/ch/minihome/Home.jsp
Tel: 877-783-7837
QuestDirect is the internet-based version of Quest Diagnostics. This service allows consumers from five states (CO, MT, UT, MO, KA) to order certain diagnostic tests over the Internet. Currently there is no toxicology testing available, however, the types of tests offered and regions covered by QuestDirect may expand in the future.

Pacific Toxicology Laboratories
http://www.pactox.com/
Contact Person: Paul Donally
Tel: 800 538-6942 ext. 232
Pacific Toxicology Laboratories is based in Woodland Hills, California. This company specializes in a wide range of biomonitoring tests. Due to federal and state regulations, Pacific Toxicology does not accept inquiries from individual patients.
For a list of biomonitoring tests performed see:
http://www.pactox.com/chemicaltests.htm

Midwest Research
http://www.mriresearch.org/
Contact Person: Tom Sack
Tel: 816-753-7600 ext. 1557
Midwest does not currently take inquiries from individual patients, but physicians may contact Midwest if they are interested in toxicology testing for research purposes.

Laboratory Corporation of America (includes National Health Labs, Roche Biomedical, Compuchem)
http://www.labcorp.com/

Tel: 800-788-9091
Biomonitoring services can only be obtained through requests from hospitals, physician's offices, physician clinic request, or by court order. In accordance with Federal and State regulations, there is no self-ordering of testing or self-receiving of test results. Services need to be billable to a physician or clinic with an account number.

D.3.b. Environmental Health Clinics

There are a number of clinical centers that specialize in diagnosing and treating disorders that have an environmental basis. Human biomonitoring is not the primary focus of these centers. These clinics tend to be controversial, as the quality of testing services cannot be assured (***see Section D.1, "Considerations in Human Biomonitoring" for a discussion of test quality concerns***).

Environmental Health Center-Dallas (EHCD)
http://www.ehcd.com/
Tel: 214-368-4132
The Environmental Health Center- Dallas was founded in 1974 By Dr. William J. Rea, a cardiovascular and general surgeon. EHCD offers a wide variety of biomonitoring services. EHCD specializes in treating disorders such as fibromyalgia, chronic fatigue syndrome, and other illnesses thought to have a strong environmental component.

D.3.c. State Health Departments and Laboratories

State Health Departments and Laboratories perform biomonitoring analyses when there is a direct, pressing public health need. State Laboratories are subject to federal and state regulations and do not test private paying customers.

State Health Departments and Laboratories
http://webtest.tdh.state.tx.us/lab/sthlthde.htm
This web site contains links to all state health department and clinical laboratory Web sites.

Association of Public Health Laboratories
http://aphl.org/
This site contains links to all state public health laboratories. It also contains descriptions of laboratory standards, and APHL publication and videos (including a video entitled "Childhood Lead Screening: An Effective Approach Video"). See "Links", then "APHL-Related Organizations" for connections to:

American Association for Clinical Chemistry **http://www.aacc.org/**
American Public Health Association **http://www.apha.org/**
American Society for Clinical Laboratory Science **http://www.ascls.org/**
Association of Schools of Public Health **http://www.asph.org/**
National Association of County and City Health Officials **http://www.naccho.org/**
National Association of Local Boards of Health **http://aphl.org/** (see "links")

For further information about APHL contact:
Dr. Lynn M. Bradley, MD, MPH.
Director of Environmental Health
Association of Public Health Laboratories
Tel: 202-822-5227 ext. 207

E. CHEMICAL RESOURCES

E.1. GENERAL CHEMICAL INFORMATION

When researching a specific chemical, it is important to first obtain some basic information. The following sites can provided you with important information, such as synonyms for a chemical, or products that contain that chemical. The Chemical Abstracts Service (CAS), a division of the American Chemical Society, has assigned each high production volume chemical a registry number. This is a unique identification number assigned to a chemical, and can often be typed into chemical information databases to facilitate researching general chemical information. This is much faster than typing complete chemical names, many of which are lengthy and go by various synonyms. CAS numbers can be found at:

http://www.cas.org/EO/regsys.html#q9

Chemical Information (Nomenclature, Identification, Structures):

ChemIDplus

http://chem.sis.nlm.nih.gov/chemidplus/

ChemIDplus is a free web-based search system that provides access to structure and nomenclature files used for the identification of chemical substances cited in National Library of Medicine (NLM) databases. ChemIDplus also provides structure searching and direct links to many biomedical resources at NLM and on the Internet for chemicals of interest. The database contains over 350,000 chemicals, including information on chemical synonyms, structures, regulatory information, and links to other databases containing information about the chemicals.

Chemfinder

http://www.chemfinder.com

This is a good place to start if one is interested in resources for a specific chemical. This site functions as a search engine. Type in the name of the chemical of concern and view links to health information, regulations, and uses of the chemical. Many of these links are already included in the guide, but this engine will group them together on a single condensed web page. Searching is faster if you know the CAS number for the chemical.

E.2. GENERAL TOXICOLOGY INFORMATION

The Toxicological Profiles produced by the Agency for Toxic Substances and Disease Registry (ATSDR) are extremely important resources. Each profile is a thin book with almost everything you could want to know about a toxic chemical. So far, 231 finalized Toxicological Profiles have been published. The determination of which chemicals are to be profiled is based on the frequency of the occurrence of the chemical at toxic (particularly Superfund) sites, the toxicity of that chemical, and the potential for human exposure. These profiles are comprehensive, and should be considered a definitive account of the toxicology of these chemicals.

E.2.a. ATSDR Toxicological Profiles

The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal agency in Atlanta, GA created by the Superfund Law and is responsible for informing the public about hazardous chemicals, particularly those present in Superfund sites. The ATSDR publishes **Toxicological Profiles** for varying chemicals. Toxicological Profiles are revised and republished no less than once every three years. ATSDR Toxicological Profiles are characterizations of the toxicological and adverse health effects information for various hazardous substances. They include public health statements that describe, in non-technical language, a substance's relevant toxicological properties. ***For an example of a complete table of contents for a representative ATSDR Toxicological Profile see Appendix N.1***.

For a **list of all finalized toxicological profiles** and ATSDR contact information see
http://www.atsdr.cdc.gov/toxpro2.html
The complete Toxicological Profiles are not currently available on the Internet. To obtain print copies of ATSDR Toxicological Profiles contact the National Technical Information Service (NTIS) which distributes the profiles for a fee. To order the complete profile contact:

National Technical Information Service
5285 Port Royal Road
Springfield, Virginia 22161
Tel: 800-553-6847 or 703-605-6000

Completed profiles may also be ordered through the NTIS Web site:
http://www.ntis.gov
Click on “search NTIS electronic catalog”, limit “Broad Search Topic” to “Medicine and Biology” and type in the name of the desired profile.

The **ATSDR ToxFAQs** are a series of summaries about hazardous substances developed by the ATSDR Division of Toxicology. Information for this series is excerpted from the ATSDR Toxicological Profiles and Public Health Statements. ***ToxFAQs are important resources and should be used at the beginning of any investigation of a specific chemical.*** Each fact sheet serves as a quick and easy to understand guide. Answers are provided to the most frequently asked questions (FAQs) about exposure to hazardous substances found around hazardous waste sites and the effects of exposure on human health. For the ToxFAQs home page see:
http://www.atsdr.cdc.gov/toxfaq.html
Through this site you can access every ATSDR ToxFAQ. They are the next best source after the complete Toxicological Profile, however the ToxFAQs are very helpful as a quick reference.

E.2.b. More Toxicological Information

Chemical Fact Sheets
Office of Pollution Prevention and Toxics (OPPT)
EPA

http://www.epa.gov/chemfact/
This site covers chemicals not covered in ATSDR in a format very similar to the ToxFAQs.

Environmental Health Criteria
International Programme on Chemical Safety (IPCS)
World Health Organization

http://www.inchem.org These print-based toxicological resources are similar to the complete ATSDR Toxicological Profiles. Each profile identifies the sources of human and environmental exposure for a chemical. It covers environmental levels, kinetics and metabolism in lab animals and humans, effects on lab mammal test systems, human health effects, and contains an evaluation of the human health risks and effects on the environment. This is a very comprehensive print resource for individual chemicals.

E.2.c. Web Sites

Chemical Safety Information IPCS
INCHEM
http://www.inchem.org/ IPCS INCHEM is a very useful site that contains a large body of information from multiple organizations. INCHEM consolidates current, internationally peer-reviewed chemical safety-related publications and database records from international bodies. It offers quick and easy electronic access to thousands of searchable full-text documents on chemical risks. This web site contains the following: CIS chemical information documents, international chemical assessment documents, environmental health criteria monographs, health and safety guides, International Agency for Research on Cancer summaries, international chemical safety cards, the IPCS evaluation of antidotes series, Joint Expert Committee on Food Additives monographs, Joint Meeting on Pesticide Residues evaluations, pesticide data sheets, poisons information monographs, and a screening information data set for high production volume chemicals.

E.2.d. Toxicology Books/Texts

Klaassen, Curtis D, (editor). **Casarett and Doull's Toxicology: The Basic Science of Poisons, 5th Edition.** New York: McGraw-Hill, 1996.

This comprehensive textbook of toxicology covers the general principles of toxicology; absorption, distribution, and excretion of chemicals; specific organ toxicology; environmental and occupational toxicology; and the toxic effects of pesticides, heavy metals, and solvents. It is intended for graduate students and experts in toxicology.

Harbison, Raymond D, and Harriet L. Hardy, (editors). **Hamilton and Hardy's Industrial Toxicology, 5th Edition.** St. Louis: Mosby, 1998.

This extensive reference work covers many heavy metals, plastics, pesticides, and other toxic chemicals used and produced in industrial processes. It also contains sections on industrial hygiene, acute and chronic exposure effects, the diagnosis and treatment of poisoning, mechanisms of action (pathophysiology), biomonitoring, and risk assessment.

E.3. TOXICOLOGY DATABASES

Toxicology Information Databases

EXTOXNET (Extension Toxicology Network)

http://ace.orst.edu/info/extoxnet/

EXTOXNET is a multi-university database intended to stimulate dialogue on toxicology issues and develop and make toxicological information available. This site has a specific focus on pesticide toxicology and environmental chemistry. Available information includes toxicology fact sheets; Pesticide Information Profiles (PIPs); and Toxicology Information Briefs (TIBs).

TOXNET (Toxicology Data Network)

http://toxnet.nlm.nih.gov

This is a master list of toxicology databases, compiled by the National Library of Medicine, containing clusters of source networks for toxicology data, literature, release information, and chemical information. It includes the HSDB, IRIS, CCRIS, GENE-TOX, TOXLINE, EMIC, DART/ETIC, TRI, and ChemID*plus*.

FEDSTATS

http://www.fedstats.gov

This is the gateway Web site for all data collected, produced, and disseminated by the federal government. More than 70 agencies in the United States Federal Government produce statistics of interest to the public. Fedstats includes a significant amount of information about chemical health effects, chemical release, chemical exposure, and other information which users of the guide may find helpful. See "Other Sites" for many other links to information providing sites.

Toxicology Data
(Factual information on toxicity and other hazards of chemicals)

HSDB: ***Hazardous Substances Data Bank:***
http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB
This database has a broad scope in human and animal toxicity, safety and handling, environmental fate of chemical substances, and more. It is scientifically peer-reviewed.

IRIS: ***Integrated Risk Information System:***
http://www.epa.gov/iris/
This Web site contains data from the EPA in support of human health risk assessment, with a focus on hazard identification and dose-response assessment.

CCRIS: ***Chemical Carcinogenesis Research Information System:***
http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?CCRIS
This database contains information on carcinogenicity, mutagenicity, tumor promotion, and tumor inhibition, provided by the National Cancer Institute (NCI).

GENE-TOX:
http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?GENETOX
This database contains peer-reviewed mutagenicity test data from the EPA.

Toxicology Literature
(Scientific studies, reports, and other bibliographic material)

TOXLINE:
http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?TOXLINE
This is an extensive array of references to literature on the biochemical, pharmacological, physiological, and toxicological effects of drugs and other chemicals.

EMIC: ***Environmental Mutagen Information Center:***
http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?TOXLINE
This database includes current and older literature on agents tested for genotoxic activity. An agent is genotoxic if it has been shown to cause damage to DNA, the chemical compound inside all living cells that is responsible for the storage of the biological information.

DART/ETIC: ***Developmental and Reproductive Toxicology and Environmental Teratology Information Center.***
http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?DARTETIC.htm
This site is a database containing current and older literature on developmental and reproductive toxicology.

F. HEAVY METALS

F.1. GENERAL INFORMATION

When investigating heavy metals it is recommended that the reader start with the Toxic Exposure Web site and the ATSDR ToxFAQs on the Internet. For further information, try the complete ATSDR Toxicological Profiles, CDC and EPA Web sites, then move to texts and journals if needed.

Heavy Metals and Health World Resources Institute (WRI)
http://www.igc.org/wri/wr-98-99/erase.htm This is a WRI Web site that presents a global view of heavy metal poisoning, with a specific focus on lead poisoning. This site includes a table of childhood blood lead levels in different countries.

Heavy Metals Occupational Safety and Health Administration (OSHA)
http://www.osha-slc.gov/SLTC/metalsheavy/index.html This is the OSHA site for occupational exposure to heavy metals. It contains many links to related resources. It also contains the compliance standards set by OSHA for many heavy metals.

F.2. MERCURY

Mercury is released to the environment from industrial processes and also naturally occurs in the environment. Mercury exists in different forms, with organic mercury, or methylmercury, posing the greatest risk for human health. Chronic exposure to methylmercury most often occurs through consumption of contaminated fish. Methylmercury can cause permanent damage to the brain and kidneys, with young children being more sensitive than adults to the neurological effects. Methylmercury can also be passed from the mother to the fetus, leading to brain damage, mental retardation, and blindness. Acute exposure to high levels of mercury vapor can cause pulmonary damage, nausea, diarrhea, vomiting, rapid heart rate, rashes, and eye irritation. There are numerous resources available for mercury exposure and its effects on human health.

F.2.a. Web Sites

ATSDR ToxFAQs: MERCURY. April 1999.
http://atsdr1.atsdr.cdc.gov/tfacts46.html
See the description of ATSDR ToxFAQS in General Toxicological Information, Section E.2.a.

Risk Assessment for Mercury
EPA
http://www.epa.gov/ncea/mercury.html
This Web site includes links to the entire recent EPA Mercury Report to Congress and the EPA's Mercury Research Strategy. The study report includes sections on anthropogenic mercury emissions in the United States, the fate and transport of mercury in the environment, an assessment of exposure to mercury, the health effects of mercury, an ecological assessment for mercury emissions, a characterization of human health and wildlife risks from mercury exposure, and an evaluation of mercury control technologies and costs.

F.2.b. Books/Texts

Committee on the Toxicological Effects of Methylmercury, Board on Environmental Studies and Toxicology, National Research Council. Toxicological Effects of Methylmercury.. Washington: National Academy Press, 2000.

This text reviews the health effects of methylmercury and discusses the estimation of mercury exposure from measured biomarkers. It also covers how differences between individuals affect mercury toxicity, and thoroughly compares the epidemiological studies available on methylmercury. Included are discussions of the effects of current mercury levels on public health, and the science and policy decisions involved in the regulation of mercury. This report is a valuable resource for individuals interested in the public health effects and regulation of mercury.

F.3. LEAD

Lead is one of the heavy metals to which humans are most commonly exposed. Lead exposure can occur through breathing air, or eating soil, food, paint chips, or other lead-containing products. Children have a higher risk of being exposed to lead, either from eating chips of lead paint or putting items in their mouths that have been contaminated with lead. Lead is particularly harmful to children, whose developing nervous systems are sensitive to lead toxicity. Childhood lead exposure has been correlated with lower intelligence scores, slow growth, and impaired hearing. Adult lead exposure can cause brain and kidney damage, joint problems, hypertension, peripheral and central nervous system damage, and memory impairment. There are many resources for information on lead exposure and its effects on human health.

F.3.a. Web Sites

ATSDR ToxFAQs: LEAD. June, 1999.
http://atsdr1.atsdr.cdc.gov/tfacts13.html

Lead Risk Assessment Values or Standards
Environmental Defense Scorecard
http://www.scorecard.org
This site includes a link to a lead hazard pollution locator (U.S. map of housing units with a high risk of lead hazards). It also contains a link to a locator map with potential sources of land contamination with lead, such as toxic waste sites identified as federal Superfund sites, and industrial facilities reporting land and underground releases of chemicals to the Toxic Release Inventory. You can get a report for your community by using your zipcode.

Lead Page
Office of Pollution Prevention and Toxics (OPPT)
EPA
http://www.epa.gov/opptintr/lead/index.html
EPA's OPPT Lead Home Page lists various technical and general information documents on lead. Many of these documents may be useful to the general public, parents, and homeowners, buyers or renters. This site also provides links to other sources of information on lead.
National Lead Information Center (NLIC)
Tel: 800-424-5323

National Primary Drinking Water Regulations, Consumer Factsheet on Lead
EPA
http://www.epa.gov/OGWDW/dwh/c-ioc/lead.html
This site includes lead releases to water and land (1987 to 1993), drinking water standards for lead, and other regulatory guidelines.

Risk Assessment for Lead
EPA
http://www.epa.gov/ncea/lead.htm
This site includes a description of the EPA's Urban Soil Lead Abatement Demonstration Project for monitoring urban soil lead concentrations and blood lead levels in humans.

Childhood Lead Poisoning Prevention Program
CDC
http://www.cdc.gov/nceh/lead/lead.htm
This is the major CDC resource for lead information. It includes the CDC Lead Fact Sheet, information on lead poisoning in children, lead topics in the news, and other links. You can also download the entire Children's Health Act of May 2000. This site contains many links, databases, and resources with an emphasis on childhood lead exposure and prevention.

F.3.b. Books/Texts

Lansdown, Richard, and William Yule (eds). **Lead Toxicity: History and Environmental Impact**. Baltimore: Johns Hopkins University Press, 1986.

This book is a comprehensive look at lead sources, exposure, and health effects. It describes lead contamination of soil, air, water, food, paint, and other sources of exposure.

F.3.c. Journal Articles

Revich BA. Lead in hair and urine of children and adults from industrialized areas. *Archives of Environmental Health*. 1994; 49(1): 59-62.

This journal article provides an analysis of lead exposure in people living in industrialized areas. It describes the use of biomonitoring in preventing industrial chemical exposure.

Christensen JM. Human exposure to toxic metals: factors influencing interpretation of biomonitoring results. *Science of the Total Environment*. 1995; 166:89-135.

This article discusses complications and the relevance of applying biomonitoring results to discussing human health risks.

Brody D, Pirkle JL, Kramer RA, Flegal KM, Matte TD, Gunter EW, Paschal DC. Blood Lead Levels in the U.S. Population: Phase 1 of the Third National Health and Nutrition Examination Survey (NHANES III, 1988 to 1991). *JAMA*. 1994; 272:277-83.

This is an important article that describes biomonitoring results for lead exposure in the NHANES study.

Pirkle JL, Brody DJ, Gunter EW, Kramer RA, Paschal DC, Flegal KM, Matte TD. The Decline in Blood Lead Levels in the United States: The National Health and Nutrition Examination Surveys. *JAMA*. 1994; 272:284-91.

This article describes trends in blood lead levels as determined by the NHANES study.

Pirkle JL, Kaufmann RB, Brody DJ, Hickman T, Gunter EW, Paschal DC. Exposure of the U.S. population to lead: 1991-1994. *Environmental Health Perspectives*. 1998; 106:745-50.

This article contains more information on national lead exposure data.

F.4. OTHER HEAVY METALS

There are many additional heavy metals which pose exposure and health risks for humans. The CDC's *National Report on Human Exposure to Environmental Chemicals* covered many heavy metals. In addition to mercury and lead, the report analyzed body burdens of Cadmium, Cobalt, Uranium, Antimony, Barium, Beryllium, Cesium Molybdenum, Platinum, Thallium and Tungsten. Information on these metals can be found in many of the same resources listed under the mercury and lead sections. The Toxic Exposure Web site and the ATSDR ToxFAQs on the

Internet are valuable resources. For further information, try the complete ATSDR Toxicological Profiles, CDC and EPA Web sites, then move to texts and journals if needed.

G. PESTICIDES

There are many different classes of pesticides. The CDC exposure report analyzed urine metabolites of 28 organophosphate pesticides, including chlorpyrifos, diazinon, fenthion, malathion, parathion, disulfoton, phosmet, phorate, temephos, and methyl parathion. Organophosphate pesticides exert their effects through the inhibition of cholinesterase, a transmitter in the nervous system. Organophosphate pesticides, such as Sarin, were developed as nerve gas agents to be used during World War II. Acute exposure to organophosphates typically results in headache, nervousness, weakness, blurred vision, nausea, cramps, diarrhea, and sweating. There is substantial toxicological evidence that repeated low-level exposure to organophosphates may affect neurodevelopment and growth in developing animals.

G.1. Web Sites

Selected ATSDR ToxFAQ's

ATSDR ToxFAQs: DDT, DDE, and DDD. September 1995.
http://www.atsdr.cdc.gov/tfacts35.html

ATSDR ToxFAQs: Aldrin and Dieldrin. April 1993.
http://www.atsdr.cdc.gov/tfacts1.html

ATSDR ToxFAQs: Chlordane. September 1995.
http://www.atsdr.cdc.gov/tfacts31.html

ATSDR ToxFAQs: Chlorpyrifos. September 1997.
http://www.atsdr.cdc.gov/tfacts84.html

ATSDR ToxFAQs: Diazinon. September 1997.
http://www.atsdr.cdc.gov/tfacts86.html

ATSDR ToxFAQ's: Dichlorvos. September 1997.
http://www.atsdr.cdc.gov/tfacts88.html

ATSDR ToxFAQ's: Ethion. February 2001.
http://www.atsdr.cdc.gov/tfacts152.html

ATSDR ToxFAQs: Methyl Parathion. September 1995.
http://www.atsdr.cdc.gov/tfacts48.html

Note: there are ToxFAQ's for additional pesticides contained in the ATSDR database.
See **http://www.atsdr.cdc.gov/toxfaq.html#alpha** for the complete listing.

EPA Web Sites

Concerned Citizens Web Page
EPA
http://www.epa.gov/pesticides/consumer.htm
This site is a database of many pesticide-related links. It is an excellent place to start investigating exposure to pesticides and their effects on health. Includes pesticides in adult and child health, EPA regulation, and further information. Click "information resources" to get access to EPA listserves for pesticide topics, Office of Pesticide Programs (OPP) mailing lists, internet-based resource guides, and telephone hotlines such as the **National Pesticide Information Center** (NPIC) (800-858-7378).

Tolerance Reassessment and Reregistration
Pesticide Chemical Reregistration Status
EPA
http://www.epa.gov/pesticides/reregistration/status.htm
When EPA completes the review and risk management decision for a pesticide that is subject to reregistration (that is, one initially registered before November 1984), the agency generally issues a **Reregistration Eligibility Decision** (or **RED** document). The RED summarizes risk assessment conclusions and outlines any risk reduction measures necessary for the pesticide to continue to be registered in the U.S.

Risk Assessment for Pesticides
EPA
http://www.epa.gov/pesticides/citizens/riskassess.htm
This site includes a brief overview of EPA's process for assessing potential risks to human health when evaluating pesticide products. It includes hazard identification, dose-response assessment, exposure assessment, and risk characterization.

Pesticides and Food
EPA
http://www.epa.gov/pesticides/food/
This site includes the guide "**What You and Your Family Need to Know**." The entire guide can be accessed in PDF format. It includes governmental regulation, pesticide residue limits on food, special childhood sensitivity, integrated pest management, organic food, types of pesticides on food, health information, and healthy food practices.
This Web site is based on an EPA brochure "Pesticides and Food," which is available in many grocery stores. To order a free paper copy of the brochure, call 800-490-9198.

Organophosphate Pesticides in Food
EPA

http://www.epa.gov/pesticides/op/primer.htm This EPA site focuses on organophosphate pesticides. It includes information on the uses, health effects, environmental effects, and EPA regulation of organophosphate pesticides.

Other Web Sites

Pesticides, Herbicides,Insecticides, Fungicides, Rodenticides CDC

http://www.cdc.gov/nceh/ehserv/EHSA/hottopics/Pesticides.htm This is a collection of pesticide information links to 20 sites. Included are farm worker exposure, EPA worker protection standards, pesticides in schools, CDC's pesticide-related illness surveillance, EPA's Citizens Guide to Pest Control and Pesticide Safety, EPA's OPP programs, FDA's glossary of pesticide chemicals, pesticides and food, National Agriculture Safety Database of farm accident data sources and research, and information on DDT's environmental persistence.

Pesticides, Endocrine Disruptors, and Other Toxic Substances CDC

http://www.cdc.gov/nceh/hsb/toxins.htm
This site describes ongoing CDC surveillance programs for pesticide-related illness.

Statement on Pesticides in Schools Physicians for Social Responsibility (PSR)

http://www.psr.org/pestschool.html
This site contains information from PSR on pesticides in schools.

Pesticide Database Pesticide Action Network

http://www.pesticideinfo.org
This web site contains current toxicity and regulatory information for pesticides.

National Pesticide Information Center (Formerly the National Pesticide Telecommunications Network)

http://npic.orst.edu/ Tel: 800-858-7378

This web site and telephone hotline contain a large amount of information including: general pesticide information, pesticide safety, evaluating pesticide risks, pesticide labels, food and

pesticides, the environment and pesticides, pets and pesticides, and pesticide disposal. This resource is excellent for general information relating to commercial pesticide products and their use in the home.

G.2. Books/Texts

Solomon, Gina MD, MPH. **Pesticides and Human Health: A Resource for Health Care Professionals**. Los Angeles: Physicians for Social Responsibility, 2000.
This book contains information on the acute and chronic human health effects of pesticides. The report includes chapters on cancer, respiratory disease, neurological and behavioral effects of pesticides, reproductive and developmental effects of pesticides, the effects of pesticides on the immune system and acute effects of pesticide exposure.

U.S. Environmental Protection Agency. **Recognition and Management of Pesticide Poisonings, Fifth Edition.** Baltimore: United Book Press, 1999.

This book covers approximately 1,500 pesticide products. It focuses on toxicology, the signs and symptoms of poisoning, and the treatment of pesticide poisoning. It also covers new pesticide products that have come on the market since 1989, and includes a chapter on disinfectants, reviews clinical experiences with pesticide poisonings, and contains detailed references.
This manual is available at:
http://www.epa.gov/oppfead1/safety/healthcare/handbook/handbook.htm
or call 703-305-7666 to order a free print copy. It is available in English and Spanish.

Repetto, Robert and Baliga, Sanjay S. **Pesticides and the Immune System: The Public Health Risks**. Washington: World Resources Institute, 1996.

This book covers research from around the world documenting widely used pesticides' effects on the immune system. This is the best single resource on this topic. The book is available at:
http://www.wri.org/wripubs.html
This Web site is a clearinghouse for all World Resources Institute publications.

National Research Council. **Pesticides in the Diets of Infants and Children**
Washington: National Academy Press, 1993.
For copies call 800-624-6242.

This report was produced by the Committee on Pesticides in the Diets of Infants and Children, the Board on Agriculture and Board on Environmental Studies and Toxicology, and the Commission on Life Sciences, of the National Research Council. It explores whether infants and children differ from adults in their susceptibility and in dietary exposures to pesticide residues. It further examines whether present regulatory approaches adequately protect children. The report also summarizes the current status of pesticide use, relevant data collection methods such as food consumption surveys, methods for toxicity testing, and federal pesticide regulation. Finally, it details the special characteristics of children (growth, development, metabolism) and analyzes toxicity information based on their exposure to pesticides. The report made a number of important recommendations that were the basis of the Food Quality Protection Act of 1996

(See Appendix 3, Federal Regulation for more information on the food Quality Protection Act). The importance of child-based standards for chemical exposure was established by this report.

G.3. Journal Articles

Eskenazi B, Bradman A, and R. Castorina. Exposures of children to organophosphate pesticides and their potential adverse health effects. *Environmental Health Perspectives*. 1999; 107(Suppl3): 409-19.

This is a review article that examines the current state of scientific research regarding childhood exposure to organophosphate pesticides and their potential adverse health effects. It concludes that few studies have assessed the extent of children's pesticide exposure, and no studies have examined whether there are adverse health effects of chronic exposure.

Heudorf U, Angerer J. Metabolites of organophosphorus insecticides in urine specimens from inhabitants of a residential area. *Environmental Research*. 2001; 86(1): 80-7.

This biomonitoring study investigated the exposure of residents of former U.S. Armed Forces housing estates in Frankfurt am Main, Germany to the OP chlorpyrifos, which was detected in household dust resulting from its earlier use up to 1993 in these housing estates. At that time, the most frequently used pesticide in U.S. homes, as well as in schools and day care centers, was chlorpyrifos.

Hill RH, Head S, Baker S, Gregg M, Shealy DB, Bailey SL, Williams CC, Sampson EJ, Needham LL. Pesticide residues in urine of adults living in the United States: Reference range concentrations. Environ Res 1995;71:99-108.

G.4. Organizations/Experts

U.S. Government Organizations

U.S. Environmental Protection Agency
Office of Pesticide Programs (OPP)
Communication Services Branch (7506C)
401 M Street, SW
Washington, DC 20460
Tel: 703-305-5017

US Department of Agriculture
1400 Independence Ave., SW
Washington, DC 20250
Meat and Poultry Hotline: 800-535-4555
National Organic Program: 202-720-3252

US Food and Drug Administration

5600 Fishers Lane
Rockville, MD 20857
FDA Food Information & Seafood Hotline: 800-332-4010

Non-Governmental Organizations

BEYOND PESTICIDES/NCAMP
(Formerly the **National Coalition Against the Misuse of Pesticides**)
http://www.beyondpesticides.org
710 E Street, SE, Suite 200
Washington, DC 20003
Tel: 202-543-5450

PESTICIDE ACTION NETWORK OF NORTH AMERICA
http://www.panna.org/panna
49 Powell Street, 6th Floor
San Francisco, CA 94102
Tel: 415-981-1771

PESTICIDE EDUCATION CENTER
http://www.pesticides.org/pesticides
P.O. Box 420870
San Francisco, CA 94142

BIO-INTEGRAL RESOURCE CENTER (BIRC)
http://www.igc.org/birc
P.O. Box 7414
Berkeley, CA 94707
Tel: 510-524-2567

H. DIOXINS/FURANS/PCB'S

Organochlorines are a large class of chemicals consisting of various types of chlorinated hydrocarbons. They are persistent and tend to accumulate in the environment and in animal and human tissues. The organochlorines known as dioxins and furans are produced when byproducts from industrial manufacturing processes mix with chlorine. This occurs when chlorine is used in bleaching processes in pulp and paper mills, and during the incineration of hazardous, medical, and municipal waste products. Another type of organochlorine, polychlorinated biphenyls (PCB's) were first produced in the U.S. in 1929. They were used as flame retardants and insulators for electrical transformers and generators. PCB use was banned in 1976 by the **Toxic Substances Control Act** (**TSCA**) (***see Appendix N.4, "Federal Regulation" for more***

information about TSCA). Despite the banning of their use, PCB's continue to pose health risks for humans due to their persistence in the environment.

Acute health effects resulting from organochlorine exposure include skin irritation, changes in liver function, and fatigue. There are numerous health effects of chronic exposure to organochlorines as well. These include: cancer (dioxin has been found to be carcinogenic in all animal species tested), developmental effects, neurological effects, immune system effects, reproductive effects, and the disruption of the endocrine system (the hormonal signaling system in the body). There are many resources for information about exposure to organochlorines and their effects on human health.

H.1. Web Sites

Selected ATSDR ToxFAQ's

ATSDR ToxFAQs: Chlorinated Dibenzo-p-dioxins(CDDs). February 1999.
http://www.atsdr.cdc.gov/tfacts104.html

ATSDR ToxFAQs: Chlorodibenzofurans (CDFs). September 1995.
http://www.atsdr.cdc.gov/tfacts32.html

ATSDR ToxFAQs: 2,3-Benzofuran. September 1995.
http://www.atsdr.cdc.gov/tfacts25.html

ATSDR ToxFAQs: Polychlorinated Biphenyls (PCBs). February 2001.
http://www.atsdr.cdc.gov/tfacts17.html

ATSDR ToxFAQs: Polybrominated Biphenyls (PBBs). September 1996.
http://www.atsdr.cdc.gov/tfacts68.html

Other Web Sites

Risk Assessment for Dioxins
EPA
http://www.epa.gov/ncea/dioxin.htm
This Web site includes links to the EPA's September 2000 Dioxin Reassessment (including exposure estimates, health assessment, and risk summary). It also covers the Dioxin Exposure Initiative (an EPA initiative since 1994 to evaluate the exposure of Americans to Dioxins), a database of sources of environmental releases of dioxin-like compounds in the U.S., and EPA regulations. The link "Dioxin: Frequently Asked Questions" takes you to a 20 page PDF file compiled by many different governmental organizations including the FDA, CDC, USDA, and EPA. This is an excellent starting point for general health information about dioxins, including nutritional advice and information about breast-feeding.
Paper copies of the EPA Dioxin Reassessment may be obtained by calling the EPA's **National Service Center for Environmental Publications** at **800-490-9198**.

Dioxin Research
National Institute of Environmental Health Sciences (NIEHS)
National Institute of Health (NIH)
http://www.niehs.nih.gov/oc/factsheets/dioxin.htm
This resource contains a brief fact sheet produced by NIEHS. It is useful as a quick reference for information about the health effects of dioxin and ongoing dioxin research at NIH. This Web site includes contact information for NIH scientists who can provide you with more information about dioxins and their health effects.

Dioxin Advisories and Guidance
Food Safety Inspection Service (FSIS)
USDA
http://www.fsis.usda.gov/OA/topics/dioxmenu.htm
This Web site is a master list from FSIS of the USDA. It includes links to sites for general information about dioxins, dioxins in food imports, and dioxin in livestock, poultry and eggs. For Consumer inquiries call the **USDA Meat and Poultry Hotline: 800-535-4555**.

Monitoring Dioxins
Agricultural Research Service (ARS)
USDA
http://www.ars.usda.gov/is/AR/archive/jan01/dioxin0101.htm
This site summarizes the latest developments in monitoring dioxins in the food supply. For further information see the ARS National Program, "Food Safety" at:
http://www.nps.ars.usda.gov

Risk Assessment for PCB's
EPA
http://www.epa.gov/ncea/pcbs.htm
This site includes a link to cancer dose-response assessment for PCBs. It shows how information on toxicity, disposition, and environmental processes are considered together to evaluate health risks from PCB mixtures in the environment.

H.2. Books/Texts

Thornton J. **Pandora's Poison: Chlorine, Health and a New Environmental Strategy**, Cambridge: MIT Press, 2000.
This text is a thorough and accessible study of how global organochlorine pollution contributes to health problems such as infertility, immune suppression, cancer, and developmental disorders in humans and animals. The author covers both the science and the public policy of chemical pollution, and proposes a major shift in environmental science and policy.

Schecter, Arnold, (ed). **Dioxins and Health**. New York: Plenum Press, 1994.

This book is a professional-level multi-author text on the health risks of dioxins. This work is considered to be the most comprehensive currently available reference on dioxins and health. The intended audience includes professionals seeking a survey of research up to 1992-1993, with important references for health and non-health professionals interested in dioxins. Chapters include dioxins and health, risk assessment, environmental sources and distribution, dioxins in food, toxicology, pharmacokinetics, immunotoxicolgy, dose-response effects, dioxins and wildlife, developmental and reproductive toxicity, aquatic toxicity, mammalian carcinogenesis, neurochemical and behavioral sequelae of exposure, exposure assessment, human health, cancer epidemiology, and reproductive epidemiology.

H.3 Journal Articles

Orban JE, Stanley JS, Schwemberger JG, Remmers JC. Dioxins and dibenzofurans in adipose tissue of the general US population and selected subpopulations. Am J Public Health 1994;84:439-45

Wolff MS, Schecter A. Accidental Exposure of Children to Polychlorinated Biphenyls. Arch Environ Contam Toxicol 1991;20:449-453.

Beck H, Eckart K, Mathar W, Witt Kowski L. Levels of PCDD's and PCDF's in adipose tissue of occupationally exposed workers. Chemosphere 1989;18:507-516.

Schecter A, Papke O, Ball M, Lis A, Brandt-Rauf P. Dioxin concentrations in the blood of workers at municipal waste incinerators. Occup Environ Med 1995;52:385-387

Jacobson JL, Jacobson SW. Intellectual impairment in children exposed to polychlorinated biphenyls in utero. New Engl J Med 1996;335:783-789.

Rogan WJ, Gladen BC. PCBs, DDE, and child development at 18 and 24 months. Annal Epidemiol 1991; 1:407-413.

Koopman-Esseboom C, Weisglas-Kuperus N, de Ridder MA, Van der Paauw CG, Tuinstra LG, Sauer PJ. Effects of polychlorinated biphenyl/dioxin exposure and feeding type on infants' mental and psychomotor development. Pediatrics. 1996; 97:700-6.

Patandin S, Lanting CI, Mulder PG, Boersma ER, Sauer PJ, Weisglas-Kuperus N. Effects of environmental exposure to polychlorinated biphenyls and dioxins on cognitive abilities in Dutch children at 42 months of age. J Pediatr. 1999;134:33-41.

Weisglas-Kuperus N, Patandin S, Berbers GA, Sas TC, Mulder PG, Sauer PJ, Hooijkaas H. Immunologic effects of background exposure to polychlorinated biphenyls and dioxins in Dutch preschool children. Environ Health Perspect. 2000;108:1203-7.

Koopman-Esseboom C, Morse DC, Weisglas-Kuperus N, Lutkeschipholt IJ, Van der Paauw CG, Tuinstra LG, Brouwer A, Sauer PJ. Effects of dioxins and polychlorinated biphenyls on thyroid hormone status of pregnant women and their infants. Pediatr Res. 1994;36:468-73.

Liem AK, Furst P, Rappe C. Exposure of populations to dioxins and related compounds. *Food Addit Contam.* 2000; 17(4):241-59.

This review article examines research into the exposure of the general human population to PCDDs, PCDFs and PCBs. It also explains specific issues that should be taken into consideration when formulating a risk assessment of these exposures.

Schecter A, Cramer P et al. Intake of dioxins and related compounds from food in the U.S. population. *J Toxicol Environ Health A.* 2001; 11;63(1):1-18.

This article describes the first U.S. nationwide food sampling with measurement of dioxins, dibenzofurans, and coplanar, mono-ortho and di-ortho polychlorinated biphenyls (PCBs). Twelve separate analyses were conducted on 110 food samples purchased in 1995 from supermarkets in Atlanta, GA, Binghamton, NY, Chicago, IL, Louisville, KY, and San Diego, CA. Human milk also was collected to estimate nursing infants' consumption.

Muckle G, Ayotte P, Dewailly E, Jacobson SW, Jacobson JL. Determinants of polychlorinated biphenyls and methylmercury exposure in Inuit women of childbearing age. *Environ Health Perspect.* 2001;109(9):957-63.

This study identified maternal characteristics associated with traditional food consumption and examined food items associated with polychlorinated biphenyls (PCBs) and mercury body burden in pregnant Inuit women from Northern Quebec

Stewart P, Darvill T, Lonky E, Reihman J, Pagano J, Bush B. Assessment of prenatal exposure to PCBs from maternal consumption of Great Lakes fish: an analysis of PCB pattern and concentration. *Environ Res.* 1999; 80(2 Pt 2):S87-S96.

This study was designed to assess the pattern and concentration of prenatal PCB exposure in the newborns of women who consumed Great Lakes fish. It concluded that maternal consumption of Great Lakes fish increases the risk of prenatal exposure to the most heavily chlorinated PCB's.

I. PHTHALATES

Phthalates are the most abundant man-made chemical in the environment. Their largest use is as plasticizers for polyvinylchloride (PVC) products. They are contained in products used in construction, medicine, automobiles, and in home products such as toys, packaging materials, and clothing. Di-2-ethylhexyl phthalate (DEHP) and di-n-butyl phthalate (DBP), the two most abundant phthalates, are found in fresh and salt water, soil, and in some fish. Food is most likely the largest source for human exposure to phthalates, although exposure can also occur through the skin and mucus membranes from contact with products containing phthalates.

Some phthalates are known to disrupt the endocrine system and cause fertility, liver, and kidney problems in animals. Little is known about the long-term effects of chronic low-dose phthalate exposure in humans and animals.

I.1. Web Sites

Selected ATSDR ToxFAQ's

ATSDR ToxFAQs: Di(2-ethylhexyl)Phthalate (DEHP). April 1993.
http://www.atsdr.cdc.gov/tfacts9.html

ATSDR ToxFAQ's: Diethyl Phthalate. September 1996.
http://www.atsdr.cdc.gov/tfacts73.html

ATSDR ToxFAQs: Di-n-butyl Phthalate. July 1999.
http://www.atsdr.cdc.gov/tfacts135.html

ATSDR ToxFAQs: Di-n-octylphthalate (DNOP). September 1997.
http://www.atsdr.cdc.gov/tfacts95.html

Other Web Sites

General Information:
Phthalates CDC
http://www.cdc.gov/nceh/dls/report/Chemicals/phthalatesgeneral.htm This site from the CDC contains general phthalate information, information about specific phthalates, methods for analyzing phthalate metabolites, and links to other sites.

I.2. Books/Texts

Kavlock, Robert (Editor). **Risks to Human Reproduction: Ntp-Cerhr Expert Panel Reports on Di(2-Ethylhexyl) Phthalate and Other Phthalates.** Diane Publishing Co., 2001.

This book analyses the risks of DEHP to human reproduction. Animal studies have shown that DEHP reduces fertility and testes weight in males. In female rats, DEHP alters estrogen levels and ovulation function.

Lundberg, P. **Diethylhexyl Phthalate.** Geneva: World Health Organization, 1992.

IPCS International Programme on Chemical Safety

This book, produced by IPCS of the WHO, covers DEHP, one of the most common phthalates. The book analyses the uses of this chemical compound, its exposure sources, and its risks to human health. Overall this work is a very accessible and comprehensive resource for information on DEHP.

Woodward, Kevin N. **Phthalate Esters: Toxicity and Metabolism.** Franklin Book Co., 1998.

This book covers the specific toxicological effects and metabolism of phthalates. It is technical in scope.

I.3. Journal Articles

Blount BC, Silva MJ, Caudill SP, Needham LL, Pirkle JL, Sampson EJ, Lucier GW, Jackson RJ, Brock JW. Levels of seven urinary phthalate metabolites in a human reference population. *Environ Health Perspect.* 2000; 108:979-982.

This NCEH study measured metabolites of seven commonly used phthalates in urine samples from a reference population of 289 adult humans. Women of reproductive age (20-40 years) were found to have significantly higher levels of monobutyl phthalate, a reproductive and developmental toxicant in rodents, than other age/gender groups

J. VOLATILE ORGANIC COMPOUNDS

Volatile Organic Compounds (VOCs), many of which are also called organic solvents, are widely used in industry and are contained in many consumer products. VOCs may be found in the air and in bodies of water, and are short-lived in the environment. Some population subgroups and occupations are exposed to elevated doses of VOC's. Cigarette smoke contains benzene, styrene, and xylene. Dry cleaning facilities are often found to have high air levels of the solvent perchlorothylene. Benzene is found in high levels near gasoline stations, in traffic, and when painting or removing paint.

The health effects of short-term solvent exposure include mild skin irritation, headache, dizziness, and nausea. Long term exposure to various organic solvents may produce central nervous system impairment, numbness and tingling in the extremities, liver and kidney damage, blood disorders such as aplastic anemia and leukemia, and reproductive defects.

Biomonitoring of VOCs is often difficult, due to their rapid excretion from the human body (often in exhaled breath). However, VOCs can be measured effectively in human breast milk (due to their lipophilicity and slower removal from breast milk than from blood). Studies have detected numerous VOCs in human breast milk (***see the resource for NHANES under "Other Biomonitoring Studies", Section C.3***)

J.1. Web Sites

Selected ATSDR ToxFAQ's

ATSDR ToxFAQ's: Benzene. September 1997.
http://www.atsdr.cdc.gov/tfacts3.html

ATSDR ToxFAQ's: Toluene. February 2001.
http://www.atsdr.cdc.gov/tfacts56.html

ATSDR ToxFAQ's: Styrene. September 1995.
http://www.atsdr.cdc.gov/tfacts53.html

J.2. Journal Articles

Wallace LA, Pellizzari ED, Hartwell TD, Whitmore R, Zelon H, Perritt R, Sheldon L. The California TEAM study: breath concentrations and personal exposures to 26 volatile compounds in air and drinking water of 188 residents of Los Angeles, Antioch,and Pittsburg, CA. Atmos Environ 1988; 22:2141-2163.

Brugnone F, Perbellini L, Gaffuri E, Apostoli P. Biomonitoring of industrial solvent exposures in workers' alveolar air. *International Archives of Occupational and Environmental Health.* 1980; 47(3):245-61.

This journal article describes a biomonitoring study that analyzed environmental exposure to the industrial solvents toluene, styrene, methylethyl ketone, acetone, dimethylformamide, cyclohexane, n-hexane, methylcyclopentane, 2-methylpentane, and 3-methylpentane, in workers during their work shift.

P Apostoli, F Brugnone. Biomonitoring of occupational toluene exposure. *International Archives of Occupational and Environmental Health.* 1982;50(2):153-68.

This study examined toluene exposure in workers involved in painting and furniture finishing. It found blood and urine levels to be higher on Friday at the end of the work shift than during the beginning of the work shift on Monday.

K. HEALTH DISORDERS AND CHEMICAL EXPOSURE

There are numerous resources for information about health disorders and exposure to industrial chemicals. The first part of this section contains resources for health information retrieval systems. Many of these listings are Web sites administered by the federal government that provide access to the enormous amount of health information produced by its various agencies.

The second part of this section focuses on specific illnesses, health conditions, or syndromes in which exposure to environmental chemicals plays an important role. These include cancer, disruption of the endocrine system, and chemical sensitivity syndromes such as Chronic Fatigue Syndrome.

K.1. GENERAL CHEMICAL INJURY DATABASES

National Library of Medicine (NLM)
http://www.nlm.nih.gov
NLM is an enormous resource for information on toxicology, general health, chemicals, and chemical release. The NLM system, known as **MEDLARS** (Medical Literature Analysis and Retrieval System), comprises 40 online databases containing millions of references. Databases include: **MEDLINEplus, MEDLINE/PubMed, ClinicalTrials.gov** (provides information for patients about clinical research studies), **DIRLINE** (a directory of health organizations), **LOCATORplus** (a catalog of books, journals, and audiovisuals in the NLM collections), **NLM Gateway** (a single Internet interface that searches multiple NLM retrieval systems) **PubMed Central** (a digital archive of life sciences journal literature), **CancerNet** (containing the National Cancer Institute's many sources of cancer information), **CANCERLIT, Chemical Substances** (chemical information on drugs, pesticides, environmental pollutants and other potential toxins), **RTECS** (a registry of toxic effects of chemical substances), and **DART** (developmental and reproductive toxicology).

Hardin Medical Dictionary of Internet Health Resources
http://www.lib.uiowa.edu/hardin/md/index.html
This directory contains hundreds of links organized by “Diseases and Conditions” and “Health Disciplines”.

Medical Matrix
http://www.medmatrix.org/reg/login.asp
This site functions as a search engine for ranked, peer-reviewed, annotated, and updated clinical medicine resources.

Public Health Data Standards Consortium
National Center for Health Statistics (NCHS*)*
CDC
http://www.cdc.gov/nchs/otheract/phdsc/phdsc.htm
This is the best Web site for accessing public health data. It contains disease registry and surveillance data, birth defects data, and many more data collections.

Surveys and Data Collection Systems
NCHS
CDC
http://www.cdc.gov/nchs/express.htm
This site contains links to surveys and data systems such as: **NHANES,** and the **National Vital Statistics System (NVSS)**

See "Publications and Information Products" for journal articles, the **National Vital Statistics Report**, and the reports "**Vital Statistics of the United States**", "**Health, United States**", "**Healthy People 2000**", and "**Americas Children: 2001**".

K.2. SPECIFIC HEALTH DISORDERS

K.2.a. Cancer

9th Report on Carcinogens
U.S. Public Health Service
http://ehis.niehs.nih.gov/roc/
This site contains a Public Health Service report, released January 2001 by the National Toxicology Program, on "substances known and reasonably anticipated to be human carcinogens". It includes profiles of arsenic, cadmium, environmental tobacco smoke, PCBs, 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD), vinyl chloride, DDT (dichlorodiphenyltrichloroethane), and di(2-ethylhexyl)Phthalate. Each profile contains information on carcinogenicity, and industrial/commercial/home use, production, routes and sources of exposure, and regulations for that particular chemical.

Breastcancer.net
http://www.breastcancer.net/
This site includes summaries and links to online news articles and scientific abstracts. It also contains support and treatment resources by state, and links to other sites concerned with breast cancer issues.

CCRIS (Chemical Carcinogenesis Research Information System)
http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?CCRIS
This online database includes information on carcinogenicity, mutagenicity, tumor promotion, and tumor inhibition. It is produced by the National Cancer Institute.

National Cancer Institute (NCI)
http://www.nci.nih.gov/
NCI's Web site contains an enormous collection of general cancer information, statistics, and information about ongoing clinical trials. NCI runs a telephone hotline that provides information about cancer and answers specific questions.
NCI Cancer Information Service: **800-422-6237**

American Cancer Society (ACS)
http://www.cancer.org/
The ACS Web site contains statistical information about cancer, general background information about different forms of cancer, prevention strategies, and information about the occupational, environmental, and genetic risk factors for cancer. It is also a great source for cancer information in the news.

K.2.b. Endocrine Disruption

Web Sites

Endocrine Disruptors Page
PSR
http://www.psr.org/edpage.htm
This page contains basic information on endocrine disruptors and updates of endocrine disruptor research. The site also includes access to the two books about endocrine disrupting chemicals: **Generations at Risk** and **Our Stolen Future**. This site is a good place to start when learning about endocrine disruptors.

Endocrine Disruptor Screening Program Web Site
EPA
http://www.epa.gov/scipoly/oscpendo/
This web site provides information about the endocrine system and how its function may be altered by some chemicals. It is also the home page of the EPA's Endocrine Disruptor Screening Program.

Introduction to Hormone Disrupting Chemicals
http://website.lineone.net/~mwarhurst/
This site, maintained by Friends of the Earth, provides a good introduction to the effects of hormone disrupting chemicals on humans and the environment. It also covers the response of governments to endocrine disrupting chemicals. It contains many useful links.

Our Stolen Future
http://www.ourstolenfuture.org/
This is an important Web site for information about endocrine system disrupting organochlorine chemicals. It updates the book of the same name with the latest news, policy updates, and press coverage of organochlorine endocrine disrupters such as PCB's DDT, styrene, and dioxin. The book may also be ordered through this Web site.

Environmental Estrogens
http://www.tmc.tulane.edu/ecme/eehome/
Maintained by the Center for Bioenvironmental Research of Tulane and Xavier Universities, this comprehensive Web site includes up-to-date information on endocrine disrupting chemicals. It includes links to recent news articles and archived material.

Books

Colburn, Theo; Dumanoski, Dianne; and John Peterson Myers. **Our Stolen Future.** New York: Penguin Books, 1996.

This book tells the story of how endocrine disruption was discovered, how it works, and how families can protect themselves and their communities. It is intended for a general audience.

Berkson, DL. **Hormone Deception: How everyday foods and products are disrupting your hormones and how to protect yourself and your family.** Chicago: Contemporary Books, 2000.

This book, written for the general public, contains information on endocrine disruptors. It covers the effects of endocrine disruptors on human health, children's health, and men's and women's reproductive health. The author, a nutritionist, suggests ways to prevent exposure in everyday life. The book may be ordered at:

http://www.hormonedeception.com/

Krimsky, Sheldon. **Hormonal Chaos: The Scientific and Social Origins of the Environmental Endocrine Hypothesis**. Baltimore: The Johns Hopkins University Press, 2000.

This book traces the emergence of the hypothesis that a broad range of modern industrial chemicals are interfering with the normal functioning of hormones in animals and humans. It explains that disrupting the endocrine system may lead to cancer, reproductive abnormalities, and cognitive problems such as Attention Deficit Disorder. It is intended for a wide range of readers.

K.2.c. Chemical Sensitivity Syndromes

There is a growing body of research exploring the role that chemical toxins play in the development of chemical sensitivity syndromes. The prototype of these syndromes is Chronic Fatigue Syndrome (CFS). According to the CDC, in order to receive a diagnosis of chronic fatigue syndrome, a patient must satisfy two criteria:

1. Have severe chronic fatigue of six months or longer duration with other known medical conditions excluded by clinical diagnosis, and
2. Concurrently have four or more of the following symptoms: substantial impairment in short-term memory or concentration, sore throat, tender lymph nodes, muscle pain, multi-joint pain without swelling or redness, headaches of a new type, pattern or severity, unrefreshing sleep, and post-exertional malaise lasting more than 24 hours.

It is possible that CFS represents a common endpoint of disease resulting from multiple causes. Conditions that have been proposed to trigger the development of CFS include infection by a virus, stress, and toxins. There is a growing collection of resources on this topic area.

Web Sites

Chronic Fatigue Syndrome

CDC

http://www.cdc.gov/ncidod/diseases/cfs/

This web site offers information about CFS, and its diagnosis and treatment. It includes links to publications about the research, definition, and treatment of CFS.

American Association for Chronic Fatigue Syndrome (AACFS)

http://www.aacfs.org/

This Web site contains information about CFS and links to other information sources about CFS.

Books/Texts

Ashford, Nicholas and Miller, Claudia. **Chemical Exposures: Low Levels and High Stakes**. New York: John Wiley and Sons, Inc., 1998.

This book examines how everyday low-level chemical exposures may be related to fatigue, memory impairment, headaches, mood changes, breathing difficulties, digestive problems, and a range of chronic unexplained illness such as Chronic Fatigue Syndrome, Gulf War Syndrome, and Sick Building Syndrome. Unusually sensitive groups include occupants of tight buildings, industrial workers who handle chemicals, residents of communities exposed to toxic chemicals, and people with random and unique exposures to various chemicals.

Natelson, Benjamin. **Facing and Fighting Fatigue: A Practical Approach.** New Haven: Yale University Press, 1998.

This book is a good place to start learning about Chronic Fatigue Syndrome (CFS). It covers the causes of fatigue (including toxin exposure), effective management of fatigue, and resources in the field of fatigue studies. It explains that low dose exposure to toxins such as pesticides may produce symptoms resembling CFS.

L. CHEMICAL EXPOSURE IN POPULATIONS

L.1. PRENATAL EXPOSURE

The developing fetus is at risk of exposure to environmental chemicals through the umbilical circulation. Fetuses have crucial periods of development when they are more vulnerable to the effects of toxins. The study of the effects that drugs, medications, chemicals, and other exposures may have on the fetus is called Teratology. There are numerous resources containing information about prenatal toxin exposure and the effects these exposures have on the developing fetus.

L.1.a. Web Sites

Childrens's Environmental Health Page
PSR
http://www.psr.org/ceh.htm
This site is PSR's page on children's environmental health. This is recommended as a starting point in examining issues related to prenatal, infant, and childhood exposure to toxic chemicals.

Chemicals That Affect Child Development and Learning
PSR
http://www.psr.org/trireport.html
This Web site contains the PSR report **Polluting our Future: Chemical Pollution in the U.S. that Affects Child Development and Learning.** This report examines the sources of toxic emissions that contribute to developmental disorders in children. It examines trends in exposure, developmental illness, and racial patterns in these categories. It concludes that African Americans are over-represented in many of the counties most affected by developmental toxins. The report concludes by recommending policy changes to reverse these trends.

DART/ETIC (Developmental and Reproductive Toxicology and Environmental Teratology Information Center)
http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?DARTETIC.htm
This database includes current and older literature on developmental and reproductive toxicology.

Organization of Teratology Information Services (OTIS)
http://www.otispregnancy.org/
Teratology Information Services (TIS) are comprehensive and multidisciplinary resources for medical consultation on prenatal exposures. TIS interpret information regarding known and potential reproductive risks into risk assessments that are communicated to individuals of reproductive age and health care providers. This site is organized by state, which enables users to click on their state to receive specific contact information.

L.1.b. Books/Texts

Schettler, Ted, et al. **In Harm's Way: Toxic Threats to Child Development**. Boston: Greater Boston Physicians for Social Responsibility, 2000.

This book is a very important and accessible resource for the latest information on toxins and child development. It covers dioxins, PCBs, pesticides, solvents, and other developmental toxins. It also contains overviews of normal brain development, health risks from exposure to neurotoxicants, genetic variability in responses to toxic exposure, and current research into developmental disabilities in children.
To download the entire report see: **http://www.igc.org/psr/ihw.htm**
To contact Greater Boston PSR directly and order the report: Tel: 617-497-7440

Schettler, Ted, et al. **Generations at Risk: Reproductive Health and the Environment.** Cambridge: The MIT Press, 1999.

This book summarizes the current state of developmental toxicology science and provides information for citizens to make informed decisions about the health risks of toxic chemicals. It includes sections on reproductive physiology and toxicology, the reproductive and developmental effects of selected substances, and a guide to investigating environmental threats to reproduction.

National Research Council. **Scientific Frontiers in Developmental Toxicology and Risk Assessment**. Washington: National Academy Press, 2000.

This professional level book examines toxic exposure and developmental defects. It includes chapters on the causes of developmental defects, risk assessment, mechanisms of developmental toxicity, the human genetics/environment interaction, and recent advances in developmental biology.

L.1.c. Journals/Specific Articles

Stewart P, Reihman J, Lonky E, Darvill T, Pagano J. Prenatal PCB exposure and neonatal behavioral assessment scale (NBAS) performance. *Neurotoxicol Teratol.* 2000; 22(1):21-9.

This journal article describes a study that found linear relationships between the most heavily chlorinated PCBs and infant performance impairments on the NBAS at 25-48 hours after birth. It concludes that chlorination and persistence of PCBs may be an important factor both for exposure assessment and for determining relationships with neurobehavioral functions.

Darvill T, Lonky E, Reihman J, Stewart P, Pagano J. Prenatal exposure to PCBs and infant performance on the Fagan test of infant intelligence. *Neurotoxicology.* 2000; 21(6):1029-38.

This study examined a sample of infants was examined at 6 months and again at 12 months of age using the Fagan Test of Infant Intelligence (FTII). Analysis of the results revealed a dose-dependent relationship between total umbilical cord-blood PCB levels and poorer FTII performance at both ages.

Vena JE, Buck GM, Kostyniak P, Mendola P, Fitzgerald E, Sever L, Freudenheim J, Greizerstein H, Zielezny M, McReynolds J, Olson J. The New York Angler Cohort Study: exposure characterization and reproductive and developmental health. *Toxicol Ind Health.* 1996; 12(3-4):327-34.

This journal article describes the New York Angler Cohort Study. The study evaluates the association between past and current consumption of contaminated fish from Lake Ontario and both short- and long-term health effect in a population-based cohort.

L.2. INFANT AND CHILDHOOD EXPOSURE

Infants and children have a special vulnerability to toxins. Infants fed on breast milk receive concentrated doses of persistent organic pollutants. Infants and children also consume more food per pound of body weight than adults, and therefore take in higher amounts of the toxins contained in food. Children tend to have behavioral patterns (such as placing objects in their mouths and crawling on the floor) that may lead to higher chemical exposures. Children also

have a longer life span than adults and consequently a longer period of time to develop health effects resulting from chemical exposures. Finally, children are less able to detoxify chemicals.

Toxins in Breast Milk

Because of the way some chemicals bind to fatty tissues in humans, measurable concentrations of toxins can accumulate and eventually work their way into mother's milk. Persistent organic pollutants are chemicals that tend to reside in the environment for long periods of time. They can get into breast milk as well. Other chemicals are not so long lasting, but people are exposed to them frequently enough that they may be a concern in breast milk. However, any level of chemicals in breast milk is a potential health concern for both mother and child. The resources listed below contain information on the types of chemicals found in breast milk and the health risks to infants, children, and mothers.

Testing Breast Milk for Chemicals

The American Academy of Pediatrics (AAP) does not currently recommend testing breast milk for DDT, Dioxins, or PCB's. Reasons behind their stance include a lack of standard laboratory procedures, and an absence of normal or reference range data with which to interpret the results of testing. AAP strongly recommends that mothers breastfeed their infants, since the many benefits outweigh the risks of chemical exposure. Breastfed infants have lower mortality rates than bottle-fed infants, and also receive essential nutrients, hormones and antibodies.
For more information see:
American Academy of Pediatrics
http://www.aap.org
Tel: 847-434-4000

L.2.a. Web Sites

Chemical Pollution and Mother's Milk
Healthy Milk, Healthy Baby
National Resources Defense Council (NRDC)
http://www.nrdc.org/breastmilk/
This Web site contains a large reservoir of information about the chemicals found in human breast milk. It covers how these chemicals enter breast milk, how mothers can limit the amount of toxic chemicals in their breast milk, and lists links to related Web sites**.**

Children's Environmental Health Page
PSR
http://www.psr.org/ceh.htm
This site is PSR's page on children's environmental health. This is recommended as a starting point in examining issues related to prenatal, infant, and childhood exposure to toxic chemicals.

National Institute of Child Health and Human Development (NICHD)

http://www.nichd.nih.gov/

NICHD conducts and supports laboratory, clinical, and epidemiological research on the reproductive, neurobiological, developmental, and behavioral processes that determine the health of children. This site is an important resource for information about children's environmental health.

America's Children and the Environment:
A First View of Available Measures
EPA

http://www.epa.gov/children/indicators/download.html

This text is the EPA's first report on trends in environmental factors that may affect the health and well being of children in the United States. This report represents an initial step in the identification, development, and compilation of a set of measures that fully reflect environmental factors important for children. This includes trends in levels of environmental contaminants in air, water, food, and soil; concentrations of lead measured in children's bodies; and childhood diseases that may be influenced by environmental factors. Printed copies of the booklet **America's Children and the Environment: A First View of Available Measures** are available free of charge from the EPA's National Service Center for Environmental Publications.
To order the text see: **http://www.epa.gov/ncepihom/ordering.htm**

Children's Environmental Health Network

http://www.cehn.org/

The Children's Environmental Health Network is a national multi-disciplinary project whose mission is to protect the fetus and the child from environmental health hazards and promote a healthy environment. This Web site is gateway to information on children's environmental health. The **Resource Guide on Children's Environmental Health** provides links to national and local organizations that are working to protect children from environmental health hazards. It includes sources of information on environmental hazards, health effects, and exposure routes. It also contains a glossary of children's environmental health terms.
For the complete guide see: **http://www.cehn.org/cehn/resourceguide/rghome.html**
Children's Environmental Health Network may be contacted at: 202-543-4033

L.2.b Books/Texts

Landrigan, Phillip J.; Needleman, Herbert L.; and Landrigan, Mary. **Raising Children Toxic Free: How to Keep Your Child Safe From Lead, Asbestos, Pesticides, and other Environmental Hazards.** New York: Farrar, Straus and Giroux, 1994.

By identifying the critical pollutants in today's environment, this book serves as a practical guide for parents and physicians. It explains how to minimize children's exposure to toxins, evaluate health risks, and ensure community compliance with cleanup laws.

L.2.c. Journal Articles

LaKind JS, Berlin CM, Naiman DQ. Infant exposure to chemicals in breast milk in the United States: what we need to learn from a breast milk monitoring program. Environ. Health Perspect. 2001;109:75-88.

Anderson HA, Wolff MS. Environmental contaminants in human milk. J Exp Anal Environ Epidemiol 2000; 10:755-760.

Kostyniak PJ, Stinson C, Greizerstein HB, Vena J, Buck G, Mendola P. Relation of Lake Ontario fish consumption, lifetime lactation, and parity to breast milk polychlorobiphenyl and pesticide concentrations. Environ Res. 1999 Feb;80(2 Pt 2):S166-S174.

L.3. WORKPLACE EXPOSURE

L.3.a. Web Sites

Occupational Safety and Health Administration (OSHA)
http://www.osha.gov/
OSHA's mission is to oversee the protection of workers and the enforcement of workplace regulations. This Web site contains information about OSHA regulation compliance, safety standards, and links to other programs.
OSHA may be contacted at: 202-219-8148

National Institute of Occupational Safety and Health (NIOSH)
http://www.cdc.gov/niosh/homepage.html
NIOSH is a federal agency responsible for conducting research and making recommendations for the prevention of work-related disease and injury.
To order the NIOSH Pocket guide to Chemical Hazards, covering 677 chemicals, and other NIOSH publications, contact the NIOSH publications office:
Tel: 800-356-4674

Occupational Health Guidelines for Chemical Hazards
NIOSH
http://www.cdc.gov/niosh/81-123.html
This Web site contains NIOSH's complete database of occupational health guidelines for chemical hazards. It lists synonyms for substances, identifying characteristics, permissible exposure limits set by OSHA, health hazard information, monitoring and measurement information, techniques for reducing occupational exposure (such as respirators and other personal protective equipment), and general sanitation procedures. This Web site is a very comprehensive resource for occupational chemical exposure and health concerns.

Material Safety Data Sheets (MSDS)

http://hazard.com/msds2/

Material Safety Data Sheets include information on health effects, first aid measures, handling, personal protection, toxicology and regulation for chemicals used in the workplace. Employers are required to provide an MSDS for each chemical to which a worker is exposed.

L.3.b. Books/Texts

Bowler RM, and JE Cone. **Occupational Medicine Secrets.** Philadelphia: Hanley & Belfus, Inc, 1999.

This book provides an overview of relevant principles, hazards, groups at risk, diseases, and practices in the field of occupational medicine. Each section stresses the importance of prevention, evaluation and effective treatment in the practice of occupational health. Chapters include specific substances of exposure and occupational health disorders.

Danse, Ilene R. **Common Sense Toxins in the Workplace.** New York: Van Nostrand Reinhold, 1991.

Targeted towards health professionals although not overly technical in language, this book covers workplace exposure to toxins. Chapters include a brief look at human toxicology, evaluating workers for toxic injury and toxic exposures, and workers compensation issues. This book also explains how to use biomonitoring in assessing occupational exposure and includes a list of commercially available screening.

M. ENVIRONMENTAL SOURCES OF EXPOSURE

M.1. GENERAL TOXIN RELEASE INFORMATION

The national Superfund legislation, established in order to clean up hazardous waste sites, has a right-to-know component. Information on Superfund sites is widely publicized, and Web sites have been developed which allow the user to access environmental pollutant release data. The resources in this section contain information about annual estimated releases of toxic chemicals to the environment.

Toxic Release Inventory (TRI)

TRI is a publicly available EPA database that contains information about specific toxic chemical releases and other waste management activities reported annually by industry groups and federal facilities. This inventory was established under the Emergency Planning and Community Right-to-Know Act of 1986 (EPCRA), which requires facilities to use their best readily available data to calculate their releases and waste management estimates. TRI currently contains data from the reporting years 1995-1999.

TRI Program

http://www.epa.gov/tri/

This EPA Web site contains the complete searchable TRI database. It contains more information but is not as user-friendly as EDF's TRI database (see below). This site also provides a link to EPA regional contacts (Click on "TRI Contacts"). This list provides contact information for the TRI Coordinator in each of the ten EPA Regions across the United States. EPA Regional Coordinators assist individuals, public interest groups, the media and others in acquiring and understanding TRI data. To contact TRI administrators:
Tel: 202-260-1488
E-mail: tri.us@epa.gov

Scorecard
Environmental Defense Fund (EDF)

http://www.scorecard.org

This site contains EDF's TRI database. It allows you to search for toxic releases from industrial facilities by zipcode. Included are air pollutants, lead contamination (Superfund sites), and Clean Water Act status. This site is more user-friendly than the TRI database on the EPA Web site.

Lead Risk Assessment Values or Standards
EDF Scorecard

http://www.scorecard.org

This site includes a link to a lead hazard pollution locator (a U.S. map of housing units with a high risk of lead hazards). It also contains a link to a locator map with potential sources of land contamination with lead, such as toxic waste sites identified as federal Superfund sites, and industrial facilities reporting land and underground releases of chemicals to the TRI. You can get a report for your community by using your zipcode.

The Right-to-Know Network

http://www.rtk.net/

The Right-to-Know Network provides free access to numerous databases, text files, and conferences on the environment. The information available on this web site allows you to identify specific sources of industrial pollution and the potential exposure risks to surrounding communities. Databases include TRI, IRIS, and information on industrial pollution discharge permits, health effects, chemical accidents, and Superfund sites.
Tel: 202-234-8494

Environmental Contamination:
Cleanup Actions at Formerly Used Defense Bases
General Accounting Office (GAO)

http://www.gao.gov/new.items/d01557.pdf

The U.S. Army Corps of Engineers has identified over 9,000 contaminated properties for cleanup actions at formerly used defense sites. This document is a comprehensive report to Congress describing the status of these cleanup operations.

M.2. WATER

Humans and wildlife risk exposure to toxic chemicals that reside in sources of water. There are many resources which provide information about toxins and drinking water.

Clean Water Action
http://www.cleanwateraction.org/
Clean Water Action is a national citizens organization working for clean, safe and affordable water. This Web site contains information about arsenic in drinking water, recent news items, right-to-know initiatives, and drinking water regulations.

Ground Water and Drinking Water
EPA
http://www.epa.gov/safewater/
This Web site, maintained by the EPA's Office of Water, contains a large amount of information on drinking water and human health, local drinking water, source water protection, drinking water standards, and public drinking water systems.

Safe Drinking Water Hotline: 800-426-4791
This EPA telephone hotline contains information about the Clean Water Act, drinking water testing, and contact information for state drinking water officers.

Drinking Water and Health Page
PSR
http://www.psr.org/dwater.html
This site covers a variety of topics including toxins in drinking water, and cancer and drinking water. The site also lists numerous drinking water fact sheets such as "Drinking Water and Disease: What Health Care Providers Should Know."

M.3. AIR

Each year, millions of tons of toxins are released into the air, mostly from manmade sources. Some air pollutants are known or suspected to cause cancer or other serious health problems. EPA studies of human exposure to air pollutants indicate that indoor levels of pollutants may be 2-5 times, and occasionally more than 100 times, higher than outdoor levels. Levels of indoor air pollutants may be of particular concern because most people spend about 90% of their time indoors.

Air Toxics Web Site
Office of Air Quality Planning and Standards

EPA
http://www.epa.gov/ttn/atw/index.html
This site is the homepage for EPA resources on air quality. It includes links to publications on air quality, information about air pollutants and pollutant sources, national air toxics assessments, and air pollution regulations.

Taking Toxics Out of the Air
Office of Air Quality Planning and Standards
EPA
http://www.epa.gov/oar/oaqps/takingtoxics
This EPA site describes what air toxics are, where they come from, and how they can impact people and the environment. It also describes the steps being taken by the EPA to reduce emissions of air toxics from major industrial sources such as chemical manufacturing plants, petroleum refineries, and steel manufacturing plants. The entire report, **Taking Toxics Out of the Air**, may be downloaded from this site.

Hazardous Air Pollutants
http://www.epa.gov/ttn/atw/188polls.html
This EPA site contains a compilation of all known hazardous air pollutants.

Indoor Air Quality
Office of Air and Radiation
EPA
http://www.epa.gov/iaq/index.html
This web site contains links to information about asthma, indoor air pollution, and secondhand smoke. The EPA runs a telephone hotline on indoor air quality.
Indoor Air Quality Information Clearinghouse: **800-438-4318**

American Lung Association
http://www.lungusa.org/
This site contains many resources and links to information about chemical toxins in the air and the health effects of air pollution.

M.4. FOOD

Food products are also a potential source of exposure to industrial chemicals. Fruits and vegetables often contain pesticide residues. Meat, poultry, and dairy products may contain dioxin and other persistent organic pollutants. Seafood may contain elevated levels of heavy metals, particularly mercury. Consuming organic food products lessens the risk of exposure to toxins in foods.

M.4.a. USDA

United States Department of Agriculture (USDA)

http://www.usda.gov/
The USDA's responsibilities include ensuring the health of land used for agricultural and overseeing the safety of meat, poultry, and egg products. This Web site is the homepage for the USDA. The USDA runs several telephone hotlines.
Meat and Poultry Hotline: 800-535-4555
National Organic Program: 202-720-3252

Dioxin Advisories and Guidance
Food Safety Inspection Service (FSIS)
USDA
http://www.fsis.usda.gov/OA/topics/dioxmenu.htm
This is a master list from the FSIS. It provides links to sites for general and scientific information on dioxins, dioxins in food imports, and dioxin in livestock, poultry and eggs.

Food Safety
Agriculture Research Service (ARS)
USDA
http://www.nps.ars.usda.gov
ARS research is organized into numerous programs. Much of this research examines chemical pollution of soil and water used to produce the nation's food supply. This Web site is the gateway to research carried out by the USDA.

M.4.b. FDA

U.S. Food and Drug Administration (FDA)
http://www.fda.gov/
The FDA's mission is to promote and protect the public health by helping safe and effective products reach the market, and to monitor products for continued safety after they are in use. The FDA sets pesticide tolerance standards.
Food Information & Seafood Hotline: 888-723-3366

A Description of the U.S. Food Safety System
FDA, USDA
http://www.fsis.usda.gov/OA/codex/system.htm
This site describes the complex system of food safety regulation in the United States. This paper is a product of a FDA/USDA collaboration.

Health Advisory for Fish Consumption
New York State Department Of Environmental Conservation (DEC)
http://www.dec.state.ny.us/website/dfwmr/seasons/foe4chad.html
The New York State DEC routinely monitors contaminant levels in fish and wildlife. The New York State Department of Health (DOH) issues advisories on eating sportfish and wildlife taken in New York State when these foods are found to contain potentially harmful levels of chemical contaminants.

Many state health departments issue advisories on fish consumption. For links to all state health departments see:

http://webtest.tdh.state.tx.us/lab/sthlthde.htm

N. APPENDIX

N.1. APPENDIX 1-SAMPLE ATSDR PROFILE

Appendix 1 contains a complete table of contents for the ATSDR Toxicological Profile for Arsenic. This is presented in order to illustrate the comprehensiveness and importance of this major resource. ATSDR ToxFAQs are condensed versions of the complete profile and are available on the Internet (see section A.2, "General Toxicology Information" for more information).

Toxicological Profile for Arsenic
U.S. Department of Health and Human Services
Public Health Service
Agency for Toxic Substances and Disease Registry

CONTENTS

N.2. APPENDIX 2-CLINICAL LAB STATE GUIDELINES

Appendix 2 is a table of guidelines in every U.S. state regarding who may order clinical laboratory tests (biomonitoring testing included) and who is authorized to receive the results.

		Authorized Individual Can:		
Region I States	**Authorized Individual (Specify Physician, etc.)**	**Order Test**	**Receive Results**	**State Licensure Law (Yes or No)**
Connecticut	Ophthalmologist, Osteopaths, Physician, Podiatrist, licensed Physician Assistant (PA), Naturopath, Nurse Midwife, Advance Practice Register Nurse (RN), Dentist, Chiropractor, patients can receive test by written request of ordering Physician only.	Yes	Yes	Yes
Massachusetts	Physician, Dentist, Chiropractor, Surgeon, licensed Podiatrist, Osteopath, or other person authorized to the report of such examinations by provision of chapter 112 (See Mass. Dept. of Public Health).	Laboratory results may only be released to the authorized person who requested the examination	See “Order Test”	Yes
Maine	MD, DO, DMD, Nurse Practitioner (NP), PA, and others allowed by their licensing requirements (e.g., chiropractors, naturopaths).	Only the individual authorized to order and those that actually ordered may receive results	See “Order Test”	Yes

		Authorized Individual Can:		
Region I States	**Authorized Individual (Specify Physician, etc.)**	**Order Test**	**Receive Results**	**State Licensure Law (Yes or No)**
New Hampshire	New Hampshire does not have any statutes defining authorized person for ordering or receiving test results. (Individual labs make policy decisions to define authorized person.) Patients receive results only at permission of the ordering person. New Hampshire has licensing law that applies only to free standing, for profit laboratories.	All	All	No
Rhode Island	Defined as Licensed Health Professionals working under the auspices of a licensed Physician or other licensed health care professional action within his/her scope of practice.	Yes	Yes	Yes
Vermont	Vermont does not have any statutes defining authorized person for ordering or receiving test results.	N/A	N/A	No

	Authorized Individual Can:			
Region II States	**Authorized Individual (Specify Physician, etc.)**	**Order Test**	**Receive Results**	**State Licensure Law (Yes or No)**
New Jersey	Physicians, Dentists, Podiatrists, Chiropractors, PA's, certified Nurse Midwives, NP's and patients.	All except patients	All	Yes
New York	Same as above	All except patients	All	Yes
Puerto Rico	Same as above	All except patients	All except patients	Yes
Virgin Islands	Same as above	All	All	No
Region III States				
District of Columbia	Physician or Advanced Practice Nurse.	Physician or advanced practice nurse	Physician or nurse (any type)	Yes
Delaware	None specified in a law.	None specified	None Specified	Yes. (but no regulation)
Maryland	Physician, Podiatrist, Court of Law, Dentist, NP, Nurse Midwife, Chiropractor.	All of those listed	All of those listed. Also patient may receive results if patient notifies lab in writing of desire to receive results and also notifies physician	Yes
Pennsylvania	"Member of the healing arts licensed in PA., or other persons authorized by statute, or authorized agent of the forgoing".	All of those listed	All of those listed	Yes
Virginia	None specified	None specified	None specified	No
West Virginia	None specified	None specified	None specified	Personnel licensure only

	Authorized Individual Can:			
Region IV States	**Authorized Individual (Specify Physician, etc.)**	**Order Test**	**Receive Results**	**State Licensure Law (Yes or No)**
Alabama	Physician, (he/she may authorize RN, NP, PA, and for screening purposes a Pharmacist) however, the physician is responsible for the interpretation of the lab results.	Yes	Yes	State licensure for all laboratories except POL's are exempt
Florida	MD, DO, Chiropractors, Podiatrists, Naturopaths, ARNP's, PA's can order.	Yes	Yes	Yes
Georgia	Physicians, Dentists, Law Enforcement Officials.	Yes	Yes	Yes
Kentucky	Licensed Physician, Licensed Osteopath, Podiatrists, Dentists, ARNP.	Yes	Yes	State licensure for independent laboratories only
Mississippi	State definition is for hospitals only, limited to those who practice medicine or dentistry. Outside hospital they allow (based on CLIA: MD, DO, NP, Dentists, Chiropractors, individuals at health fairs and pharmacies). Most labs set their own policies for persons that they will accept lab requisitions from.	Yes	Yes	No

	Authorized Individual Can:			
Region IV States	**Authorized Individual (Specify Physician, etc.)**	**Order Test**	**Receive Results**	**State Licensure Law (Yes or No)**
North Carolina	Physicians, Dentists, Podiatrists, PA's, NP's.	Yes	Yes	No
South Carolina	Physicians, Dentists, professionals authorized by the Physician, Chiropractors and Podiatrists-limited to the area of their practice.	Yes	Yes	No
Tennessee	Physicians, Dentists, Optometrists, licensed professionals authorized by their statute.	Yes	Yes	Yes
Region V States				
Illinois	MD, DO, Podiatrist, Dentist, Officer of Court.	Yes	Yes	No
Indiana	Anyone may authorize a laboratory test to be performed. However, due to payment reimbursement and other issues, all laboratories in Indiana do not do testing based on authorization of private individuals.	Yes	Yes	No. Indiana does not have a state licensure requirement for laboratories

	Authorized Individual Can:			
Region V States	**Authorized Individual (Specify Physician, etc.)**	**Order Test**	**Receive Results**	**State Licensure Law (Yes or No)**
Michigan	Physicians, PA's, LNP-these providers are defined by state law, and alluded to by the CLIA regulations, but only for moderate and/or high complexity tests. There are no provisions for defining authorized personnel for waived tests under CLIA regulations, i.e., anybody can order waived tests.	Yes	Yes	Yes. Not enforced since the CLIA regulations have a more comprehensive scope of laboratory oversight
Minnesota	Physicians, Dentists, Clinical Nurse Specialists, PA's, and Chiropractors are allowed to order lab tests under their professional practice act statutes. They are allowed to order tests within the scope of their practice.	Yes	Yes	No. Minnesota does not have regulations for licensure of clinical labs

	Authorized Individual Can:			
Region V States	**Authorized Individual (Specify Physician, etc.)**	**Order Test**	**Receive Results**	**State Licensure Law (Yes or No)**
Ohio	Defined by scope of practice, Dentists, Podiatrists, Physician, Chiropractor (limited), PA's and Nurse under physician supervision. Ohio law does not allow or disallow an individual from self-ordering tests. State medical board opinion states that ordering lab tests is the practice of medicine. This is not law.	"Physician" as defined by scope of practice can order and receive test results. State medical board opinion states the results are to go to the "physician".	See "Order Test"	No clinical laboratory licensure overall. Limited permit/ODH director approvals involving proficiency testing, legal alcohol/drugs, lead testing license required. Lead law based on CLIA compliance.
Wisconsin	Wisconsin does not have any statutes defining authorized person for ordering tests or receiving test results.	N/A	N/A	No
Region VI States				
Arkansas	Does not have any statutes defining authorized person for ordering or receiving test results. They are silent on the issue.	N/A	N/A	No
Louisiana	Same as above	Same as above	Same as above	No
New Mexico	Same as above	Same as above	Same as above	No
Texas	Same as above	Same as above	Same as above	No
Region VII States				
Iowa	Not defined	Not defined	Not defined	No
Kansas	Not defined	Not defined	Not defined	No
Missouri	Not defined	Not defined	Not defined	No

	Authorized Individual Can:			
Region VIII States	**Authorized Individual (Specify Physician, etc.)**	**Order Test**	**Receive Results**	**State Licensure Law (Yes or No)**
Colorado	Law is silent	Law is silent	Law is silent	No
Montana	Law is silent	Law is silent	Law is silent	Laboratory personnel licensure
North Dakota	Law is silent	Law is silent	Law is silent	Laboratory personnel licensure
South Dakota	Law is silent	Law is silent	Law is silent	No
Utah	Utah law specifies that only those individuals that can utilize laboratory results can order laboratory tests. Utah Attorney General interpretation says ordering laboratory tests is not the practice of medicine. Therefore, it appears anyone can order a test.	Attorney General interpretation says receiving laboratory results is not the practice of medicine. Only those individuals that can utilize test results can receive test results. Diagnosing from laboratory test results or interpreting the data would be considered the practice of medicine and would require a license.	See "Order Test"	
Wyoming	Law is silent	Law is silent	Law is silent	Yes-not implemented

	Authorized Individual Can:			
Region IX States	**Authorized Individual (Specify Physician, etc.)**	**Order Test**	**Receive Results**	**State Licensure Law (Yes or No)**
American Samoa	No law	No law	No Law	No
Arizona	MD, DO, Podiatrists, Chiropractors, Naturopaths, Homeopaths, Dentists, NP's, and PA's.	Any authorized individual can order and receive test results	See "Order Test"	No
California	MD, DO, NP under a Physician's supervision, other health care providers (such as Podiatrist, Chiropractor when the test results can be used to modify treatment of their patient).	MD, DO, NP under a physician's supervision, PA under a physician's supervision, other health care providers (such as Podiatrist, Chiropractor when the test results can be used to modify treatment of their patients). Only a few tests in CA. Law can be self-referred (but there is pressure to expand).	Same as "Order Test". However, a physician may authorize results to be released to his/her patient, or may release them directly. The SA is concerned about internet transmission of test results without physician approval, and tests coming from out- of-state on self-referred tests.	No
Guam	No law	No law		
Hawaii	MD, DO, Podiatrist, Dentist, Clinical Psychologist (limited ordering), Veterinarian (limited), Naturopaths, APRN (limited, i.e., need MD f/u).	Any authorized individual can order and receive test results.	See "Order Test"	Yes

	Authorized Individual Can:			
Region IX States	**Authorized Individual (Specify Physician, etc.)**	**Order Test**	**Receive Results**	**State Licensure Law (Yes or No)**
Nevada	MD, DO, NP under the protocols of their Physician, PA under the protocols of their Physician.	Patients can receive their own test results. Health care provider providing services in rural hospital can receive test results in order to provide patient care.	See "Order Test"	Yes
Region X States				
Alaska	Not specified in law or regulation. Labs currently limit to licensed practitioners (NP, PA, and up).	None specifically authorized. Default to anyone.	None specifically authorized. Default to anyone.	Not for labs
Idaho	MD, DO, DDS, Optometrist, Chiropractor, PA, NP, Naturopath, Midwives.	Yes	Yes	Not for labs
Oregon	MD, DO, DPM, PA, DC, ND (Naturopath), CNP, Certified Nurse Midwife, DDS, DMD, Anyone can order certain tests (not toxicological).	Yes. Only licensed personnel.	Yes. Only licensed personnel.	Yes, but dormant until CLIA goes away.
Washington	Anyone is authorized to order tests. Labs are encouraged to develop policies.	Yes. Interpretation of test results is considered practice of medicine.	Yes. Interpretation of test results is considered practice of medicine.	Yes. All "Medical Test Sites" are licensed.

N.3. APPENDIX 3-ENVIRONMENTAL HEALTH

Environmental Health is an interdisciplinary field which brings together many topic areas already covered in the guide. This science is concerned with toxin exposure, exposure sources, the human health effects of exposure, environmental contamination, and regulatory and prevention strategies. This appendix contains resources, including a section of "best reads", which cover a wide area of related topics in environmental health. It also includes a section on federal regulations pertinent to the topics covered in this guide.

N.3.a. Web Sites

The National Environmental Health Association (NEHA)
http://www.neha.org/
This site is the home page for NEHA and provides many useful environmental health resources. It also contains a link to:

The Journal of Environmental Health
http://www.neha.org/JEHPreview.html
The Journal of Environmental Health publishers position papers on children's environmental health, endocrine disrupters, secondhand tobacco smoke, pesticides, and additional articles on environmental health.

National Council for Science and the Environment
http://www.cnie.org/
This web site provides a link to search Congressional Research Service Reports (from the National Library for the Environment (NLE), part of the Library of Congress). The NLE covers topics such as air pollution, pesticides, and water pollution, and contains thousands of specially prepared congressional documents.

INFORM, Inc.
http://www.informinc.org/
INFORM, Inc. is an independent research organization that examines the effects of business practices on the environment and human health. This site includes a large list of publications. See "publications" then "chemical hazards prevention" to access the documents "**Preventing Industrial Toxic Hazards: A Guide for Communities**" and "**Environmental Dividends: Cutting More Chemical Wastes**."

United States Environmental Protection Agency (EPA)
http://www.epa.gov
The mission of the EPA is to protect human health and safeguard the natural environment. The EPA homepage provides many resources for investigating environmental threats to human health. Many additional EPA resources are featured in this guidebook. There are ten regional

EPA offices throughout the United States. You may access contact information for the regional offices directly by clicking "contact us".
EPA Tel: 202-260-2090

Right to Know Page
EPA
http://www.epa.gov/epahome/r2k.htm
This site is a great resource with links to the Toxic Releases Inventory (TRI), and right-to-know information about food quality protection, air pollution, water quality, the EPA's lead program, hazardous waste, and many other resources for community action.

Search Your Community
EPA
http://www.epa.gov/epahome/commsearch.htm
This web site allows you to search the EPA's databases for environmental toxin release information by zip code.
http://www.epa.gov/enviro/html/tris/tris_query.html
This site enables you to retrieve TRI data from the database by zip code, specific industrial facility, SIC (Standard Industrial Classification) code, and by chemical name. (For more information see **Section M1**, **General Toxin Release Information**).

National Institute of Environmental Health Sciences (NIEHS)
http://www.niehs.nih.gov/
NIEHS is one of 25 institutes of the National Institutes of Health (NIH). The mission of NIEHS is to reduce the burden of human illness from environmental causes by understanding each of these elements and how they interrelate. The NIEHS web site contains information and links related to the field of environmental health, including the journal which can be accessed at:
http://ehis.niehs.nih.gov/

Environmental Health Perspectives (EHP)
NIEHS
http://ehis.niehs.nih.gov/
EHP is a leading journal in the field of environmental health. It is an excellent resource for the latest research in the field.

Children's Environmental Health Page
NIEHS
http://ehpnet1.niehs.nih.gov/children/
This page contains resources for childrens environmental health, with a focus on recent events as reported in the news media and EHP.

N.3.b. Books/Texts

Williams, Luanne Kemp; Langley, Ricky L. **Environmental Health Secrets**. Philadelphia: Hanley and Belfus, Inc., 2001.

This text is a brief yet comprehensive review of the field of environmental health. It includes sections on water quality, hazardous waste, risk assessment from incineration and combustion sources, environmental rules and regulations, federal agencies involved in regulation, environmental carcinogens, endocrine disrupters, persistent environmental contaminants, biomarkers and biomonitoring, pesticides, and lead exposure. It is geared towards environmental health workers and occupational medicine professionals, yet is accessible to a wide audience.

Legator, Marvin; and Strawn, Sabrina (editors). **Chemical Alert: A Community Action Handbook**. Austin: University of Texas Press, 1993.

This book contains information about the health effects of chemicals, with a focus on community release and exposure. It also promotes community health activism, and describes how communities can initiate their own health surveys.

N.3.c. Best Reads in Environmental Health

Steingraber, Sandra. **Having Faith: An Ecologist's Journey to Motherhood** Cambridge: Perseus Publishing, 2001.

Dr. Steingraber, a biologist, author, and journalist tells the month by month story of her own pregnancy, incorporating new scientific understanding of embryology and human development and the maternal experience. She makes a balanced presentation of threats posed by industrial chemicals to conception, pregnancy and the safety of breast milk.

Steingraber, Sandra. **Living Downstream : A Scientist's Personal Investigation of Cancer and the Environment**. New York: Addison-Wesley Publishing Company, Inc., 1997.

In this book the author traces the elevated incidence of cancer and the high concentrations of environmental toxins in her native rural Illinois. She goes on to show similar correlation in other communities, such as Boston and Long Island, and throughout the United States, where cancer rates have risen alarmingly since mid-century.

Ashford, Nicholas A.; Spadafor, Christine J.; and Hattis, Dale B. **Monitoring the Worker for Exposure and Disease: Scientific, Legal, and Ethical Considerations in the Use of Biomarkers**. Baltimore: The Johns Hopkins University Press, 1990.

This book explains the science of human biomonitoring, which is increasingly being used as a supplement or replacement for environmental monitoring of toxic substances in the workplace. It also examines the medical, legal, and ethical issues of such testing and develops policy recommendations. This book is suitable for a general audience.

Thornton J. **Pandora's Poison: Chlorine, Health and a New Environmental Strategy**, Cambridge: MIT Press, 2000.

This text is a thorough and accessible study of how global organochlorine pollution contributes to health problems such as infertility, immune suppression, cancer, and developmental disorders in humans and animals. The author covers both the science and the public policy of chemical pollution, and proposes a major shift in environmental science and policy.

Colburn, Theo; Dumanoski, Dianne; and John Peterson Myers. **Our Stolen Future.** New York: Penguin Books, 1996.

This book tells the story of how endocrine disruption was discovered, how it works, and how families can protect themselves and their communities. It is intended for a general audience.

Berkson, DL. **Hormone Deception: How everyday foods and products are disrupting your hormones and how to protect yourself and your family.** Chicago: Contemporary Books, 2000.

This book, written for the general public, contains information on endocrine disruptors. It covers the effects of endocrine disruptors on human health, children's health, and men's and women's reproductive health. The author, a nutritionist, suggests ways to prevent exposure in everyday life. The book may be ordered at: **http://www.hormonedeception.com/**

Krimsky, Sheldon. **Hormonal Chaos: The Scientific and Social Origins of the Environmental Endocrine Hypothesis**. Baltimore: The Johns Hopkins University Press, 2000.

This book traces the emergence of the hypothesis that a broad range of modern industrial chemicals are interfering with the normal functioning of hormones in animals and humans. It explains that disrupting the endocrine system may lead to cancer, reproductive abnormalities, and cognitive problems such as Attention Deficit Disorder. It is intended for a wide range of readers.

Ashford, Nicholas and Miller, Claudia. **Chemical Exposures: Low Levels and High Stakes**. New York: John Wiley and Sons, Inc., 1998.

This book examines how everyday low-level chemical exposures may be related to fatigue, memory impairment, headaches, mood changes, breathing difficulties, digestive problems, and a range of chronic unexplained illness such as Chronic Fatigue Syndrome, Gulf War Syndrome, and Sick Building Syndrome. Unusually sensitive groups include occupants of tight buildings, industrial workers who handle chemicals, residents of communities exposed to toxic chemicals, and people with random and unique exposures to various chemicals.

Natelson, Benjamin. **Facing and Fighting Fatigue: A Practical Approach.** New Haven: Yale University Press, 1998.

This book is a good place to start learning about Chronic Fatigue Syndrome (CFS). It covers the causes of fatigue (including toxin exposure), effective management of fatigue, and resources in the field of fatigue studies. It explains that low dose exposure to toxins such as pesticides may produce symptoms resembling CFS.

Schettler, Ted, et al. **In Harm's Way: Toxic Threats to Child Development**. Boston: Greater Boston Physicians for Social Responsibility, 2000.

This book is a very important and accessible resource for the latest information on toxins and child development. It covers dioxins, PCBs, pesticides, solvents, and other developmental toxins. It also contains overviews of normal brain development, health risks from exposure to neurotoxicants, genetic variability in responses to toxic exposure, and current research into developmental disabilities in children.
To download the entire report see: **http://www.igc.org/psr/ihw.htm**
To contact Greater Boston PSR directly and order the report: Tel: 617-497-7440

Schettler, Ted, et al. **Generations at Risk: Reproductive Health and the Environment.** Cambridge: The MIT Press, 1999.

This book summarizes the current state of developmental toxicology science and provides information for citizens to make informed decisions about the health risks of toxic chemicals. It includes sections on reproductive physiology and toxicology, the reproductive and developmental effects of selected substances, and a guide to investigating environmental threats to reproduction.

Landrigan, Phillip J.; Needleman, Herbert L.; and Landrigan, Mary. **Raising Children Toxic Free: How to Keep Your Child Safe From Lead, Asbestos, Pesticides, and other Environmental Hazards.** New York: Farrar, Straus and Giroux, 1994.

By identifying the critical pollutants in today's environment, this book serves as a practical guide for parents and physicians. It explains how to minimize children's exposure to toxins, evaluate health risks, and ensure community compliance with cleanup laws.

N.c.4. Environmental Organizations

Physicians for Social Responsibility
Environment and Health Page
http://www.psr.org/enviro.htm

The PSR site for environmental health is a very comprehensive resource. It includes connections to PSR sites on persistent organic pollutants, medical waste incineration, children's environmental health, drinking water and health, and recent news articles on environmental health. This site also contains links to many documents about environmental health including: **Polluting our Future: Chemical Pollution in the U.S. that Affects Child Development and Learning**, **Environmental Pollutants and Health**, **Putting the Lid on Dioxin: Protecting Human Health and the Environment**, **Pesticides and Children: What Primary Care Physicians Should Know**, and **Children and Lead: A Guide for Parents and Day Care Providers**.

To contact PSR directly: Tel: 202-898-0150 Email: psrnatl@psr.org

Public Interest Research Groups (PIRGs)
http://www.pirg.org/

PIRGs are alliances of state-based, citizen-funded organizations that advocate for the public interest. This web site may be used to contact PIRGs from individual states for more information on local health and environmental hazards.

Environmental Defense Fund (EDF)
http://www.edf.org/

EDF is a large nonprofit environmental organization that includes as one of its many goals, the protection of human health. This site allows you to view its many publications in the field of environmental health.

Tel: 212-505-2100

Environmental Research Foundation (ERF)

http://www.rachel.org/home_eng.htm

ERF was founded in 1980 to provide easily understandable scientific information about the influence of toxic substances on human health and the environment. It publishes **Rachel's Environmental and Health News**. This site provides access to ERF's many publications and links to related sites. Tel: 888-272-2435 E-mail: erf@rachel.org

To view current and back issues of Rachel's Environment & Health News see:

http://www.rachel.org/bulletin/index.cfm?St=1

You may also subscribe to receive weekly issues over email. Rachel's newsletter, written by Pert Montague, is probably the best single source for well documented, readable, timely and useful information about environmental health topics.

N.4. APPENDIX 4-FEDERAL REGULATION

CLINICAL LABORATORY IMPROVEMENT ACT

The Clinical Laboratory Improvement Act (CLIA) of 1967 was the first attempt of the federal government to regulate laboratory testing performed on humans. In 1988 CLIA was amended by the Clinical Laboratory Improvement Amendments. The **Centers for Medicare and Medicaid Services (CMS)** (Formerly the **Health Care Financing Administration**) regulate all laboratory testing (except research) performed on humans in the United States through CLIA. In total CLIA covers approximately 171,000 laboratory entities. The Division of Laboratories and Acute Care Services, under the Center for Medicaid and State Operations, has the responsibility for implementing the CLIA Program. The objective of the CLIA program is to ensure quality laboratory testing. To learn more about CLIA see:

CLIA Program Home Page
CMS
http://www.hcfa.gov/medicaid/clia/cliahome.htm
This web site contains the entire text of CLIA, program descriptions, program updates, test categorization under CLIA, a registry of all laboratories covered by CLIA, and other related information.

Toxic Substances Control Act (TSCA)
http://www.epa.gov/region5/defs/html/tsca.htm
TSCA was enacted in 1976 by Congress to give EPA the ability to track the 75,000 industrial chemicals currently produced or imported into the United States. EPA screens these chemicals and can require reporting or testing of those that may pose an environmental or human-health hazard. EPA can ban the manufacture and import of those chemicals that pose an unreasonable risk. The full text of TSCA can be downloaded from this site.
TSCA Hotline: 202-554-1404
Email: tsca-hotline@epamail.epa.gov

Food Quality Protection Act (FQPA)
http://www.epa.gov/opppsps1/fqpa/
FQPA of 1996 amended the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Federal Food Drug, and Cosmetic Act (FFDCA). These amendments fundamentally changed the way EPA regulates pesticides. The requirements included a new safety standard that must be applied to all pesticides used on foods. This web site provides background information on FQPA's provisions and discusses some of the specific issues raised by FQPA, as well as status of implementation of this important law.

Clean Air Act (CAA)
http://www.epa.gov/region5/defs/html/caa.htm
The Clean Air Act of 1970 is the comprehensive Federal law that regulates air emissions from area, stationary, and mobile sources. This law authorizies the EPA to establish National Ambient

Air Quality Standards (NAAQS) to protect public health and the environment. The entire text of CAA may be downloaded from this site.

Clean Water Act (CWA)

http://www.epa.gov/region5/defs/html/cwa.htm

The Clean Water Act is a 1977 amendment to the Federal Water Pollution Control Act of 1972, which set the basic structure for regulating discharges of pollutants to waters of the United States. The law gave EPA the authority to set effluent standards on an industry Basis and continued the requirements to set water quality standards for all contaminants in surface waters. The CWA makes it unlawful for any person to discharge any pollutant from a point source into navigable waters unless a permit NPDES is obtained under the Act. The 1977 amendments focused on toxic pollutants. In 1987, the CWA was reauthorized and again focused on toxic substances, authorized citizen-initiated lawsuits on the basis of CAA violations. The entire text of the CAA may be downloaded from this site.

Emergency Planning and Community Right to Know Act (EPCRA)

http://www.epa.gov/region5/defs/html/epcra.htm

EPCRA was enacted by Congress as the national legislation on community safety. This law was designated to help local communities protect public health, safety, and the environment from chemical hazards. The entire text of the act may be downloaded from this site.

Occupational Safety and Health Act

http://www.epa.gov/region5/defs/html/osha.htm

Congress passed the Occupational Safety and Health Act to ensure worker and workplace safety. Their Goal was to make sure employers provide their workers a place of employment free from recognized hazards to safety and health, such as exposure to toxic chemicals, excessive noise levels, mechanical dangers, heat or cold stress, or unsanitary conditions. In order to establish standards for workplace health and safety, the Act also created the National Institute for Occupational Safety and Health (NIOSH) as the research institution for the Occupational Safety and Health Administration (OSHA). The entire text of the act may be downloaded from this site.

Chemical Risk Assessment: Selected Federal Agencies' Procedures, Assumptions, and Policies
General Accounting Office (GAO)

http://www.gao.gov/cgi-bin/getrpt?gao-01-810

This site contains a GAO document which details the risk assessment procedures of various federal agencies. For example, the report covers the EPA Office of Pesticide Program's process for setting exposure standards. FDA and OSHA risk assessment are also covered in detail.

O. Body Burdens of Industrial Chemicals in the General Population: An Essay

BIOMONITORING OF INDUSTRIAL POLLUTANTS:
HEALTH AND POLICY IMPLICATIONS OF THE CHEMICAL BODY BURDEN

Joe Thornton, Ph.D.[1]
Michael McCally, M.D., Ph.D.[2*]
Jane Houlihan, M.S.[3]

1. The Earth Institute and Department of Biological Sciences, Columbia University, New York, NY; jt121@columbia.edu
2. Department of Community and Preventive Medicine, Mount Sinai School of Medicine, New York University, New York, NY; michael.mccally@mssm.edu Tel 212 241 5436 Fax 212 360 6965
3. Environmental Working Group, Washington DC; jane@ewg.org

Biomonitoring of industrial chemicals in human tissues and fluids has shown that all persons, not just those working in or living near major pollution sources, carry a "body burden" of synthetic chemicals in their blood, fat, mother's milk, semen, urine, and breath. In March of 2001 the Centers for Disease Control and Prevention (CDC) presented its National Report on Human Exposure to Environmental Chemicals, the first of a planned series of annual studies of the types and amounts of industrial chemicals that Americans have in their blood and urine (1).

An immense chemical industry that grew rapidly after World War II provides materials now used in virtually every sector of commerce and in every home in the United States. Some 70,000 individual industrial chemicals are registered with the Environmental Protection Agency for commercial use (2). Only a very small fraction of these substances have been characterized for their biological activity or human toxicity (3). Approximately 1,500 new chemicals are introduced onto the market each year (4). Several classes of chemicals, including the organochlorines and heavy metals, are the object of considerable public health and regulatory concern due to their tendency to persist in the environment, bioaccumulate and bioconcentrate in food webs, and disrupt biological processes at low doses.

Residues of industrial chemicals can now be found in air, soil, water and food webs in the most remote reaches of the planet (5,6). All humans are now exposed to synthetic pollutants in drinking water, air, and the food supply (7,8), as well as consumer products and home pesticides (9,10). Some of these chemicals resist metabolism and excretion, and therefore accumulate in body tissues. The quantity of an exogenous substance or its metabolites that accumulates in an individual or population is defined as a "body burden." The toxicology of individual industrial chemicals is covered in textbooks (11,12) and in government reports such as the Agency for Toxic Substances and Disease Registry (ATSDR) Toxicological Profile Series (13). Here we comment on biomonitoring and its importance for public health research and practice; we discuss research and policy issues raised by the existence of the universal chemical body burden.

MONITORING THE CHEMICAL BODY BURDEN

Biomarkers of exposure, susceptibility, and effect are important for establishing causality and identifying mechanisms that link chemical exposure and adverse health outcomes (11,12). An individual's body burden of a pollutant is estimated by measuring the concentration of that substance in one or more tissues (14). Such measurements serve as indicators of recent or long-past chemical exposures.

Body burdens are complex and dynamic in a number of ways. First, tissue levels of a pollutant are not stable over time. The concentration at any one time reflects a dynamic balance between the amount taken in and the amount excreted or metabolized into another material. Many industrial chemicals, like formaldehyde, benzene and some pesticides, are rapidly excreted or metabolized, producing a negligible long-term body burden. Others have long or intermediate biological half-lives and therefore accumulate progressively in a person's tissues as exposures continue (15). Tetrachlorodibenzo-p-dioxin (TCDD), for example, has an estimated half-life in humans of seven years, and body burdens generally increase with age (8). Body burdens are not distributed homogeneously within an individual, either. The partitioning of a pollutant among various tissues and fluids reflects the substance's relative affinity for water, fat, or mineral matrices; for example, PCBs, like other hydrophobic pollutants, accumulate in adipose tissue, and calcium-mimicking lead concentrates in bone.

The ability of chemical analyses to characterize the full range of contaminants is limited by technology and existing information (14,16). Compounds can be identified only if they are present in concentrations above a detection limit (usually in the parts per trillion or billion). Moreover, routine analyses can identify only compounds that can be matched against a reference database of chemical signatures; novel or exotic compounds therefore remain unidentified in even the most rigorous analyses. Standards have yet to be developed for the vast majority of industrial chemicals and their environmental and metabolic byproducts, so the population's body burden remains uncharacterized to a large extent. The adipose tissue of the U.S. general population contains an estimated 700 contaminants that have not yet been chemically identified (16).

THE GENERAL POPULATION'S BODY BURDEN

The human body burden of specific industrial substances has been well-characterized in selected populations, including victims of chemical accidents (17) workers in agriculture (18), chemical (19) and incineration industries (20), military personnel exposed to herbicides like Agent Orange (21), and persons exposed through contaminated food (22).

A substantial body of research has examined chemical contamination of persons with no special exposures. This work indicates that the general public bears a body burden of a diverse group of industrial chemicals and pesticides, presumably due to global contamination and universal exposure. A review of the literature, for example, shows that over 190 synthetic organochlorines have been detected in the blood, adipose tissue, mother's milk, semen, breath, and urine of the general population of the United States and Canada (23).

Most studies to date have focused on a few chemicals in relatively small study populations. We conducted a pilot study for a planned investigation of attitudinal and behavioral responses to information about one's personal body burden. We measured an extensive panel of more than 150 chemicals in the blood and urine of a convenience sample of nine normal subjects with no unusual exposures. The results (Table 1) corroborate the view that a body burden of phthalate plasticizers, dioxins, furans, PCBs, metals, and pesticides is a truly universal phenomenon.

Chemical body burdens have been studied in several large surveys using nationally representative samples of the U.S. population. The National Health and Nutrition Examination Survey (NHANES II) examined the levels of lead and 36 pesticides and pesticide metabolites in the blood of a national sample of nearly 6,000 people ages 12 to 74 years during the period 1976 to 1980; follow-up research in NHANES III and IV included other heavy metals and volatile organic compounds (24). Savage and coworkers reported on pesticide levels in human breast milk in a broad geographic sample of the U.S. nursing mother population (25).

From the early 1970s to 1992 the Environmental Protection Agency's National Human Adipose Tissue Survey (NHATS) estimated the general population's body burden of several hundred synthetic chemicals, using surgical and post-mortem body fat specimens (26). Although the NHATS programs has been criticized for lacking a standardized methodology and using a sample of individuals that may not accurately reflect the nation's population, but the program's results remain one of the most comprehensive available data sets on the general population's body burden. In the 1980s, EPA's TEAM study measured a large number of industrial chemicals in human breath in 12 volunteers from New Jersey and North Carolina (27). Another EPA analysis identified several dozen synthetic chemicals in mother's milk from 42 women in New Jersey, Pennsylvania, and Louisiana (28).

In 1991, a committee of the National Academy of Sciences called for a national program to monitor blood samples from the general population for the presence of a list of target substances, based on a standardized protocol (14). Subsequently, the National Center for Environmental Health, a division of the CDC, initiated the National Exposure Report program (1). The first results from this program reported on the presence of heavy metals, phthalates, and several pesticides in a very large sample of the United States population, with data on the variability of contaminant levels with age, sex, and region. In subsequent years, the study will be expanded to address a larger list of about 100 substances.

A particular value of the CDC's national biomonitoring program is its capacity to establish reference ranges – descriptions of the concentration of a particular substance normally present in the general population. A reference range serves as a standard against which a public health laboratory can say that results for any group or individual are high, in a "normal" range, or low (29). For well-studied materials like lead (31), selected pesticides (31), dioxins and PCBs (32), good reference values already exist because large numbers of persons have been studied using standardized methods. But for most substances, laboratory methods have varied over time and few nationally representative populations have been studied, providing no reference for interpreting biomonitoring data on a specific individual or cohort.

A lack of historical data for most pollutants and changes in analytical methods make results difficult to compare. As a result, tracking time trends in population exposures for most pollutants is difficult. If continued over the long-term, CDC's biomonitoring program promises to address this problem. For some pollutants, however, there is good historical data available now; these indicate that the existence of an unappreciable body burden of industrial chemicals is a recent phenomenon. For example, dioxins in preserved human tissue samples from pre-industrial times are non-detectable or present at only a very small fraction of current concentrations (33,34). It is also clear that concentrations of organochlorines the use and/or production of which were restricted in industrialized nations – such as PCBs, DDT, dieldrin, heptachlor, and other pesticides -- declined in adipose tissue and mother's milk in the 1980s and early 1990s, and then apparently leveled off (35,36,37).

There is also only limited data on the distribution of body burdens among age groups, and children are of special concern. Once persistent pollutants take up residence in human fatty tissues, there is no effective way to eliminate them. Women, however, excrete accumulated persistent chemicals into the fat of breast milk and, in smaller quantities, across the placenta into the fetus (38,39). The nursing infant is exposed to these compounds during critical periods of development when sensitivity to chemically-induced disruption is high (40). After weaning, children continue to receive substantial exposures, due to higher intake rates of food as a fraction of body-weight. With the exception of lead, there have been no comprehensive analyses of the chemical body burdens of children. A large national prospective longitudinal cohort study of American children has recently been proposed (41), which would investigate the role of various risk factors, including early exposure to environmental toxicants, in a variety of developmental outcomes. A large-scale study of pollutants in the milk of U.S. mothers has also been proposed (38).

PUBLIC HEALTH AND RESEARCH IMPLICATIONS

Public health scientists and practitioners can use biomonitoring information for tracking, control and treatment. The traditional purpose of biomonitoring programs is to assess the health risks of occupationally or environmentally exposed individuals. Because body burdens integrate

exposures that occur across time and environmental media and reflect the accumulation of pollutants after metabolic and partitioning processes, biomonitoring data can also play a critical role in identifying novel hazards and high-risk populations, tracking trends in human exposure, and characterizing exposure levels that pose health hazards (14).

From a public health perspective, the critical question raised by the existence of a universal chemical body burden is whether low-level chemical exposures can cause large-scale impacts on the health of the general population. Even in the absence of new external exposures, accumulated pollutants serve as a reservoir for continuing internal doses (42) and transfer to the developing child *in utero* and via nursing (43). The demonstration of significant biological effects at very low levels of exposure (44,45,46) suggests that two toxicological axioms -- all chemicals have thresholds below which they cause no adverse effects, and "the dose makes the poison" -- should be reevaluated. Indeed, findings in developmental toxicology indicate that the timing of exposure may often be more important than the dose (47).

Evaluating the possibility of a link between universal chemical exposure and health impairment poses a major challenge to public health scientists. When the exposed population is the general public, there is no unexposed or even less exposed group to serve as a reference; it is therefore impossible for the existence of chemically-induced effects at the low end of the general population's exposure distribution to be directly inferred epidemiologically (48). It is possible, however, to compare groups from the general population that differ slightly or moderately in the magnitude of their exposures in order to study the hazards of elevated exposures. When the differences between exposed and reference groups are small – as they must be for findings to be relevant to background exposures -- very accurate characterizations of exposure and effect are required. Unfortunately, relevant impacts (e.g., deficits in immunity, fertility, or cognition) are often subtle, difficult to quantify, vary naturally within the population, take years to be expressed, and reflect exposure to chemical mixtures, non-chemical agents, and other confounders. Epidemiology is therefore quite limited in its ability to untangle the causal webs that link long-past, complex exposures to subtle forms of population health damage. As a result, conclusive and specific causal links are likely to be established between universal exposures and health impacts in the general population only in rare cases, even though effects that escape detection could be of considerable public health significance.

Determination of health impacts at background doses therefore requires an integrated approach to evidence from diverse sources, and biomonitoring data can play a critical role in this strategy. For example, body burden measurements automatically account for differences in metabolism and excretion, increasing confidence in interspecies and inter-individual estimates of toxicity (8). Biomonitoring therefore allows comparisons between well-controlled studies on laboratory animals and the general public's exposures. Studies of this type have found that current "background" body burdens of dioxins, PCBs and several other well-studied organochlorines in humans are at or near the range at which adverse effects occur in laboratory animals. For example, the body burden of dioxins and furans in the average American adult has been found to be 8 to 13 parts per trillion, expressed as TCDD-equivalents (TEQ) (49); when dioxin-like PCBs are included, the total TEQ in blood lipids in the 1990s is 25 parts per trillion (8). In comparison, a dioxin dose that produces a level of just 5 parts per trillion in blood lipids of pregnant rats reduces sperm density by 25 percent in the male offspring. At a maternal body burden of 13 parts per trillion, puberty is delayed and penises and ducts in the testes are smaller (50). Other animal studies have established endocrine, neurobehavioral, and reproductive system

impacts of persistent pesticides and other substances in the range of the general population's body burdens (49,51,52,53).

Body burden data can also facilitate the geographically-based evaluation of chemical exposures and its relation to health impacts. For example, clear links have been between consumption of fish from the Great Lakes and large-scale reproductive, developmental, endocrine, and immunological dysfunction in birds, fish, and mammals. Body burdens of bioaccumulated pollutants are only about 5 to 10 times higher than in otherwise identical inland populations from the same region that eat less contaminated fish and do not manifest the same impacts (54). These data suggest the possibility that subtle effects may also occur in the comparison population and other wildlife populations in locations around the world. The body burdens of dioxins and PCBs observed to cause developmental impairment in Great Lakes wildlife range from 35 to 1000 parts per trillion in the embryo (TEQ), the lower end of which is close to the levels found in the general human population (54).

Body burden data have also emerged as an important biomarker for epidemiological inference. Effects with decades-long latencies often make direct assessment of relevant exposures impractical. Body burdens, however, provide a present indicator of long-term exposure, allowing a putative link between the risk of disease and tissue levels of one or more pollutants to be studied. This type of data is particularly useful for examining developmental impacts: maternal body burdens provide a biomarker of the fetus' *in utero* exposure, and contaminant levels in mother's milk are a biomarker of exposure through nursing. A number of studies have used body burden data to establish that exposure to dioxins and PCBs early in life is associated with reduced cognitive ability, shortened attention span, thyroid hormone disruption, and compromised immune defenses. In these studies, women and their children drawn from the general human population have been studied; the offspring of mothers at the higher end of the reference range for PCB and/or dioxin body burden have been found to have significantly greater risks of developmental impairment than those in the lower end, even after controlling for a wide variety of confounders (55,56,57,58,59,60). Careful analysis has allowed the relative roles of in utero and lactational exposure to be evaluated, with most studies finding the former to be of the greatest importance (55,56,57).

IMPLICATIONS FOR HEALTH POLICY AND EDUCATION

The existence of a universal, low-level chemical body burden raises questions about the adequacy of current environmental health policies. Regulations in most industrialized nations allow unlimited production and use of synthetic chemicals, but discharges of some specific substances from individual facilities are limited to levels predicted to produce "acceptable" levels of local contamination and exposure. The general population's body burden, however, indicates that even very small discharges of persistent, bioaccumulative substances can build to significant levels over time. Furthermore, the focus on single substances, single facilities, and local environments takes no account of the total global pollution burden produced by thousands of permitted activities occurring simultaneously. Policies could more effectively reduce the total environmental load and human exposure burden by seeking to diminish the production and use of all potentially hazardous chemicals in a systematic, prioritized fashion (23). Sweden, for example, has established a national program to reduce its overall reliance on synthetic chemicals; the strategy requires a phase-out by 2015 of substances that are persistent, bioaccumulative, carcinogenic, mutagenic, or toxic to the reproductive or endocrine systems. This program will

also reverse the burden of proof, so that substances that have not been toxicologically evaluated must be withdrawn from the market by 2010 (61).

The complexity of the human body burden and the limits of epidemiology have important implications for the use of science in environmental and health policy. Some commentators, citing the absence of conclusive and direct epidemiological demonstrations of causal linkages, have concluded that "background" levels of chemical exposure are not causing health damage in the general population and that preventive measures are unnecessary (62). But the limitations of epidemiological analysis make such a standard of proof difficult or sometimes impossible to achieve. Insistence on conclusive causal links that can only be established with great difficulty prevents timely action to reduce health risks, even in the face of a suggestive body of evidence that chemical exposure has the potential to cause long-term, global health impairment. To demand proof actually requires large-scale health damage to occur in the human population before preventive action can be taken. Policies of this type conflict with the "do no harm" ethical basis of health and medical practice.

The limits of environmental health science have led to an increasing acceptance and application in environmental law of the precautionary principle (63): environmental damage should be anticipated and prevented in the face of uncertainty by avoiding potentially damaging activities whenever possible. Precaution is entirely consistent with the primacy of prevention among the principles of public health practice. Precautionary action implies a progressive effort to implement safer products and processes, reducing the production and use of all potentially hazardous chemicals. Such a program would almost certainly reduce the burden of toxic substances in the environment and in human tissues.

Biomonitoring can play an important role in health education by providing workers and citizens with knowledge of their personal chemical exposures. One of the subjects in our pilot study was the journalist Bill Moyers, who used his own body burden profile in his television documentary about the chemical industry, *Trade Secrets*. Mr. Moyers, like the other eight subjects, was surprised at the number and diversity of chemicals in his own tissue, curious about where and when his exposures occurred, and concerned about their potential health effects.

When individuals understand that their bodies are contaminated and identify the sources and pathways of exposure, they may modify their diet or change their residence or occupation. They may ask for health screening and medical advice about their risk factors. Awareness of the universal nature of such exposures may lead them to take political action and seek systematic reductions in the release of pollutants to the environment. Information on the universal chemical body burden may therefore be an important tool in environmental protection and the environmental health education of the general public.

References:

1. Centers for Disease Control and Prevention. National Report on Human Exposure to Environmental Chemicals. Atlanta, 2001.
2. Rom WN. Environmental and Occupational Medicine: Second Edition. Boston: Little, Brown & Co. 1992, p. 738.
3. Roe D, Pease W, Florini K, Silbergeld E, Leiserson K, Below C, Chang J, Abercrombie D. Toxic Ignorance: The Continuing Absence of Basic Health Testing for Top-Selling Chemicals in the United States. NewYork: Environmental Defense Fund, 1997.
4. Yang RSH. Toxicology of Chemical Mixtures. New York: Academic Press, 1994:1-10; 99-117.
5. Loganathan BG, Kannan K. Global organochlorine contamination trends: An overview. Ambio 1994;23:187-191.
6. Simonich SL, Hites RA. Global distribution of persistent organochlorine compounds. Science 1995;269:1851-1854.
7. Wu C, Schaum J. Exposure assessment of trichloroethylene. Environ Health Perspect. 2000; 108 Suppl 2:359-63.
8. U.S. Environmental Protection Agency, National Center for Environmental Assessment. Exposure and Human Health Reassessment of 2,3,7,8-Tetrachlorodibenzo-p-dioxin (TCDD) and Related Compounds, Part III (SAB Review Draft). Washington DC, 2000.
9. Hill RH Jr, Ashley DL, Head SL, Needham LL, Pirkle JL. p-Dichlorobenzene exposure among 1,000 adults in the United States. Arch Environ Health 1995;50:277-80.
10. Zartarian VG, Ozkaynak H, Burke JM, Zufall MJ, Rigas ML, Furtaw EJ Jr. A modeling framework for estimating children's residential exposure and dose to chlorpyrifos via dermal residue contact and nondietary ingestion. Environ Health Perspect. 2000; 108:505-14.
11. Klaassen CD, ed. Casarett & Doull's Toxicology: The Basic Science of Poisons, Fifth Edition. New York: McGraw-Hill, 1996.
12. Lippman M, ed. Environmental Toxicants: Human Exposures and Their Health Effects. Second Edition, New York: Wiley Interscience 2000.
13. Agency for Toxic Substances and Disease Registry. Toxicological Profile Series, Washington, DC, US Public Health Service 1989-1999.
14. National Research Council, Committee on National Monitoring of Human Tissues. Monitoring Human Tissues for Toxic Substances. Washington, D.C.: National Academy Press, 1991.
15. Landrigan PJ. Relation of body burden measures to ambient measures. Epidemiology & Health: Risk Assessment, ed. S. Gordish. New York/Oxford: Oxford University Press, 1988.
16. Onstot J, Ayling R, Stanley J. Characterization of HRGC/MS Unidentified Peaks from the Analysis of Human Adipose Tissue. Volume 1: Technical Approach. Washington, DC: U.S. Environmental Protection Agency Office of Toxic Substances (560/6-87-002a), 1987.
17. Wolff MS, Schecter A. Accidental Exposure of Children to Polychlorinated Biphenyls. Arch Environ Contam Toxicol 1991;20:449-453.
18. Brock JW, Melnyk LJ, Caudill SP, Needham LL, Bond AR. Serum levels of several organochlorine pesticides in farmers correspond with dietary exposure and local use history. Toxicol Ind Health 1998;14:275-289.

19. Beck H, Eckart K, Mathar W, Witt Kowski L. Levels of PCDD's and PCDF's in adipose tissue of occupationally exposed workers. Chemosphere 1989;18:507-516.
20. Schecter A, Papke O, Ball M, Lis A, Brandt-Rauf P. Dioxin concentrations in the blood of workers at municipal waste incinerators. Occup Environ Med 1995;52:385-387.
21. Kang HK, Watanabe KK, Breen JJ, et al. Dioxins and dibenzofurans in adipose tissue of US Vietnam veterans and controls. Am J Public Health 1991;81:344-349.
22. Ryan JJ, Schecter A, Masuda Y, Kikuchi M. Comparison of PCDDS and PCDFs in the tissue of Yusho patients with those from the general population in Japan and China. Chemosphere 1987;16:2017-2025.
23. Thornton J. Pandora's Poison: Chlorine, Health and a New Environmental Strategy, MIT Press, Cambridge, MA, 2000.
24. Murphy R, Harvey C. Residues and metabolites of selected persistent halogenated hydrocarbons in blood specimens from a general population survey. Environ Health Perspect 1985;60:115-120.
25. Savage E, Keefe TJ, Tessari JD, Wheeler HW, Applehans FM, Goes EA, Ford SA. National study of chlorinated hydrocarbon insecticide residues in human milk, USA. 1. Geographic distribution of dieldrin, heptachlor, heptachlor epoxide, chlordane, oxychlordane, and mirex. Am J Epidemiol 1981;113:413-422.
26. Orban JE, Stanley JS, Schwemberger JG, Remmers JC. Dioxins and dibenzofurans in adipose tissue of the general US population and selected subpopulations. Am J Public Health 1994;84:439-45.
27. Wallace LA, Pellizzari ED, Hartwell TD, Whitmore R, Zelon H, Perritt R, Sheldon L. The California TEAM study: breath concentrations and personal exposures to 26 volatile compounds in air and drinking water of 188 residents of Los Angeles, Antioch,and Pittsburg, CA. Atmos Environ 1988; 22:2141-2163.
28. Pellizzari ED, Hartwell TD, Harris BS, Waddell RD, Whitaker DA, Erickson MD. Purgeable organic compounds in mother's milk. Bull Environ Contam Toxicol 28:322-328, 1982.
29. Pirkle JL, Needham LL, Sexton K. Improving exposure assessment by monitoring human tissues for toxic chemicals. J Exp Anal Environ Epidemiol 1995;5:405-424.
30. Paschal DC, Ting BG, Morrow JC, Pirkle JL, Jackson RJ, Sampson EJ, Miller DT, Caldwell KL. Trace metals in urine of United States Residents: Reference range concentrations. Environ Res 1998;76:53-59.
31. Needham LL, Hill RH, Ashley DL, Pirkle JJ, Sampson EJ. The priority toxicant reference range study: Interim report. Environ Health Perspect 1995;103:89-94.
32. Needham LL, Patterson DG Jr, Burse VW, Paschal DC, Turner WE. Reference range data for assessing exposure to selected environmental toxicants. Toxicol Ind Health 1996;12(3-4):507-513.
33. Ligon WV, Dorn SB, May RJ. Chlorodibenzofuran and chlorodibenzo-p-dioxin levels in Chilean mummies dated to about 2800 years before the present. Environ Sci Technol 1989; 23:1286-1290.
34. Tong HY, Gross MLO, Schecter A, Monson SJ, Dekin A. Sources of dioxin in the environment: second stage study of PCDD/Fs in ancient human tissue and environmental samples. Chemosphere 1990; 20:987-992.
35. Hill RH, Head S, Baker S, Gregg M, Shealy DB, Bailey SL, Williams CC, Sampson EJ, Needham LL. Pesticide residues in urine of adults living in the United States: Reference range concentrations. Environ Res 1995;71:99-108.

36. Kutz FW, Wood PH, Bottimore DP. Organochlorine pesticides and polychlorinated biphenyls in human adipose tissue. Rev Environ Contam Toxicol 1991;120:1-82.
37. Mes J. Temporal changes in some chlorinated hydrocarbon residue levels of Canadian breast milk and infant exposure. Environ Pollution 1994;84:261-268.
38. LaKind JS, Berlin CM, Naiman DQ. Infant exposure to chemicals in breast milk in the United States: what we need to learn from a breast milk monitoring program. Environ. Health Perspect. 2001;109:75-88.
39. Anderson HA, Wolff MS. Environmental contaminants in human milk. J Exp Anal Environ Epidemiol 2000; 10:755-760.
40. Committee on Hormonally Active Agents in the Environment, Board on Environmental Studies and Toxicology, Commission on Life Sciences, National Research Council. Hormonally Active Agents in the Environment. Washington, DC: National Academy Press, 1999.
41. Berkowitz GS, Wolff MS, Matte T, Susser E, Landrigan PJ. The rationale for a national prospective cohort study of environmental exposure and childhood development. Environ Res. 2001; 85(2):59-68
42. Anderson LM, Beebe LE, Fox SD, Issaq HJ, Kovatch RM. Promotion of mouse lung tumors by bioaccumulated polychlorinated aromatic hydrocarbons. Exp Lung Res 1991; 17:455-71.
43. National Research Council. Committee on Pesticides in the Diets of Infants and Children. Pesticides in the Diets of Infants and Children. Washington, DC: National Academy Press, 1993.
44. Lanphear BP, Dietrich K, Auinger P, Cox C. Cognitive deficits associated with blood lead concentrations <10 microg/dL in US children and adolescents. Public Health Rep 2000; 115:521-9.
45. Gray LE Jr, Kelce WR, Monosson E, Ostby JS, Birnbaum LS. Exposure to TCDD during development permanently alters reproductive function in male Long Evans rats and hamsters: reduced ejaculated and epididymal sperm numbers and sex accessory gland weights in offspring with normal androgenic status. Toxicol Appl Pharmacol 1995;131:108-18.
46. Howdeshell KL, Hotchkiss AK, Thayer KA, Vandenbergh JG, vom Saal FS.Exposure to bisphenol A advances puberty. Nature 1999; 401:763-4..
47. Axelrod D, Davis DL, Hajek RA, Jones LA. It's time to rethink dose: The case for combining cancer and birth and developmental defects. Env Health Perspect 2001; 109: A246-A249.
48. Rose G. Environmental factors and disease: the man made environment. Brit Med J 1987; 294:963-965.
49. DeVito MJ, Birnbaum LS, Farland WH, Gasiewicz TA. Comparisons of estimated human body burdens of dioxinlike chemicals and TCDD body burdens in experimentally exposed animals. Environ Health Perspect 1995;103:820-831.
50. Gray LE, Ostby JS, Kelce WR. A dose-response analysis of the reproductive effects of a single gestational dose of 2,3,7,8-tetrachlorodibenzo-p-dioxin in male Long Evans hooded rat offspring. Toxicol Appl Pharmacol 1997;146:11-20.
51. Ulrich, EM, Caperell-Grant, A, Jung, S, Hites, RA, Bigsby, RM. Environmentally relevant xenoestrogen tissue concentrations correlated to biological responses in mice. Environ Health Perspect 2000; 108: 973-977.
52. Seegal RF, Schantz SL. Neurochemical and behavioral sequelae of exposure to dioxins and PCBs. In: Schecter A, ed. Dioxins and Health. New York: Plenum Press, 1994: 409-448.

53. Markowski VP, Zareba G, Stern S, Cox C, Weiss B. Altered operant responding for motor reinforcement and the determination of benchmark doses following perinatal exposure to low-level 2,3,7,8-tetrachlorodibenzo-p-dioxin. Environ Health Perspect 2001;109:621-7.
54. Giesy JP, Ludwig JP, Tillitt DJ. Dioxins, dibenzofurans, PCBs and wildlife. In: Schecter A, ed. Dioxins and Health. New York: Plenum, 1994b:249-308.
55. Jacobson JL, Jacobson SW. Intellectual impairment in children exposed to polychlorinated biphenyls in utero. New Engl J Med 1996;335:783-789.
56. Rogan WJ, Gladen BC. PCBs, DDE, and child development at 18 and 24 months. Annal Epidemiol 1991; 1:407-413.
57. Koopman-Esseboom C, Weisglas-Kuperus N, de Ridder MA, Van der Paauw CG, Tuinstra LG, Sauer PJ. Effects of polychlorinated biphenyl/dioxin exposure and feeding type on infants' mental and psychomotor development. Pediatrics. 1996; 97:700-6.
58. Patandin S, Lanting CI, Mulder PG, Boersma ER, Sauer PJ, Weisglas-Kuperus N. Effects of environmental exposure to polychlorinated biphenyls and dioxins on cognitive abilities in Dutch children at 42 months of age. J Pediatr. 1999;134:33-41.
59. Weisglas-Kuperus N, Patandin S, Berbers GA, Sas TC, Mulder PG, Sauer PJ, Hooijkaas H. Immunologic effects of background exposure to polychlorinated biphenyls and dioxins in Dutch preschool children. Environ Health Perspect. 2000;108:1203-7.
60. Koopman-Esseboom C, Morse DC, Weisglas-Kuperus N, Lutkeschipholt IJ, Van der Paauw CG, Tuinstra LG, Brouwer A, Sauer PJ. Effects of dioxins and polychlorinated biphenyls on thyroid hormone status of pregnant women and their infants. Pediatr Res. 1994;36:468-73.
61. Committee on New Guidelines on Chemicals Policy. Non-Hazardous Products. Stockholm: Swedish Ministry of the Environment, 2000.
62. Juberg DR. Traces of Environmental Chemicals in the Human Body: Are They a Risk to Health? Washington DC: American Council on Science and Health, April 1999;1-15.
63. Raffensperger C and Tickner J, eds. Protecting Public Health & the Environment. Washington DC and Covelo CA: Island Press, 1999.