

TEFLON AND HUMAN HEALTH: DO THE CHARGES STICK?

*Assessing the Safety of
the Chemical PFOA*

*Project Co-ordinator:
Rivka Weiser*

*Editor:
Gilbert L. Ross, M.D.*

Prepared for
THE AMERICAN COUNCIL ON SCIENCE AND HEALTH

April 2005



AMERICAN COUNCIL ON SCIENCE AND HEALTH
1995 Broadway, 2nd Floor, New York, NY 10023-5860
Tel. (212) 362-7044 • Fax (212) 362-4919
URL: <http://www.acsh.org> • E-mail: acsh@acsh.org

THE AMERICAN COUNCIL ON SCIENCE AND HEALTH GRATEFULLY ACKNOWLEDGES THE COMMENTS AND CONTRIBUTIONS OF THE FOLLOWING INDIVIDUALS, WHO REVIEWED ALL OR PART OF THE LONGER POSITION PAPER ON WHICH THIS BOOKLET IS BASED.

Larry Beeson, Dr.P.H. <i>Loma Linda University</i>	Manfred Kroger, Ph.D. <i>Pennsylvania State University</i>
Hinrich L. Bohn, Ph.D. <i>University of Arizona</i>	Roger P. Maickel, Ph.D. <i>Purdue University</i>
Joseph F. Borzelleca, Ph.D. <i>Virginia Commonwealth University</i>	Thomas H. Milby, M.D. <i>Walnut Creek, CA</i>
John Doull, M.D., Ph.D. <i>University of Kansas</i>	Ian C. Munro, Ph.D. <i>Cantox Health Sciences International</i>
Gordon W. Gribble, Ph.D. <i>Dartmouth College</i>	Roy F. Spalding, Ph.D. <i>University of Nebraska</i>
F. Peter Guengerich, Ph.D. <i>Vanderbilt University School of Medicine</i>	Arlene Weiss, M.S., DABT <i>Environmental Medicine, Inc.</i>
Theodore R. Holford, Ph.D. <i>Yale University School of Medicine</i>	James J. Worman, Ph.D. <i>Rochester Institute of Technology</i>
Rudolph J. Jaeger, Ph.D. <i>Environmental Medicine, Inc.</i>	

TEFLON AND HUMAN HEALTH: DO THE CHARGES STICK?
Assessing the Safety of the Chemical PFOA
Copyright © 2005 by American Council on Science and Health, Inc. All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission of the publisher, except in the case of brief quotations embodied in critical articles and reviews. Inquiries should be addressed to American Council on Science and Health, 1995 Broadway, 2nd Floor, New York, NY 10023. Telephone: 212-362-7044. Fax: 212-362-4919. Email: acsh@acsh.org.

Printed in the United States of America

Cover design by Yelena Ponirovskaya

TABLE OF CONTENTS

I. Introduction and summary	5
II. What is PFOA?	6
III. How are humans exposed to PFOA?	6
IV. How much PFOA are people exposed to? ..	6
A. Amount based on human blood levels of PFOA	6
B. Amount based on water levels of PFOA	7
V. What do we know about the health effects of PFOA?	7
A. From studies of animals	7
B. From studies of humans	8
VI. Is the amount of PFOA that people are exposed to a cause for concern?	9
A. Risk analysis based on blood PFOA levels	9
B. Risk analysis based on administered doses of PFOA	10
VII. Conclusions	10
References	11

I. Introduction and summary

Recently, the public has become concerned about the potential human health effects of PFOA (perfluorooctanoic acid or perfluorooctanoate), a chemical used to produce substances needed to manufacture Teflon and many other products. The Environmental Protection Agency (EPA) has been reviewing the scientific data on PFOA and at press time for this publication was working on its final report about the human health effects associated with PFOA (the draft assessment was released in January 2005). In 2004, concerns about PFOA were widely reported in the media because the EPA claimed that DuPont, the manufacturer of Teflon, had not adequately reported information about PFOA's presence in water supplies and its ability to cross the placenta from mother to fetus. It is important to note that even while some media reports may have caused misunderstanding by calling PFOA a "Teflon chemical," PFOA is not present in the final product of Teflon-coated cookware; it is only used in the manufacturing process of the product.

While concerns about PFOA's effects on humans have arisen recently, data on PFOA's presence in humans and its effects on both animals and humans has been collected for more than 20 years and can be used to evaluate the potential for harm from PFOA. Research has shown that very high doses of PFOA can cause harm in animals, but the amount of PFOA to which the general population is exposed is hundreds to thousands of times lower, and biological differences may make concerns about some of the observed effects irrelevant to humans. Additionally, studies of workers (who are exposed to much higher doses of PFOA than the general population) have not shown the same effects in humans that occur in animals.

II. What is PFOA?

PFOA* is mainly used to produce other chemicals, such as APFO (ammonium perfluorooctanoic acid - often referred to as C-8). (1) These chemicals are then used in the production of products such as Teflon coating on cookware. While the use of PFOA to make Teflon is most widely known, most of these chemical products of PFOA are used in other industries such as automotive, electronics, and defense. For example, they are used to produce insulation for wires, power steering and brake assemblies in cars, and gear lubrication.

III. How are humans exposed to PFOA?

While the presence of PFOA in the environment is at least partially due to the production, use, and disposal of PFOA itself, it may also result from a breakdown of other substances that are used in consumer products. (2) It is unclear, however, how much each source contributes to the chemical's presence in the environment. PFOA has been found in air, water, living organisms, and landfills, but there is only limited data on its levels. Mostly, PFOA levels have been measured in areas (particularly in water) near production plants that use PFOA. (1)

When PFOA is absorbed through inhalation or ingestion, some of it binds to proteins in the blood, and it can also accumulate in organs such as the liver and kidneys. (9) The length of time that PFOA remains in the body has been assessed only in one study, and that study included only nine workers. (10)

IV. How much PFOA are people exposed to?

A. Amount based on human blood levels of PFOA

A number of studies have measured the levels of PFOA in the blood of people around the world,

* In this document, references to PFOA also imply C-8 and APFO.

both in the general population and in workers who are much more highly exposed to PFOA. (3-7) Because these studies have analyzed the blood of large numbers of people in widespread locales, we can be fairly confident that the studies represent the PFOA blood concentrations in the entire population. On average, the general population has about 5 parts per billion (ppb) of PFOA in their blood, with high values at about 20-30 ppb. (3-6) These concentrations do not seem to vary by age. (4, 5) Some workers in factories that use or manufacture PFOA have levels much higher than those found in the general population, averaging about 1-10 parts per million (ppm) (equivalent to 1,000 to 10,000 ppb). (7)

B. Amount based on water levels of PFOA

Drinking water levels of PFOA probably represent the largest source of human exposure to PFOA (1, 8) and can be used to estimate the amount of PFOA that people ingest (see section VI). Studies have measured PFOA levels in areas near plants that use or manufacture PFOA and sites contaminated with PFOA but have not reported country-wide, comprehensive levels of PFOA in air, soil, or water. (1, 8) While these studies cannot give us an idea of how much the average person is exposed to PFOA, they can be used to estimate the exposure to PFOA of people in the population expected to be most highly exposed. In areas surrounding plants in West Virginia and in Alabama, the levels of PFOA in drinking water have averaged about one part per billion (ppb), ranging up to about 10 parts per billion. (1,8) In a six-city survey, drinking water levels of PFOA were much lower, ranging from non-detectable to 0.029 ppb. (1)

V. What do we know about the health effects of PFOA?

A. From studies of animals

Various studies have shown that very high doses of PFOA have harmful effects on animals. In stud-

ies in which animals such as rats, rabbits, and monkeys ingested high doses of PFOA, the animals experienced adverse effects including liver changes, weight loss, and gastrointestinal irritation. (9) When exposed to high levels of PFOA in the air, these animals showed symptoms such as irregular breathing, changes in liver weight, weight loss, and eye corrosion. (9) High-dose studies of APFO have shown reproductive and developmental effects on rats; the offspring of these rats experienced increased mortality and weight loss. (11) One study found that rats exposed to high doses of PFOA had increased rates of liver, testicular, and pancreatic cancers. (9)

In applying these studies to predict risk for humans, it is important to note both that the animals were very highly exposed to PFOA (see section VI) and that a variety of studies suggest that the mechanisms by which PFOA causes cancer and other health effects in rats may not even be applicable to humans. (9) However, the exact biological mechanisms related to some of the health effects found in animals are not completely understood. (9)

B. From studies of humans

Some studies have been performed on worker populations in the U.S. and Europe who have been exposed to much higher doses of PFOA than the general population. These studies aimed at detecting in humans a variety of adverse effects that had been seen in laboratory animals but did not find these effects in workers. (12,13) A study of almost 4,000 workers did not find a relationship between PFOA exposure and all-cause mortality or cancer mortality. (9) Contrary to the results of an earlier study of workers (14), there was also no association between PFOA exposure (measured by length of employment) and prostate cancer. (9)

An unpublished report claimed that people who drank water contaminated with PFOA had higher

rates of various cancers. This report was made to support a lawsuit and was not reviewed by peers in the scientific community for its methodology and the accuracy of its claims (as studies published in peer-reviewed journals are). (15) Aside from this claim, the current data do not support a connection between PFOA and cancer, even in workers (who are most highly exposed to PFOA).

VI. Is the amount of PFOA that people are exposed to a cause for concern?

The data on effects of PFOA in humans do not give us a way to directly evaluate the potential human health risks of PFOA. However, regulatory agencies try to estimate the risk by either (A) comparing blood PFOA levels of animals experiencing adverse effects to the blood levels found in humans or (B) comparing the doses of PFOA associated with adverse effects in animals to the doses to which humans are exposed. These methods, however, are based on the assumption that the same biological mechanisms are present in humans, and that may not be true.

A. Risk analysis based on blood PFOA levels

Blood levels are not routinely measured in high-dose toxicology studies of animals, but one reproductive study recorded them for some animals. (16) The Environmental Protection Agency's preliminary risk assessment (17) was based on levels from that study, which indicated that the lowest parental PFOA blood levels associated with adverse effects in offspring were 0.37 parts per million for female rats and 51.1 parts per million in male rats. These levels are 100 to 10,000 times greater than the 5 parts per billion average level of PFOA found in blood of the general human population (in other words, there is a 100- to 10,000-fold margin of safety). (17)

Another risk assessment that used estimated blood PFOA levels based on ingested dose of PFOA concluded that the levels of PFOA in

humans were about 1,000 to 10,000* times lower than the levels that began to cause adverse effects in animals. (19)

B. Risk analysis based on administered doses of PFOA

One study indicated that the greatest amount of administered PFOA that does not cause adverse effects is 10 mg/kg/day in female rats and 3 mg/kg/day in male rats. (16) However, others suggest that this level is lower, because doses of 0.5 to 1 mg/kg/day (500 to 1000 micrograms/kg/day) of PFOA were associated with liver effects on laboratory animals. (18) As discussed earlier, the highest level of PFOA that has been measured in water is approximately 10 ppb (10 micrograms/liter). Therefore, in order to reach even the lower estimate of the amount of PFOA suspected to cause adverse effects (500 micrograms/kg/day), the average person (of 70 kg) would need to drink more than 3,500 liters of this most highly contaminated water daily.** Using water intake and weight guidelines for children, a similar calculation would also indicate a margin of safety that is somewhat smaller but still very large.

VII. Conclusions

While research has shown adverse effects of high doses of PFOA in animals, the existing studies of workers who are highly exposed do not indicate health effects of PFOA. Risk analysis based upon blood levels of PFOA and ingested amounts of PFOA by the general population show that laboratory animals experiencing adverse effects from PFOA are exposed to amounts that are hundreds to thousands of times higher than those to which the general human population is exposed.

There is doubt, however, as to whether at least some of the effects observed in animals are rele-

* *The variation depends on which effect is being examined.*
**(70 kg X 500 micrograms/kg/day)/(10 micrograms/liter) = 3,500 liters/day.

vant to humans at all, since some biological mechanisms that produce these effects are not present in humans. Additionally, workers with blood levels of PFOA equal to or higher than those that have been found to cause adverse effects in animals have themselves not shown adverse effects. This suggests that the margins of safety for the general population may be even higher than the risk analyses predict.

While further research is needed in order to more fully understand how PFOA acts in the body, the current data indicate that we can expect no risk to human health associated with the levels of PFOA exposure found in the general population.

References

1. U.S. Environmental Protection Agency. Revised Draft Hazard Assessment of Perfluorooctanoic Acid and Its Salts. Office of Pollution Prevention and Toxics, Risk Assessment Division, Washington, D.C. (2002)
2. Hagen, D.F., Belisle, J., Johnson, J.D., and Venkateswarlu, P. Characterization of fluorinated metabolites by a gas chromatographic-helium microwave plasma detector; the biotransformation of 1H, 1H, 2H, 2H-perfluorodecanol to perfluorooctanoate. *Analytical Biochemistry*. 118:336-343. (1981)
3. Olsen, G.W., Church, T.R., Miller, J.P., Burris, J.M., Hansen, K.J., Lundberg, J.K., Armitage, J.B., Herron, R.M., Medhdizadehkashi, S., Nobiletti, J.G., O'Neill, E., Mandel, J.H., and Zobel, L.R. Perfluorooctanesulfonate and other fluorochemicals in the serum of Red Cross adult blood donors. *Environ. Health Perspect.* 111:1892-1901. (2003)
4. Olsen, G.W., Church, T.R., Hansen, K.J., Burris, J.M., Butenhoff, J.L., Mandel, J.H., and Zobel, L.R. Quantitative evaluation of perfluorooctane sulfonate (PFOS) and other fluorochemicals in the serum of children. *J. Children's Health* (in press)

5. Olsen, G.W., Church, T.R., Larson, E.B., van Belle, G., Lundberg, J.K., Hansen, K.J., Burris, J.M., Mandel, J.H., and Zobel, L.R. Serum concentrations of perfluorooctanesulfonate and fluorochemicals in an elderly population from Seattle, Washington. *Chemosphere* 54:1599-1611. (2004)
6. Kannan, K., Corsolini, S., Falandysz, J., Kumar, K.S., Loganathan, B.G., Mohd, M.A., Olivero, J., van Wouwe, N., Yang, J.H., and Aldous, K.M. Perfluorooctanesulfonate and related fluorochemicals in human blood from several countries. *Environ. Sci. Technol.* 38(17):4489-4495. (2004)
7. Olsen, G.W., Burris, J.M., Burlew, M.M., and Mandel, J.H. Epidemiologic assessment of worker serum perfluorooctanesulfonate (PFOS) and perfluorooctanoate (PFOA) concentrations and medical surveillance examinations. *J. Occup. Environ. Med.* 45(3):260-270. (2003)
8. West Virginia Department of Environmental Protection. Ammonium Perfluorooctanoate (C-8) Groundwater Investigation Steering Team Report. Division of Water and Waste Management, Charleston, WV. (2003)
9. Kennedy, G.L. Jr., Butenhoff, J.L., Olsen, G.W., O'Connor, J.C., Seacat, A.M., Perkins, R.G., Biegel, L.B., Murphy, S.R., and Farrar, D.G. The toxicology of perfluorooctanoate. *Crit. Rev. Toxicol.* 34(4):351-384. (2004)
10. Burris, J.M., Lundberg, J.K., Olsen, G., Simpson, C., and Mandel, J. Interim report No. 2, Determination of serum half-lives of several fluorochemicals. 3M Company, St. Paul, MN. (U.S. EPA Public Docket AR-226) (2002)
11. Butenhoff, J.L., Kennedy, G.L., Frame, S.R., O'Connor, J.C., and York, R.G. The reproductive toxicology of ammonium perfluorooctanoate (APFO) in the rat. *Toxicology* 196:95-116. (2004)

12. Gilliland, F.D. and Mandel, J.S. Serum perfluorooctanoic acid and hepatic enzymes, lipoproteins and cholesterol: A study of occupationally exposed men. *J. Occup. Med.* 29:560-568. (1996)
13. Olsen, G.W., Butenhoff, J.L., and Mandel, J.H. Assessment of lipid, hepatic and thyroid function in relation to an occupational biologic limit value for perfluorooctanoate. U.S. EPA Public Docket AR-226. (2003)
14. Gilliland, F.D. and Mandel, J.S. Mortality among employees of a perfluorooctanoic acid production plant. *J. Occup. Med.* 35:950-954. (1993)
15. Renner, R. DuPont disputes PFOA cancer claim. *Env. Sci. Technol.* 38(14):264A-265A. (2004)
16. York, R.G. Oral (gavage) two-generation (one litter per generation) reproduction study of ammonium perfluorooctanoic acid (APFO) in rats. Argus Research Laboratories, Inc. Protocol Number: 418-020, Sponsor Study Number: T-6889.6. (2002)
17. U.S. Environmental Protection Agency. Preliminary Risk Assessment of the Developmental Toxicity Associated with Exposure to Perfluorooctanoic Acid and its Salts. Division of Prevention, Pesticides and Toxic Substances, Washington, D.C. (2003)
18. West Virginia Department of Environmental Protection. Ammonium Perfluorooctanoate (C8): Assessment of Toxicity Team (CATT) Report. Charleston, WV. (2002)
19. Butenhoff, J.L., Gaylor, D.W., Moore, J.A., Olsen, G.W., Rodricks, J., Mandel, J.H., and Zobel, L.R. Characterization of risk for general population exposure to perfluorooctanoate. *Regul. Toxicol. Pharmacol.* 39:363-380. (2004)

ACSH BOARD OF DIRECTORS

John H. Moore, Ph.D., M.B.A. <i>Chairman of the Board ACSH Grove City College</i>	Thomas R. DeGregori, Ph.D. <i>University of Houston</i>	Mark C. Taylor, M.D. <i>Physicians for a Smoke-Free Canada</i>
Elissa P. Benedek, M.D. <i>University of Michigan</i>	Henry I. Miller, M.D. <i>Hoover Institution</i>	Lorraine Thelton <i>Ketchum Public Relations</i>
Norman E. Borlaug, Ph.D. <i>Texas A&M University</i>	A. Alan Moghissi, Ph.D. <i>Institute for Regulatory Science</i>	Kimberly M. Thompson, Sc.D. <i>Harvard School of Public Health</i>
Michael B. Bracken, Ph.D., M.P.H. <i>Yale University School of Medicine</i>	Albert G. Nickel <i>Lyons Lavey Nickel Swift, Inc.</i>	Elizabeth M. Whelan, Sc.D., M.P.H. <i>American Council on Science and Health</i>
Christine M. Bruhn, Ph.D. <i>University of California</i>	Kenneth M. Prager, M.D. <i>Columbia College of Physicians and Surgeons</i>	Robert J. White, M.D., Ph.D. <i>MetroHealth Medical Center, OH</i>
Taiwo K. Danmola, C.P.A. <i>Ernst & Young</i>	Stephen S. Sternberg, M.D. <i>Memorial Sloan-Kettering Cancer Center</i>	

ACSH EXECUTIVE STAFF

Elizabeth M. Whelan, Sc.D., M.P.H.
President

ACSH BOARD OF SCIENTIFIC AND POLICY ADVISORS

Ernest L. Abel, Ph.D. <i>C.S. Mott Center</i>	Francis F. Busta, Ph.D. <i>University of Minnesota</i>	John Diebold <i>The Diebold Institute for Public Policy Studies</i>
Gary R. Acuff, Ph.D. <i>Texas A&M University</i>	Elwood F. Caldwell, Ph.D., M.B.A. <i>University of Minnesota</i>	Ralph Dittman, M.D., M.P.H. <i>Houston, TX</i>
Julie A. Albrecht, Ph.D. <i>University of Nebraska, Lincoln</i>	Zarie L. Carpenter, Ph.D. <i>Texas A&M University</i>	John E. Dodes, D.D.S. <i>National Council Against Health Fraud</i>
James E. Alcock, Ph.D. <i>Glendon College, York University</i>	C. Jelleff Carr, Ph.D. <i>Columbia, MD</i>	Sir Richard Doll, M.D., D.Sc., D.M. <i>University of Oxford</i>
Thomas S. Allams, M.D., M.P.H. <i>San Francisco, CA</i>	Robert G. Cassens, Ph.D. <i>University of Wisconsin, Madison</i>	Theron W. Downes, Ph.D. <i>Michigan State University</i>
Richard G. Allison, Ph.D. <i>American Society for Nutritional Sciences</i>	Ercole L. Cavaliere, D.Sc. <i>University of Nebraska Medical Center</i>	Michael Patrick Doyle, Ph.D. <i>University of Georgia</i>
John B. Allred, Ph.D. <i>Ohio State University</i>	Russell N. A. Cecil, M.D., Ph.D. <i>Albany Medical College</i>	Adam Drewnowski, Ph.D. <i>University of Washington</i>
Philip R. Alger, M.D. <i>University of California, San Francisco</i>	Rino Cerio, M.D. <i>Barts and The London Hospital Institute of Pathology</i>	Michael A. Dubick, Ph.D. <i>U.S. Army Institute of Surgical Research</i>
Karl E. Anderson, M.D. <i>University of Texas Medical Branch, Galveston</i>	Marris E. Chafetz, M.D. <i>Health Education Foundation</i>	Greg Dubord, M.D., M.P.H. <i>RAM Institute</i>
Dennis T. Avery <i>Hudson Institute</i>	Bruce M. Chassy, Ph.D. <i>University of Illinois, Urbana-Champaign</i>	Edward R. Duffin, Jr., M.D. <i>Savannah, GA</i>
Ronald Bachman, M.D. <i>Kaiser-Permanente Medical Center</i>	Dale J. Chodos, M.D. <i>Portage, MI</i>	David F. Duncan, Dr.P.H. <i>Duncan & Associates</i>
Robert S. Baratz, D.D.S., Ph.D., M.D. <i>International Medical Consultation Services</i>	Martha A. Churchill, Esq. <i>Milan, MI</i>	James R. Dunn, Ph.D. <i>Averill Park, NY</i>
Nigel M. Bark, M.D. <i>Albert Einstein College of Medicine</i>	Emil William Chynn, M.D. <i>New York Eye & Ear Infirmary</i>	Robert L. DuPont, M.D. <i>Institute for Behavior and Health</i>
Stephen Barrett, M.D. <i>Allentown, PA</i>	Dean O. Cliver, Ph.D. <i>University of California, Davis</i>	Henry A. Dymysz, Ph.D. <i>University of Rhode Island</i>
Thomas G. Baumgartner, Pharm.D., M.Ed. <i>University of Florida</i>	F. M. Clydesdale, Ph.D. <i>University of Massachusetts</i>	Michael W. Easley, D.D.S., M.P.H. <i>International Health Management & Research Associates</i>
W. Lawrence Beeson, Dr.P.H. <i>Loma Linda University School of Public Health</i>	Donald G. Cochran, Ph.D. <i>Virginia Polytechnic Institute and State University</i>	J. Gordon Edwards, Ph.D. <i>San Jose State University</i>
Sir Colin Berry, D.Sc., Ph.D., M.D. <i>Institute of Pathology, Royal London Hospital</i>	W. Ronnie Coffman, Ph.D. <i>Cornell University</i>	George E. Ehrlich, M.D., M.B. <i>Philadelphia, PA</i>
Barry L. Beyerstein, Ph.D. <i>Simon Fraser University</i>	Bernard L. Cohen, D.Sc. <i>University of Pittsburgh</i>	Michael P. Elston, M.D., M.S. <i>Western Health</i>
Steven Black, M.D. <i>Kaiser-Permanente Vaccine Study Center</i>	John J. Coherence, Esq. <i>Public Health Policy Advisory Board</i>	William N. Elwood, Ph.D. <i>Guidance Clinic of the Middle Keys</i>
Blaine L. Blad, Ph.D. <i>Kanosh, UT</i>	Neville Calman, M.D., Ph.D. <i>St. Luke's Roosevelt Hospital Center</i>	James E. Enstrom, Ph.D., M.P.H. <i>University of California, Los Angeles</i>
Hinrich L. Bohn, Ph.D. <i>University of Arizona</i>	Gerald F. Combs, Jr., Ph.D. <i>USDA Grand Forks Human Nutrition Center</i>	Stephen K. Epstein, M.D., M.P.P., FACEP <i>Beth Israel Deaconess Medical Center</i>
Ben Bolch, Ph.D. <i>Rhodes College</i>	Michael D. Corbett, Ph.D. <i>Omaha, NE</i>	Myron E. Essex, D.V.M., Ph.D. <i>Harvard School of Public Health</i>
Joseph F. Borzelleca, Ph.D. <i>Medical College of Virginia</i>	Morton Corn, Ph.D. <i>John Hopkins University</i>	Terry D. Eihertson, Ph.D. <i>Pennsylvania State University</i>
Michael K. Bots, Esq. <i>Ankeny, IA</i>	Nancy Cotugno, Dr.Ph., R.D., C.D.N. <i>University of Delaware</i>	R. Gregory Evans, Ph.D., M.P.H. <i>St. Louis University Center for the Study of Bioterrorism and Emerging Infections</i>
George A. Bray, M.D. <i>Pennington Biomedical Research Center</i>	H. Russell Cross, Ph.D. <i>National Beef</i>	William Evans, Ph.D. <i>University of Alabama</i>
Ronald W. Brether, Ph.D., C.Chem., DABT <i>GlobalTox International Consultants, Inc.</i>	James W. Curran, M.D., M.P.H. <i>Rollins School of Public Health, Emory University</i>	Daniel F. Forkas, Ph.D., M.S., P.E. <i>Oregon State University</i>
Robert L. Brent, M.D., Ph.D. <i>Alfred I. duPont Hospital for Children</i>	Charles R. Curtis, Ph.D. <i>Ohio State University</i>	Richard S. Fawcett, Ph.D. <i>Huxley, IA</i>
Allan Brett, M.D. <i>University of South Carolina</i>	Ilene R. Danse, M.D. <i>Bolinas, CA</i>	John B. Fenger, M.D. <i>Phoenix, AZ</i>
Kenneth G. Brown, Ph.D. <i>KBinc</i>	Harry G. Day, Sc.D. <i>Indiana University</i>	Owen R. Fennema, Ph.D. <i>University of Wisconsin, Madison</i>
Gale A. Buchanan, Ph.D. <i>University of Georgia</i>	Robert M. Devlin, Ph.D. <i>University of Massachusetts</i>	Frederick L. Ferris, III, M.D. <i>National Eye Institute</i>
George M. Burditt, J.D. <i>Bell, Boyd & Lloyd LLC</i>	Seymour Diamond, M.D. <i>Diamond Headache Clinic</i>	David N. Ferro, Ph.D. <i>University of Massachusetts</i>
Edward E. Burns, Ph.D. <i>Texas A&M University</i>	Donald C. Dickson, M.S.E.E. <i>Gilbert, AZ</i>	Madelon L. Finkel, Ph.D. <i>Cornell University Medical College</i>

ACSH BOARD OF SCIENTIFIC AND POLICY ADVISORS

Jack C. Fisher, M.D.
University of California, San Diego

Kenneth D. Fisher, Ph.D.
Office of Disease Prevention and Health

Leonard T. Flynn, Ph.D., M.B.A.
Morganville, NJ

William H. Foegen, M.D., M.P.H.
Emory University

Ralph W. Fogelman, D.V.M.
Doylstown, PA

Christopher H. Foreman, Jr., Ph.D.
University of Maryland

E. M. Foster, Ph.D.
University of Wisconsin, Madison

F. J. Francis, Ph.D.
University of Massachusetts

Glenn W. Franing, Ph.D.
University of Nebraska, Lincoln

Vincent A. Fulginitti, M.D.
University of Colorado

Arthur Furst, Ph.D., Sc.D.
University of San Francisco

Robert S. Gable, Ed.D., Ph.D., J.D.
Claremont Graduate University

Shayne C. Gad, Ph.D., D.A.B.T., A.T.S.
Gad Consulting Services

William G. Gaines, Jr., M.D., M.P.H.
Scott & White Clinic

Charles O. Gallina, Ph.D.
Professional Nuclear Associates

Raymond Gambino, M.D.
Quest Diagnostics Incorporated

Randy R. Gaugler, Ph.D.
Rutgers University

J. Bernard L. Gee, M.D.
Yale University School of Medicine

K. H. Ginzler, M.D.
University of Arkansas for Medical Sciences

William Paul Glezen, M.D.
Baylor College of Medicine

Jay A. Gold, M.D., J.D., M.P.H.
Medical College of Wisconsin

Roger E. Gold, Ph.D.
Texas A&M University

Renee M. Goodrich, Ph.D.
University of Florida

Frederick K. Goodwin, M.D.
The George Washington University Medical Center

Timothy N. Gorski, M.D., F.A.C.C.G.
University of North Texas

Ronald E. Gots, M.D., Ph.D.
International Center for Toxicology and Medicine

Henry G. Grabowski, Ph.D.
Duke University

James Ian Gray, Ph.D.
Michigan State University

William W. Greaves, M.D., M.S.P.H.
Medical College of Wisconsin

Kenneth Green, D.Env.
Reason Public Policy Institute

Laura C. Green, Ph.D., D.A.B.T.
Cambridge Environmental, Inc.

Saul Green, Ph.D.
Zol Consultants

Richard A. Greenberg, Ph.D.
Hinsdale, IL

Sander Greenland, Dr.P.H., M.S., M.A.
UCLA School of Public Health

Gordon W. Gribble, Ph.D.
Dartmouth College

William Grierson, Ph.D.
University of Florida

Lester Grinspoon, M.D.
Harvard Medical School

F. Peter Guengerich, Ph.D.
Vanderbilt University School of Medicine

Caryl J. Guth, M.D.
Advance, NC

Philip S. Guzelein, M.D.
University of Colorado

Terry J. Hartman, Ph.D., M.P.H., R.D.
The Pennsylvania State University

Clare M. Heister, Ph.D.
The Robert Mondavi Institute of Wine and Food Science, University of California, Davis

Robert D. Havener, M.P.A.
Sacramento, CA

Virgil W. Hays, Ph.D.
University of Kentucky

Cheryl G. Heaton, Dr.PH.
Columbia University

Clark W. Heath, Jr., M.D.
American Cancer Society

Dwight B. Heath, Ph.D.
Brown University

Robert Heimer, Ph.D.
Yale School of Public Health

Robert B. Helms, Ph.D.
American Enterprise Institute

Zane R. Helsel, Ph.D.
Rutgers University, Cook College

Donald A. Henderson, M.D., M.P.H.
Johns Hopkins Bloomberg School of Public Health

James D. Herbert, Ph.D.
Drexel University

Gene M. Heyman, Ph.D.
McLean Hospital/Harvard Medical School

Richard M. Hoar, Ph.D.
Williamstown, MA

Theodore R. Halford, Ph.D.
Yale University School of Medicine

Robert M. Hollingsworth, Ph.D.
Michigan State University

Edward S. Horton, M.D.
Joslin Diabetes Center/Harvard Medical School

Joseph H. Hotchkiss, Ph.D.
Cornell University

Steve E. Hruddy, Ph.D.
University of Alberta

Susanne L. Huttner, Ph.D.
University of California, Berkeley

Robert H. Imrie, D.V.M.
Seattle, WA

Lucien R. Jacobs, M.D.
University of California, Los Angeles

Alejandro R. Jadad, M.D., D.Phil., F.R.C.P.C.
University of Toronto

Rudolph J. Jaeger, Ph.D.
Environmental Medicine, Inc.

William T. Jarvis, Ph.D.
Loma Linda University

Michael Kamrin, Ph.D.
Michigan State University

John B. Kaneene, Ph.D., M.P.H., D.V.M.
Michigan State University

P. Andrew Karam, Ph.D., CHP
Rochester Institute of Technology

Philip G. Keeney, Ph.D.
Pennsylvania State University

John G. Keller, Ph.D.
Olnsey, MD

Kathryn E. Kelly, Dr.P.H.
Delta Toxicology

George R. Kerr, M.D.
University of Texas, Houston

George A. Keyworth II, Ph.D.
Progress and Freedom Foundation

Michael Kirsch, M.D.
Highland Heights, OH

John C. Kirschtman, Ph.D.
Emmaus, PA

Ronald E. Kleinman, M.D.
Massachusetts General Hospital/Harvard Medical School

Leslie M. Klevay, M.D., S.D.in Hyg.
University of North Dakota School of Medicine

David M. Klurfeld, Ph.D.
U.S. Department of Agriculture

Kathryn M. Kolasa, Ph.D., R.D.
East Carolina University

James S. Koopman, M.D., M.P.H.
University of Michigan School of Public Health

Alan R. Kristal, Dr.P.H.
Fred Hutchinson Cancer Research Center

David Kritchevsky, Ph.D.
The Wistar Institute

Stephen B. Kritchevsky, Ph.D.
Wake Forest University Baptist Health Sciences

Mitzi R. Krocaver, M.D.
Scottsdale, AZ

Manfred Kroger, Ph.D.
Pennsylvania State University

Laurence J. Kulp, Ph.D.
University of Washington

Sandford F. Kuvshin, M.D.
University of Miami School of Medicine/Hebrew University of Jerusalem

Carolyn J. Lackey, Ph.D., R.D.
North Carolina State University

J. Clayburn LaForce, Ph.D.
University of California, Los Angeles

Pagona Lagiou, M.D., DrMedSci
University of Athens Medical School

James C. Lamb, IV, Ph.D., J.D., D.A.B.T.
Blasland, Bouck & Lee

Lawrence E. Lamb, M.D.
San Antonio, TX

William E. M. Lands, Ph.D.
College Park, MD

Lillian Langseth, Dr.P.H.
Lyda Associates, Inc.

Brian A. Larkins, Ph.D.
University of Arizona

Larry Loudon, Ph.D.
National Autonomous University of Mexico

Tom B. Leamon, Ph.D.
Liberty Mutual Insurance Company

Jay H. Lehr, Ph.D.
Environmental Education Enterprises, Inc.

Brian C. Lentle, M.D., FRCP, DMRD
University of British Columbia

Floyd Lilley, J.D.
Amelia Island, FL

Paul J. Lioy, Ph.D.
UMDNJ-Robert Wood Johnson Medical School

William M. London, Ed.D., M.P.H.
Walden University

Frank C. Lu, M.D., BCFE
Miami, FL

William M. Lunn, Ph.D.
Oregon State University

Daryl Lund, Ph.D.
University of Wisconsin

George D. Lundberg, M.D.
Medscape General Medicine

Howard D. Maccabee, Ph.D., M.D.
Radiation Oncology Center

Janet E. Macheleidt, M.D., M.S., M.P.H.
Houston, TX

Roger P. Maickel, Ph.D.
Purdue University

Henry G. Manne, J.S.D.
George Mason University Law School

Karl Maramorosch, Ph.D.
Rutgers University, Cook College

Judith A. Marlett, Ph.D., R.D.
Sun City, AZ

James R. Marshall, Ph.D.
Roswell Park Cancer Institute

Margaret N. Maxey, Ph.D.
University of Texas, Austin

Mary H. McGrath, M.D., M.P.H.
University of California, San Francisco

Alan G. McHughen, D.Phil.
University of California, Riverside

James D. McKean, D.V.M., J.D.
Iowa State University

John J. McKetta, Ph.D.
University of Texas, Austin

Donald J. McNamara, Ph.D.
Egg Nutrition Center

Michael H. Merson, M.D.
Yale University School of Medicine

Patrick J. Michaels, Ph.D.
University of Virginia

Thomas H. Milby, M.D., M.P.H.
Walnut Creek, CA

Joseph M. Miller, M.D., M.P.H.
University of New Hampshire

ACSH BOARD OF SCIENTIFIC AND POLICY ADVISORS

William J. Miller, Ph.D.
University of Georgia

Dade W. Moeller, Ph.D.
Harvard University

Grace P. Monaco, J.D.
Medical Care Management Corp.

Brian E. Mondell, M.D.
Baltimore Headache Institute

Eric W. Mood, LL.D., M.P.H.
Yale University School of Medicine

John W. Margan, Dr.P.H.
California Cancer Registry

W. K. C. Margan, M.D.
University of Western Ontario

Stephen J. Moss, D.D.S., M.S.
New York University College of Dentistry/Health Education Enterprises, Inc.

Brooke T. Mossman, Ph.D.
University of Vermont College of Medicine

Allison A. Muller, Pharm.D.
The Children's Hospital of Philadelphia

Ian C. Munro, F.A.T.S., Ph.D., FRCPath
Cantox Health Sciences International

Harris M. Nagler, M.D.
Beth Israel Medical Center/Albert Einstein College of Medicine

Daniel J. Nacziyana, M.D.
Durban Institute of Technology

Phillip E. Nelson, Ph.D.
Purdue University

Joyce A. Nettleton, D.Sc., R.D.
Denver, CO

John S. Neuberger, Dr.P.H.
University of Kansas School of Medicine

Gordon W. Newell, Ph.D., M.S., F.A.T.S.
Palo Alto, CA

Thomas J. Nicholson, Ph.D., M.P.H.
Western Kentucky University

Steven P. Novella, M.D.
Yale University School of Medicine

James L. Oblinger, Ph.D.
North Carolina State University

Deborah L. O'Connor, Ph.D.
University of Toronto/The Hospital for Sick Children

John Patrick O'Grady, M.D.
Tufts University School of Medicine

James E. Oldfield, Ph.D.
Oregon State University

Stanley T. Omaye, Ph.D., F.A.T.S., FAOQ, CNS.
University of Nevada, Reno

Michael T. Osterholm, Ph.D., M.P.H.
University of Minnesota

Michael W. Pariza, Ph.D.
University of Wisconsin, Madison

Stuart Patton, Ph.D.
University of California, San Diego

James Marc Perrin, M.D.
Mass General Hospital for Children

Timothy Dukes Phillips, Ph.D.
Texas A&M University

Mary Frances Picciano, Ph.D.
National Institutes of Health

David R. Pike, Ph.D.
University of Illinois, Urbana-Champaign

Thomas T. Poleman, Ph.D.
Cornell University

Gary P. Posner, M.D.
Tampa, FL

John J. Powers, Ph.D.
University of Georgia

William D. Powrie, Ph.D.
University of British Columbia

C.S. Prakash, Ph.D.
Tuskegee University

Marvin P. Pritts, Ph.D.
Cornell University

Daniel J. Raiten, Ph.D.
National Institute of Health

David W. Ramey, D.V.M.
Ramey Equine Group

R.T. Ravenholt, M.D., M.P.H.
Population Health Imperatives

Russel J. Reiter, Ph.D.
University of Texas, San Antonio

Katherine L. Rhyne
King & Spalding LLP

William O. Robertson, M.D.
University of Washington School of Medicine

J. D. Robinson, M.D.
Georgetown University School of Medicine

Bill D. Roebuck, Ph.D., D.A.B.T.
Dartmouth Medical School

David B. Roll, Ph.D.
The United States Pharmacopeia

Dale R. Romsos, Ph.D.
Michigan State University

Joseph D. Rosen, Ph.D.
Cook College, Rutgers University

Steven T. Rosen, M.D.
Northwestern University Medical School

Kenneth J. Rothman, Dr.P.H.
Boston University School of Public Health

Stanley Rothman, Ph.D.
Smith College

Edward C. A. Runge, Ph.D.
Texas A&M University

Stephen H. Safe, D.Phil.
Texas A&M University

Wallace I. Sampson, M.D.
Stanford University School of Medicine

Harold H. Sandstead, M.D.
University of Texas Medical Branch

Charles R. Santerre, Ph.D.
Purdue University

Sally L. Satel, M.D.
American Enterprise Institute

Lowell D. Satterlee, Ph.D.
Vergas, MN

Jeffrey W. Savell
Texas A&M University

Marvin J. Schissel, D.D.S.
Roslyn Heights, NY

Lawrence J. Schneiderman, M.D.
University of California, San Diego

Edgar J. Schoen, M.D.
Kaiser Permanente Medical Center

David Schottenfeld, M.D., M.Sc.
University of Michigan

Joel M. Schwartz, M.S.
Reason Public Policy Institute

David E. Seidemann, Ph.D.
Brooklyn College

Patrick J. Shea, Ph.D.
University of Nebraska, Lincoln

Michael B. Sherner, Ph.D.
Skeptic Magazine

Sidney Shindell, M.D., LL.B.
Medical College of Wisconsin

Sarah Short, Ph.D., Ed.D., R.D.
Syracuse University

A. J. Siedler, Ph.D.
University of Illinois, Urbana-Champaign

Mark K. Segel, M.D.
New York University School of Medicine

Lee M. Silver, Ph.D.
Princeton University

Michael S. Simon, M.D., M.P.H.
Wayne State University

S. Fred Singer, Ph.D.
Science & Environmental Policy Project

Robert B. Sklaroff, M.D.
Elkins Park, PA

Anne M. Smith, Ph.D., R.D., L.D.
Ohio State University

Gary C. Smith, Ph.D.
Colorado State University

John N. Sofos, Ph.D.
Colorado State University

Roy F. Spalding, Ph.D.
University of Nebraska, Lincoln

Leonard T. Sperry, M.D., Ph.D.
Barry University

Robert A. Squire, D.V.M., Ph.D.
Johns Hopkins University

Ronald T. Stanko, M.D.
University of Pittsburgh Medical Center

James H. Steele, D.V.M., M.P.H.
University of Texas, Houston

Robert D. Steele, Ph.D.
Pennsylvania State University

Judith S. Stern, Sc.D., R.D.
University of California, Davis

Ronald D. Stewart, O.C., M.D., FRCPC
Dalhousie University

Martha Barnes Stone, Ph.D.
Colorado State University

Jon A. Story, Ph.D.
Purdue University

Michael M. Sveda, Ph.D.
Gaithersburg, MD

Glenn Swogger, Jr., M.D.
Topeka, KS

Sita R. Tatin, Ph.D.
University of Minnesota

Steve L. Taylor, Ph.D.
University of Nebraska, Lincoln

James W. Tillotson, Ph.D., M.B.A.
Tufts University

Dimitrios Trichopoulos, M.D.
Harvard School of Public Health

Murray M. Tuckerman, Ph.D.
Winchendon, MA

Robert P. Upchurch, Ph.D.
University of Arizona

Mark J. Uwell, M.D.
University of Rochester Medical Center

Shashi B. Verma, Ph.D.
University of Nebraska, Lincoln

Willard J. Visok, M.D., Ph.D.
University of Illinois College of Medicine

Lynn Washwell, Ph.D., C.H.E.S.
University of Medicine and Dentistry of New Jersey, School of Public Health

Donald M. Watkin, M.D., M.P.H., F.A.C.P.
George Washington University

Miles Weinberger, M.D.
University of Iowa Hospitals and Clinics

John Weisburger, Ph.D.
Institute for Cancer Prevention/New York Medical College

Janet S. Weiss, M.D.
The ToxDoc

Simon Wesley, M.D., FRCP
King's College London and Institute of Psychiatry

Steven D. Waxner, M.D.
Cleveland Clinic Florida

Joel Elliot White, M.D., F.A.C.R.
John Muir Comprehensive Cancer Center

Carol Whitlock, Ph.D., R.D.
Rochester Institute of Technology

Christopher F. Wilkinson, Ph.D.
Burke, VA

Mark L. Willenbring, M.D.
National Institute on Alcohol Abuse and Alcoholism

Carl K. Winter, Ph.D.
University of California, Davis

James J. Worman, Ph.D.
Rochester Institute of Technology

Russell S. Worrall, O.D.
University of California, Berkeley

Steven H. Zeisel, M.D., Ph.D.
University of North Carolina

Michael B. Zemel, Ph.D.
Nutrition Institute, University of Tennessee

Eckhard E. Ziegler, M.D.
University of Iowa