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# The Political Science of Agent Orange and Dioxin

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**Between 1961 and 1970,** the United States military sprayed the herbicide Agent Orange, a mixture of two widely used agricultural chemicals, over the enemy-controlled jungles (now called "rain forests") and crop-growing regions of South Vietnam.[1] Agent Orange was shipped to Vietnam in 55-gallon drums circled by a stripe of orange paint for easy sorting from other herbicides—Agents White, Blue, Purple, and so on.

While under development in the mid-1940s, one of the chemicals in Agent Orange—*2,4-d*ichlorophenoxyacetic acid or 2,4-D

1. For general information about the use of Agent Orange during the Vietnam War, see M. Gough, *Dioxin, Agent Orange* (New York: Plenum, 1986), pp. 63–120, and Institute of Medicine (IOM), *Veterans and Agent Orange* (Washington, D.C.: National Academy Press, 1993), pp. 23–110.

—was used to kill dandelions in front of the Smithsonian Institution on the National Mall. It continues in worldwide use as an effective herbicide against broadleaf weeds, and it's available in every hardware and most grocery stores in "Weed-B-Gon" and other popular products. The other Agent Orange component, *2,4,5-t*richlorophenoxyacetic acid or 2,4,5-T, was removed from markets around the world, after about thirty years of use, in the late 1970s and 1980s because of concerns that dioxin, specifically 2,3,7,8-*t*etra*c*hloro*d*ibenzo-para-*d*ioxin or 2,3,7,8-TCDD or TCDD, an unavoidable contaminant of the manufacture of 2,4,5-T, was a cause of cancer and other diseases.[2]

Some $3 billion have been spent on researching possible health effects from dioxin, and the results show that the risks were overstated. Last year, the Environmental Protection Agency's Science Advisory Board concluded that the evidence that dioxin is a cause of human cancer and other diseases is unconvincing.[3] Furthermore, studies of workers exposed to the highest levels of dioxin ever experienced—levels that will never be seen again—have failed to produce any conclusive evidence of connections between dioxin and cancer[4] and the other health effects.[5]

The United States stopped using Agent Orange in Vietnam in 1970—eight years before 2,4,5-T was taken off the market in this country—because of North Vietnamese and Viet Cong charges that herbicides were a form of chemical warfare forbidden by international treaty and claims from Vietnamese, Americans, and

2. Gough, *Dioxin*, pp. 137–48.

3. U.S. Environmental Protection Agency, Science Advisory Board (SAB), *Dioxin Reassessment—An SAB Review of the Office of Research and Development's Reassessment of Dioxin* (EPA-SAB-EC-01-006) (Washington, D.C.: EPA, May 2001).

4. T. B. Starr, "Significant Shortcomings of the U.S. Environmental Protection Agency's Latest Draft Risk Characterization for Dioxin-Like Compounds," *Toxicological Sciences* 64 (2001): 7–13.

5. SAB, 2001.

others that the herbicides were causing birth defects among Vietnamese children as well as severe, perhaps irreversible, ecological damage. The most important immediate factor in the decision was laboratory tests, carried out by scientists at the Dow Chemical Company, that showed dioxin to be the most potent cause of birth defects ever tested in laboratory animals.

## Veterans' Claims

By 1975, Vietnam veterans, supported by some scientists and politicians, blamed Agent Orange as the cause of their own diseases and of birth defects in their children and demanded medical treatment and monetary compensation. Their efforts received a huge boost from two television programs that associated Agent Orange with cancer in veterans and birth defects in their children.[6]

The programs found audiences ready to believe that Agent Orange caused diseases. For one thing, the United States public, long ago disenchanted with the Vietnam war and, by the late 1970s, immersed in guilt about its treatment of Vietnam veterans, willingly accepted the idea that a chemical—Agent Orange—was at the root of veterans' complaints. Moreover, environmental chemicals as the cause of human disease were staples of nightly newscasts, magazine and newspaper articles, environmental organizations' fund-raising and public-relations campaigns, lawyers looking for companies to sue, and government officials eager to increase the agencies' reach by expanding the fight against disease-causing environmental pollution. Agent Orange and dioxin became the ugly poster children for nasty environmental chemicals.

6. F. A. Wilcox, *Waiting for an Army To Die* (New York: Random House, 1983), p. 10 (of Introduction) presents a dramatic description of one of those television programs.

Through 1978, the Veterans Administration (VA) rebuffed veterans' claims for treatment and compensation for "Agent Orange diseases," saying that there was no evidence for a link between Agent Orange and the diseases for which claims were made. The veterans then took their claims to Congress.

## Congress Orders Studies About Health Effects and Agent Orange Exposures

Congress could have responded to veterans' claims by directing the VA to provide medical care and to pay compensation to the veterans, in the absence of any evidence about causation, basing its decision on compassion or other policy considerations. It didn't do that. In retrospect, it would have been a clean and clearly political decision as compared to the political decisions that ushered in a series of bad scientific decisions.

The clamor for providing treatment for Agent Orange–related diseases decreased in the 1980s when the VA, with increased funding for its hospitals (Public Law 97-72, enacted in November 1981) provided treatment for "Agent Orange–related diseases." Importantly, the veteran did not have to prove exposure to Agent Orange to qualify for treatment. Instead, Congress presumed that any veteran who had served in Vietnam had been exposed and that the exposure to Agent Orange caused the veteran's illness unless a congenital condition or some other exposure was shown to be a more likely cause.[7] In practice, the law makes any disease in Vietnam veterans treatable as an Agent Orange disease because difficult, expensive, and unlikely-to-be-conclusive tests would be necessary to test the presumption.

Earlier, in 1979, Congress (Public Law 96-151) had ordered VA to plan and carry out a study of the health of Agent Orange–

7. IOM 1994, p. 50, and references there.

exposed veterans.[8] VA failed to get the study under way in a timely manner (in fairness to VA, such a study had never been done, and it was far beyond the expertise and experience of VA staff). The Centers for Disease Control (the agency is now the Centers for Disease Control and Prevention, but I'll use the old name and abbreviation "CDC," a part of the Department of Health and Human Services, DHHS) maneuvered itself into being made responsible for the study in 1982.

## CDC's "Vietnam Experience Studies"

In 1982, because there was no way to determine whether an individual had been exposed to Agent Orange, CDC decided to compare the health of Vietnam veterans with the health of veterans who had not served in Vietnam in the "Vietnam experience studies."[9] The CDC found nothing to link Vietnam service with any health problems that had not been seen in veterans of other wars.

Many people who had looked for the Vietnam Experience Studies to verify that the war was causing health problems were disappointed. In particular, and with justification, they said that the effects of Agent Orange might have been overlooked because there was no way to identify veterans who had been exposed to it.

8. Ibid.; also Gough, *Dioxin*, pp. 89–103. As part of the legislation that mandated the Veterans Administration study, Congress directed the Office of Technology Assessment to review and approve the plan for the study and to monitor the conduct of the study. I was put in charge of that activity in early 1980.

9. See reports of the Centers for Disease Control Vietnam Experience Study: "Postservice Mortality Among Vietnam Veterans," *JAMA* 257 (1987): 790–95; "Health Status of Vietnam Veterans. II. Physical Health," ibid. 259 (1988): 2708–14; "Health Status of Vietnam Veterans. III. Reproductive Outcomes and Child Health," ibid. 259 (1988): 2715–19.

## CDC's Measurements of Agent Orange Exposure

After it enters the body by absorption through the skin, inhalation, or ingestion, dioxin, the toxic contaminant in Agent Orange, is deposited in the lipid (or fat) of the human body. It is only very slowly eliminated from lipid so that measuring dioxin concentrations in lipid today can provide information about exposures that happened decades ago. In the mid-1980s, CDC imported sensitive methods and instruments from Sweden that allowed scientists to determine dioxin levels in blood, which is about 4 percent lipid. The availability of the technique made it possible for CDC to do an Agent Orange study, relying on dioxin in blood measurements as an estimate of exposure.

In its Agent Orange exposure study, the CDC identified 600 Vietnam veterans who had been present at times and in areas near where the Air Force's Operation Ranch Hand had sprayed Agent Orange and compared the concentrations of dioxin in the blood lipids (these concentrations are called "body burdens") of those veterans with the concentrations in some 100 other veterans who had never served in Vietnam. The dioxin concentrations in the "exposed" and nonexposed veterans were the same, and the concentrations in both groups fell within the concentrations measured in the general population.[10]

These results were no surprise to experts in pesticide application and dispersal, who had argued all along that the concentrations of Agent Orange reaching the ground where troops might be exposed were insignificant.[11] Some veterans and some mem-

10. The Centers for Disease Control Vietnam Experience Study, "2,3,7,8-tetrachlorodibenzo-p-dioxin Levels in US Army Vietnam-era Veterans," ibid. 260 (1988): 1249–54.

11. See, e.g., Gough, *Dioxin*, pp. 259–62.

bers of Congress dismissed these results, as they had dismissed the results of the Vietnam experience studies, as incompetently done or, worse, as "cover-ups."

## The Ranch Hand Study

In 1982, the U.S. Air Force began a twenty-year-long study of the health of the 1,200 Ranch Hands, the Air Force personnel who sprayed 90 percent of the Agent Orange used in Vietnam, and a Comparison group of Air Force personnel who flew planes similar to those flown by Ranch Hands but did not handle herbicides. (The Ranch Hands flew C-123s; the Comparisons, C-130s.) Measurements of dioxin levels confirm that many of the Ranch Hands were exposed to Agent Orange.

The Ranch Hands and Comparisons have undergone week-long physical and psychological examinations at five-year intervals beginning in 1982, with the last examinations begun in the fall of 2002. The examinations are carried out in civilian hospitals by physicians and technicians who are not told which men are in the Ranch Hand and which are in the Comparison group.

The Air Force scientists who direct the Ranch Hand study concluded, in 1997, that dioxin exposure is associated with increased risk of adult-onset diabetes,[12] which is the only disease that they link to dioxin. In their most recent comment on the possible dioxin-diabetes link, the Air Force scientists state that the evidence for a connection is "weaker" in the data collected in the 1997 exams than in the data from the 1992 exams.[13] I doubt that

12. G. L. Henrikson et al., "Serum Dioxin and Diabetes Mellitus in Veterans of Operation Ranch Hand," *Epidemiology* 8 (1997): 252–58.

13. J. E. Michalek and N. S. Ketchum, April 23, 2002, "Diabetes and Dioxin in Air Force Health Study Participants," typescript, 9 pp., prepared for the Department of Health and Human Services advisory committee to the Ranch Hand study.

anyone besides the Air Force investigators, who are under enormous political pressure "to find something" associated with Agent Orange, an Institute of Medicine (IOM) committee (see below), and some champions of Vietnam veterans' health claims, would interpret the available data to indicate that any connection exists.

## Politics Takes Over

In 1988, congressional leaders, led by then-Representative, now-Senator Tom Daschle, who pushed the Agent Orange–causes-diseases agenda, faced a dilemma. The despised CDC studies had been negative. There was no expectation of designing a study that would differ very much from those studies or produce results that would be different.

Congress could have set aside the scientific findings and based decisions on other factors—compassion, equity, log-rolling, pork-barreling, vote-buying—or it could have sorted among competing findings and conclusions and chosen those that satisfied whatever criteria it wanted. It decided, instead, in Public Law 102-4, "The Agent Orange Act of 1991,"[14] to establish a committee in the prestigious National Academy of Sciences (NAS), to provide advice about health effects of Agent Orange.

As a result of that action, decisions about Agent Orange exist as if the CDC and Air Force studies had never been done. In late 2001, the VA was compensating 9,000 Vietnam veterans for some ten "Agent Orange–related diseases"—the number of veterans receiving compensation and the number of compensable diseases will surely increase—and it is compensating veterans' children born with a serious birth defect.

The politicians who welcome support of their preconceived

14. Bill Summary and Status for the 102d Congress: HR556, Public Law: 102-4 (02/06/91). http://thomas.loc.gov/cgi-bin/bdquery/D?d102:1.

opinions that Agent Orange has been a scourge among veterans, as well as citizens who receive compensation or otherwise benefit from those results, and the far larger number of citizens who see the compensation decisions as the "right thing" to do, laud the IOM committee for its "good science." In their eyes, it has extracted truth from the morass of bad experiments, bad observations, bad studies, and bad interpretations that do not support the politicians' conclusions, veterans' claims, and citizens' desires. In reality, the process has substituted an officially sanctioned, politically constrained objectivity for science at the NAS.

## Congress and the Institute of Medicine

The legislation that emerged as "The Agent Orange Act of 1991" was introduced on January 17, 1991, and passed the House on January 29 by a vote of 412–0. It was sent to the Senate the next day, on January 30, where it was considered and passed by a vote of 99–0 on the same day. The legislation

> Directs the Secretary [of the Department of Veterans Affairs] to enter into an agreement with the National Academy of Sciences (NAS) under which NAS shall review and summarize the scientific evidence (and its strength) concerning the association between exposure to a herbicide agent during service in Vietnam and each disease suspected to be associated with such exposure.[15]

The text of Section 3 of the law repeats the language in the summary, and it goes on:

> For each disease reviewed, the Academy shall determine (to the extent that available scientific data permit meaningful determinations)—(A) whether a statistical association with herbicide exposure exists, taking into account the strength of

15. Ibid.

> the scientific evidence and the appropriateness of the statistical and epidemiological methods used to detect the association"[16]

As we shall see, the difference between "shall review and summarize the scientific evidence," as appears in the summary and the first paragraph of Section 3, and "whether a statistical association . . . exists," which appears in a subordinate paragraph of Section 3, was crucial to the NAS's discharge of its duty.

## The NAS Assigns the "Veterans and Agent Orange" Program to the IOM

The NAS and its sister organizations, the National Academy of Engineering and the Institute of Medicine (IOM), are composed of about 5,000 scientists, engineers, physicians, and other experts elected to membership because of their accomplishments. According to its congressional charter, the NAS is to provide advice to Congress when requested. The usual way by which Congress obtains NAS advice is through legislation that directs an Executive Branch agency to contract with the NAS for advice. Congress directed VA to contract with the NAS, NAS assigned the Agent Orange review to the IOM, and the IOM assembled a 16-member committee whose members

> . . . were selected because they are leading authorities in their scientific fields, are well-respected by their colleagues and peers, have no conflicts of interest with regard to the matters under study, and, indeed, have taken no public positions concerning the potential health effects of herbicides in Vietnam veterans or related aspects of herbicide or dioxin exposures.[17]

16. HR556, Agent Orange Act of 1991. http://thomas.loc.gov/cgi-bin/query/D?c102:1:./temp/c102dK9rK6:e7899:

17. IOM, 1994, p. vii.

Although the committee enjoys the prestige of being called an "IOM committee" (or even a "National Academy committee"), only a single member of the IOM served on the Agent Orange Committee. The other fifteen committee members were selected from universities and medical and public health schools.

## Conflicts of Interest

It surprises me that IOM could find committee members who knew anything about herbicides and health but who had taken no public position on an issue that had raged for over a decade, though their not having taken a public position does not imply that they had no private position. That, however, is not the primary difficulty that arises from eliminating conflicts of interest. The primary difficulty with eliminating people who have conflicts of interest is the elimination of the people who best know the literature and research. A glance at the reference lists at the end of each chapter in the IOM 1994 report reveals hundreds of papers about the toxicology and epidemiology of herbicides. Some of those papers are good, some bad—some criminally bad. People with conflicts of interest know those papers. Without such people on the committee, the committee members are overly dependent on IOM staff or on committee members who have or develop private agendas to read, critique, and summarize the contents of the scientific literature.

There is an alternate method to deal with conflict of interest. During my tenure at the congressional Office of Technology Assessment (OTA), I put together several advisory panels and made no effort to eliminate conflicts of interest. Had I made the effort, I would have failed because I did not recognize some conflicts until a study was well under way. Instead of eliminating conflicts of interest, OTA tried to balance known conflicts of interest. Having people with conflicts of interest had the obvious advantage of

bringing opinions about the scientific literature to the panel discussions, making it impossible for staff to guide the panel's deliberations.

Advisory panel members with conflicts of interest had, what was to me, an unexpected benefit. They set limits to the panel's discussion and consideration: no panel member is likely to venture beyond the speculations and conclusions of those staked-out interests. Moreover, having people with conflicts of interest is not disruptive. People on opposing sides often know each other, and if they don't, they know each other by reputation. They are polite and congenial and accommodating because of their desire to convince the other panel members of the correctness of their positions.

In its review, the IOM emphasized the subordinate clause of Section 3 of Public Law 102-4 that directed it to determine whether a "statistical association" exists between herbicide exposure and health effects. How looking for statistical associations differs from a scientific review isn't entirely clear, but the IOM points out that it did not examine the data for evidence of "causality, as is common in scientific reviews."[18]

## Exposures to Environmental Chemicals and Disease

Cancer has been at center stage from the opening curtain of the Agent Orange controversy. In animal tests, dioxin is a very potent carcinogen, and it's known that dioxin is present in the environment.

For at least thirty years, the combinations of animal test results showing that a chemical causes cancer and reports that the chemical is present in the environment have been behind federal agen-

18. Ibid., p. 7.

cies' and environmental organizations' barrages of reports, allegations, and suggestions that environmental exposures are a major cause of cancer and that we are in the middle of a chemically caused cancer epidemic. The reports, allegations, and suggestions are wrong. In the early 1980s, scientists who studied cancer causation estimated that, at most, environmental exposures are associated with 2 or 3 percent of all cancers.[19] A few years later, EPA scientists and managers produced a document that agreed with that estimate.[20]

There is no cancer epidemic; cancer rates remained essentially constant (except for increases in smoking-associated cancers) from 1933, when national records were first kept, until the early 1990s, when rates began to fall.[21] The decreases that were first seen in the early 1990s have continued and deeper declines are expected.[22] (See Ames and Gold, this volume, for information about causes of cancer.)

Until "chemicals cause cancer" accusations lost their capacity to excite the public, little attention was paid to the possibility that chemicals might cause other health effects, but such possibilities are now at center stage. I will not dwell on the "chemicals cause

19. R. Doll and R. Peto, "The Causes of Cancer: Quantitative Estimates of Avoidable Risks of Cancer in the United States Today," *J. Natl. Cancer Inst.* 66 (1981), 1191–1308. And see OTA (Office of Technology Assessment), 1981, *Assessment of Technologies for Determining Cancer Risks from the Environment* (OTA2DH2D138) (Washington, D.C.: U.S. Government Printing Office), pp. 31–109.

20. M. Gough, "Estimating Cancer Mortality: Epidemiological and Toxicological Methods Produce Similar Assessments," *Environ. Sci. and Tech.* 23 (1989): 925–30.

21. P. A. Wingo et al., "Annual Report to the Nation on the Status of Cancer 1973–1996, with a Special Section on Lung Cancer and Tobacco Smoking," *J. Natl. Cancer Inst.* 91 (1999): 675–90.

22. H. L. Howe et al., "Annual Report to the Nation on the Status of Cancer (1973 Through 1998) Featuring Cancers with Recent Increasing Trends," ibid. 93 (2001): 824–42.

other health effects" accusations, but there is essentially no evidence that environmental exposures cause them.

In the absence of evidence that environmental exposures are associated with cancer or other health effects, it would be reasonable to expect IOM committee members to have been skeptical about claims of such associations. Indeed, skepticism is the hallmark of science. The IOM committee veered far away from science.

## What's Risky in Herbicides?

At very high doses, such as experienced by a few chemical workers and attempted suicides, herbicides can cause symptoms of acute chemical poisoning. Environmental exposures do not cause such effects, and none was reported in the Ranch Hands.

The IOM committee failed to read or heed its own conclusions about health risks from herbicides: "In contrast to TCDD ["dioxin," as used here], there is no convincing evidence in animals of, or mechanistic basis for, carcinogenicity or other health effects of any of the herbicides, although they have not been studied as extensively as TCDD."[23]

Ignoring its own conclusion that "there is no convincing evidence in animals of, or mechanistic basis for, carcinogenicity or other health effects," the IOM committee bounded ahead to review reports of disease rates in men who were classified as exposed to "herbicides." In the vast majority of the reviewed studies there is, however, no verification of exposure.

23. IOM, 1994, p. 3.

## The IOM Committee Decides About Associations of Herbicides with Diseases

The IOM committee reviewed reports about possible associations between herbicide exposures and each of thirty-two diseases and conditions and put the evidence for each association into one of four categories:

- Sufficient Evidence of an Association
- Limited/Suggestive Evidence of an Association
- Inadequate/Insufficient Evidence to Determine Whether an Association Exists
- Limited/Suggestive Evidence of *No* Association (emphasis in original)[24]

Congress had already declared that veterans who suffered from any of four diseases—chloracne, porphyria cutanea tarda, soft-tissue sarcoma, or non-Hodgkin's leukemia—were entitled to compensation. The IOM committee essentially endorsed the congressional decisions when it concluded that there was sufficient evidence for associations between herbicides and those four diseases.

The committee also decided that there was sufficient evidence for an association between herbicides and Hodgkin's disease. This addition was almost inevitable in light of IOM's evaluation of the evidence about soft-tissue sarcoma and non-Hodgkin's leukemia, for which the committee had depended on the epidemiological studies done by a group of Swedish researchers. The same researchers had published similar results from their studies of Hodgkin's disease:

24. Ibid., pp. 6–7.

> When these three cancers (soft-tissue sarcoma, non-Hodgkin's leukemia, and Hodgkin's disease) are considered as a whole, it is noteworthy that the strongest evidence for an association with exposure to phenoxy herbicides is the series of case-control studies conducted by Hardell [Lennart Hardell, a Swedish physician] and colleagues and the cohort studies of herbicide applicators and agricultural workers.[25]

Whatever Hardell and his colleagues investigated, it was not exposure to dioxin-containing herbicides. As detailed in a paper by Hardell and others in 1986, workers who had been classified as exposed to herbicides in Hardell's studies did not have elevated levels of dioxin in their bodies.[26] The IOM committee states, "Studies in other countries are sometimes positive, but not as consistently," as reported by Hardell. Indeed. Some "studies in other countries" are flatly contradictory,[27] and the ones that can be interpreted to support Hardell's findings have no verification of exposures.

The IOM committee decided to disregard the many questions and criticisms about Hardell's studies by many other reviewers. U.S. EPA, in its massive 2000 review of risks from dioxin,[28] does not rely on Hardell's studies, and the International Agency for Research on Cancer (IARC),[29] and the European Commission[30] and World Health Organization (WHO)[31] disregard them.

25. Ibid., pp. 9–10.

26. M. Nygren, C. Rappe, O. Lindstrom, M. Hansson, P.-A. Bergqvist, S. Markland, L. Domellof, L. Hardell, and M. Olsson, "Identification of 2,3,7,8-substituted Polychlorinated Dioxins and Dibenzofurans in Environmental and Human Samples," in C. Rappe, G. Choudhary, and L. H. Keith, eds., *Chlorinated Dioxins and Dibenzofurans in Perspective* (Chelsea, Mich.: Lewis, 1986), pp. 15–34.

27. M. Gough, "Human Health Effects: What the Data Indicate," *Science of the Total Environ.* 104 (1991): 129–58.

28. U.S. EPA 2001.

29. International Agency for Research on Cancer, *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans: Polychlorinated Dibenzo-*

In addition to deciding that there was sufficient evidence for associations between herbicides and five diseases, the IOM committee concluded that there was "limited/suggestive" evidence for associations with respiratory cancer, prostate cancer—the two most common cancers in males—and multiple myeloma. IOM relied upon studies of chemical plant workers to decide that dioxin was associated with respiratory cancer, and in particular upon a study of U.S. chemical plant workers.[32]

The U.S. study included mortality records from twelve chemical plants. In only two of those twelve plants was there any information about smoking, and in those two plants the smoking information was collected in the 1980s. To me, it is simply unimaginable that in a study that ended up focused on respiratory cancers so little information was obtained about smoking, which is associated with some 90 percent of respiratory cancer. In particular, there is no information about the smoking rates in men who died before the 1980s, who are, after all, the source of much of the data in a mortality study.

The IOM committee's conclusions about prostate cancer and

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para-*dioxins and Polychlorinated Dibenzofurans* 69 (Lyon, France: IARC, 1997). Information about this publication can be found at www.iarc.fr/ by clicking on "IARC Press" and following prompts to a listing of the Monographs and scrolling to Monograph no. 69.

30. European Commission, Scientific Committee on Food, "Opinion of the Scientific Committee on Food on the Risk Assessment of Dioxins and Dioxin-Like PCBs in Food," Adopted on May 30, 2001. http://europa.eu.int/comm/food/fs/sc/scf/out90_en.pdf.

31. Food and Agricultural Organization of the United Nations, World Health Organization, Joint FAO-WHO Expert Committee on Food Additives, 57th Meeting, Rome, June 5–14, 2001. Summary and Conclusions. Annex 4: Contaminants. 3. Polychlorinated Dibenzodioxins, Polychlorinated Dibenzofurans, and Coplanar Polychlorinated Biphenyls. http://www.who.int/pcs/jecfa/Summary57-corr.pdf. pp. 24–40.

32. M. Fingerhut et al., "Cancer Mortality in Workers Exposed to 2,3,7,8-Tetrachlorodibenzo-*p*-dioxin," *N. Engl. J. Med.* 324 (1991): 212–18.

multiple myeloma were based on studies of farmers who reported spraying herbicides. There is no information in those studies about body burdens of dioxin, and limited and inconsistent efforts were made to investigate other exposures that might have contributed to cancer rates. Neither the EPA, the European Commission, IARC, nor WHO associates herbicides or dioxin with the occurrence of prostate cancer and multiple myeloma.

Based on the IOM committee's decisions about statistical associations, the Secretary of the VA established mechanisms to pay compensation to veterans for the diseases for which the IOM committee found sufficient or limited/suggestive evidence for associations with herbicides.[33]

## OTA Fails to Raise its Voice

In the 1980s, in compliance with a congressional mandate, OTA was a major player in the Agent Orange controversy. My colleague, Hellen Gelband, and I organized an advisory panel of scientists, veterans, and representatives of chemical manufacturers to review the plans and, subsequently, the results from the CDC's studies of Vietnam veterans. We prepared written reports and testified before congressional committees about OTA's conclusions and recommendations. In general, OTA agreed with CDC's conclusions that there were no significant differences between Vietnam veterans' health and the health of other veterans and that there were no measurable exposures to Agent Orange among ground-troop veterans. Somewhat remarkably, although the IOM 1994 report "was reviewed by an independent panel of

33. Information about that compensation program can be found at http://www.vba.va.gov/bln/21/benefits/Herbicide/index.htm.

distinguished experts,"[34] not a single member of OTA's advisory panel or staff was asked to participate in the review.[35]

In 1985, I left OTA, and during 1986 through 1990, I worked at a consulting firm, Environ, and a middle-of-the-road think tank, Resources for the Future. My book *Dioxin, Agent Orange* was published in 1986, and I continued to do research related to dioxin and became more and more convinced that few if any Vietnam veterans had any exposure to dioxin beyond the level common in all people, and that there was no credible evidence that environmental exposures to dioxin caused health effects.[36]

From 1987 through 1990, I chaired the VA's Advisory Committee on Health-Related Effects of Herbicides, which, despite its name, was largely responsible for addressing veterans' complaints about VA health care. The committee probably had a lot

34. IOM, 1994, p. v.

35. IOM did not publish a list of reviewers. The comment that no OTA staff or panel member participated is based on Hellen Gelband's and my personal contacts.

36. See the following articles by M. Gough: "Dioxin Exposure at Monsanto," *Nature* 318 (1985): 404 (letter); "Environmental Epidemiology: Separating Science from Politics," *Issues in Sci. and Tech.* 3 (1987): 21–30; "From Plant Hormones to Agent Orange," *ChemMatters*, February 1988; "Past War: Future Risk?" *ChemMatters*, April 1988; "The Most Potent Carcinogen?" *Resources* 92 (1988): 2–5; "Science Policy Choices and Estimation of Cancer Risk Associated with TCDD," *Risk Analysis* 8 (1988): 337–42; "The Politics of Agent Orange," in A. Young and G. Reggiani, eds., *Agent Orange and Its Associated Dioxin: Assessment of a Controversy* (New York and Amsterdam: Elsevier, 1988), pp. 181–190; "Agent Orange Studies," *Science* 245 (1989): 1031 (letter); "Human Health Effects: What the Data Indicate," *Science of the Total Environ.* 104 (1991): 129–58; "Agent Orange: Exposure and Policy," *Am. J. Public Health* 81 (1991): 289–90 (editorial); "Human Exposure from Dioxin in Soil—A Meeting Report," *J. Tox. Environ. Health* 32 (1991): 205–45; "Reevaluating the Risks from Dioxin," *J. Regulation Social Costs* 1 (1991): 5–24. Also: M. Gough and D. Turnbull, "Use of a Threshold Model for the Estimation of Risk Associated with Exposure to Chlorinated Dibenzo-p-dioxins and Dibenzofurans," in H. A. Hattemer-Frey and C. C. Travis, eds., *Health Effects of Municipal Waste Incineration* (Boca Raton, Fla.: CRS Press, 1989), pp.20131–46.

to do when it was established in 1979, but by the late 1980s, the VA had improved its medical services. In 1990, I informed the Secretary of the DVA that I was going to resign from the chairmanship. I also explained to him that the committee, so far as I could see, had largely outlived its usefulness. The Secretary decided not to appoint another chairman and to dissolve the committee.

In 1990, I returned to OTA to manage one of its nine programs, and Roger Herdman, who was a deputy director at OTA in 1990, informed me that I would have no responsibility for OTA's continuing involvement with Agent Orange because of my well-known controversial positions.[37] (I was, however, appointed to chair the DHHS committee that advises the Air Force on its study of the health of the Ranch Hands in 1990. I resigned from that committee in 1995, but accepted a reappointment from DHHS Secretary Donna Shalala in 2000, and I continue to serve on it.)

Soon after the 1992 election, John H. Gibbons, who had been its director, left OTA to become the director of the Office of Science and Technology Policy (OSTP) in the White House, and Roger Herdman became the OTA director. When the IOM report was published, Gibbons called Herdman and asked if OTA was going to respond. Gibbons, correctly, saw that the IOM report contradicted everything that OTA had said for a decade. Herdman told me that he'd decided that OTA would say nothing. At the time,

37. As set forth in: M. Gough, "Dioxin: Perceptions, Estimates, and Measures," in K. R. Foster, D. Bernstein, and P. Huber, eds., *Phantom Risk: Scientific Inference and the Law* (Cambridge, Mass.: MIT Press, 1993), pp. 249–278; M. Boroush and M. Gough, "Can Cohort Studies Detect Any Human Cancer Excess That May Result from Exposure to Dioxin? Maybe," *Regul. Toxicol. and Pharmacol.* 20 (1994): 198–210; J. A. Moore, R. A. Kimbrough, and M. Gough, "The Dioxin TCDD: A Selective Study of Science and Policy Interaction," in M. F. Uman, ed., *Keeping Pace with Science and Engineering: Case Studies in Environmental Regulation* (Washington, D.C.: National Academy Press, 1993), pp. 221–42.

OTA was undergoing a Herdman-initiated reorganization that would result in my program and two others being eliminated, and I was more interested in trying to fight that than taking on the IOM. I didn't advise Herdman that OTA should take a stand.

When OTA didn't speak out, no one did. Other organizations no longer had a stake in Agent Orange. CDC was no longer involved in Agent Orange research. Neither were the chemical companies after the settlement (in 1984) of a lawsuit brought by Vietnam veterans against them.[38] Veterans and members of Congress welcomed the IOM conclusions as vindication. Soon, because no one objected to them, they were being touted as good science. And, of course, they weren't science at all, as IOM had said.

## Associations "Keep on Comin' ": IOM Updates, 1996, 1998, and 2000

Public Law 102-4 directs IOM to publish biannual updates, which are to include new information about conclusions already reached, as well as information that supports additional associations between herbicides and diseases. IOM has formed somewhat different committees for each update, adhering to its criterion that committee members have taken no public position on the issue of herbicides and human health. This must be an increasingly difficult task.

### Update 1996—Spina Bifida in Veterans' Children

If scientists considered the IOM reports to be of scientific value, the 1996 update would be among the most frequently cited doc-

38. Gough, *Dioxin*, pp. 83–87. The most complete coverage is in P. Schuck, *Agent Orange on Trial* (Cambridge, Mass.: Harvard University Press, 1986).

uments in the biomedical literature.[39] Scientists don't, and the report, according to the NAS Web site (11/27/01), is no longer sold.

The IOM update committee concluded that there is limited/suggestive evidence that a man's exposure to an herbicide is associated with an increased risk of spina bifida in his children. This conclusion flies in the face of IOM's acknowledgment that there is no known mechanism by which a father's exposures can cause birth defects.[40]

Neither dioxin nor 2,4-D nor 2,4,5-T is a mutagen; therefore none of those agents can cause a mutation in the DNA that can be transferred in sperm from a father to a child. Dioxin, which remains in a person's body years after exposure, could possibly be transferred from a man to a woman via his sperm, but sperm are so tiny that the few molecules of dioxin in a sperm would have little effect on the number already in the far-larger egg. Moreover, doses of Agent Orange large enough to cause toxic effects in male mice did not cause birth defects in mice fathered by the treated animals.[41]

In reaching its conclusion about spina bifida, the IOM committee relied primarily on the results from the Ranch Hands. There was no difference in the frequency of all birth defects in the children of Ranch Hands and Comparisons.[42] There were, however, four neural tube defects—three cases of spina bifida and one

39. Institute of Medicine, *Veterans and Agent Orange: Update 1996* (Washington, D.C.: National Academy Press, 1997).

40. IOM, 1994, pp. 593–95.

41. J. C. Lamb, J. A. Moore, and T. A. Marks, "Evaluation of 2,4-dichlorophenoxyacetic Acid (2,4-D) and 2,4,5-trichlorophenoxyacetic Acid (2,4,5-T) and 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) Toxicity in C57BL-6 Mice," Publication NTP-80-44 (Research Triangle Park, N.C.: National Toxicology Program, 1980).

42. W. H. Wolfe et al., "Paternal Serum Dioxin and Reproductive Outcomes Among Veterans of Operation Ranch Hand," *Epidemiology* 6 (1995): 17–22.

case of anencephaly—among the children born to Ranch Hands, and none in the children born to the Comparisons.

Chance almost certainly explains the difference in the occurrence of the neural tube defects, as it explains many other results in epidemiology. For instance, many early studies of possible effects from exposures to herbicides reported increases in cleft lip and cleft palate (none of which was considered significant)[43] among children born to exposed parents. In contrast, there were five cases of cleft lip and cleft palate among the children born to the Comparisons and none in the children born to Ranch Hands. No one would argue that Agent Orange prevents cleft lip and palate based on this observation.

Chance is a far more likely explanation for the occurrence of four cases of neural tube defects among the Ranch Hand children as compared to zero cases among the Comparison children, just as it is the most likely explanation for the occurrence of five cleft lip/cleft palate cases among the Comparison children and their absence from Ranch Hand children. The alternative explanation that herbicides cause spina bifida and prevent cleft lip/cleft palate is not at all credible.

The authors of the Ranch Hand Study, the Department of Health and Human Services committee that reviewed the study before publication,[44] the reviewers and editors of the journal *Epidemiology* that published the study, and a scientist who wrote a comment about the Ranch Hand study for *Epidemiology* found no support for an association between herbicide exposure and any birth defect. Only the IOM committee identified the biologically implausible association.

On September 19, 1996, in testimony before the Senate Committee on Veterans' Affairs, I disagreed with the IOM committee's

43. See Gough, *Dioxin*, pp. 117–20 for references.
44. I chaired that committee at that time.

interpretation of the data: "Congress asked IOM for a scientific evaluation. The IOM committee did not behave as scientists; it attached too much importance to a single finding, ignored conflicting evidence, and produced an incorrect evaluation. I believe that it is wrong and unfair to base policy on flawed science."[45]

Visibly angry, Senator Jay Rockefeller of West Virginia, a strong advocate of veterans' claims about harms from Agent Orange, questioned my scientific qualifications, my motives, and my conclusions. He invited the chairman of the IOM committee back to the witness table to respond to my comments. The chairman declined, saying he didn't want to enter into a debate. Senator Rockefeller then directed IOM to present me with a written criticism of my remarks. More than six years have passed. I've seen nothing from the IOM.

The 1996 IOM committee made findings about other two diseases. The committee downgraded IOM's evaluation of the evidence for associations between herbicide exposures and the rare metabolic disease, porphyria cutanea tarda, from sufficient to limited/suggestive. Significantly, this decision indicates that the update committees can revise earlier classifications, but it makes no difference to VA compensation decisions.

The 1996 report also added acute and subacute transient peripheral neuropathy to the list of diseases for which there is limited/suggestive evidence of an association with herbicide exposures. The committee relied upon case reports—physicians' accounts of one or a few cases of neurological problems such as tingling in hands or feet—to support its conclusions. The committee makes it clear that the case reports lacked information about such critical measures as the patients' neurological status before exposure and about other possible exposures, but decided

45. M. Gough, "Testimony before Committee on Veterans' Affairs," U.S. Senate, September 19, 1996.

such deficits were not enough to set aside its finding of limited/suggestive evidence for associations. This IOM decision will not affect VA compensation policies because any transient neuropathies would have occurred long ago and would not leave a veteran disabled.

## The 1998 IOM Update—No Changes

The IOM committee in 1998 made no changes to the conclusions published in the earlier volumes.[46]

## The 2000 IOM Updates

IOM produced two volumes about Agent Orange in 2000. One is a special report about herbicides and diabetes. The other is an update that added a childhood cancer to the list of diseases caused by parental exposures to herbicides.

### *Diabetes*

Like the 1996 decision about spina bifida, the IOM committee's conclusion that there is limited/suggestive evidence for an association between herbicide exposure and adult onset diabetes[47] draws upon the results from the Ranch Hand study.[48] Although the frequency of diabetes among the Ranch Hands and the Comparisons is essentially equal, in 1992, the Air Force showed a video tape to participants in the Ranch Hand health study that stated

46. Institute of Medicine, *Veterans and Agent Orange: Update 1998* (Washington, D.C.: National Academy Press, 1999).

47. Institute of Medicine, *Veterans and Agent Orange: Herbicide/Dioxin Exposure and Type 2 Diabetes* (Washington, D.C.: National Academy Press, 2000).

48. G. L. Henrikson et al., "Serum Dioxin and Diabetes Mellitus in Veterans of Operation Ranch Hand," *Epidemiology* 8 (1997): 252–58.

that an association was present between Agent Orange and diabetes.[49]

The maximum body burden of dioxin in the Comparisons is 55 ppt (parts per trillion of dioxin in fat taken from a blood sample), about ten times less than the maximum of 618 ppt in the Ranch Hands, but the incidence of diabetes is the same in both populations. The IOM 2000 committee's report about diabetes is masterful. It emphasizes every factoid that can be interpreted to support its conclusion about a limited/suggestive association and brushes aside all the contradictory information. Based on the committee's finding of a limited/suggestive association, the DVA is paying compensation to Vietnam veterans who have diabetes.

### *Childhood Leukemia*

Making reference to a study of U.S. veterans who reported that they had served in Vietnam and to a study of Australian veterans of the Vietnam war, the IOM committee concluded that fathers' exposures could increase the occurrence of acute myelogenous leukemia in their children.[50] The IOM committee conceded that there is no information about exposure to herbicides in either study, and it ignored the data from the Ranch Hand study, which showed no excess of leukemias during the first eighteen years of the lives of Ranch Hand children.

The conclusion about acute myelogenous leukemia has the same biological implausibility as the conclusion about spina bifida. Because dioxin is not a mutagen, it is very difficult to imagine how a father's exposure to it could affect his child.

To its credit, the IOM, in 2002, reversed its decision that linked

49. I saw this videotape at the Scripps Clinic, La Jolla, California, when the 1992 medical examination was being administered.

50. Institute of Medicine, *Veterans and Agent Orange: Update 2000* (Washington, D.C.: National Academy Press, 2000).

veterans' exposures to Agent Orange with leukemia in their children because of the discovery of a computational error in one of the studies of veterans' children.[51] The IOM reversal is a welcome change because it eliminates a linkage that was drawn with no information about exposures and no hypothesis about cause and effect.

## Summary of IOM Findings

The IOM committees have not provided scientific advice to Congress. Rather than looking at the data as scientists typically do to look for evidence of causality, it has picked and chosen data. A decision that limited/suggestive data for an association exists when "at least one high-quality study shows a positive association, but the results of other studies are inconsistent."[52] As I stated in my testimony before the Senate Veterans' Affairs Committee,

> . . . focus on results from "one high-quality study" flies in the face of objective science that requires that all data be considered and weighed together. In fact, it literally throws out any consideration of data that do not support an association because it lets the analysts focus on a single, isolated finding as the proof of their case. Associations can arise by chance . . . [or for reasons not considered in a study], and this criterion [one high-quality study] places undue weight on them. This criterion is bad science. Congress did not, as is sometimes suggested, force it on IOM. IOM set its own criteria.

Congress asked IOM for scientific advice. It also asked for a discussion of judgments about statistical associations, but it did not preclude the IOM from behaving as scientists.

51. IOM, "Revised Analysis Leads to Different Conclusion About Agent Orange Exposure and Childhood Leukemia," press release, February 27, 2002. News@nas.edu.

52. IOM, 1994, p. 7.

## Agent Orange and Dioxin Decisions: Political or Scientific?

The most damning indictment of the IOM committee's deliberations and conclusions came early in March 2002, at a meeting about Agent Orange in Hanoi. At that meeting, contrasts were drawn between the compensation that is being paid to American veterans and the absence of compensation for Vietnam citizens. Christopher Portier, director of the Environmental Toxicology Program at the National Institute of Environmental Health Sciences, dismissed U.S. decisions to compensate U.S. veterans for "Agent Orange–related diseases" as "political."[53]

Remarkably, Portier has provided some of the risk assessments for EPA's efforts to label dioxin as a human cancer risk and to calculate risks from environmental exposures to dioxin. I don't know why he dismisses the IOM committee's very similar opinions about the health effects of Agent Orange as "political," but I agree with him.

## What IOM Should Do

The IOM committees are much clearer about what they don't do than about what they do do. The 2000 *Update* says: "Consistent with the mandate of P.L. 102-4, the distinctions between categories are based on 'statistical association,' not on causality, as is common in scientific reviews. Thus, standard criteria used in epidemiology for assessing causality [reference omitted] do not strictly apply."[54] It leaves unsaid what criteria do apply.

53. "U.S. Scientists Question Vietnam Dioxin Studies," Reuters, March 4, 2002. I subsequently called Dr. Portier and asked him if he had made the "political" remark. He confirmed that he had. Personal communication, telephone call, April 30, 2002.

54. IOM, *Update 2000*, p. 6.

IOM committees are to revisit all the IOM's earlier decisions in each of their updates. If Congress or NAS and IOM management are serious about the IOM committees' doing a scientific review of the literature about health risks from herbicides, it can insist on the committees' addressing the following issues.

## Exposure

IOM should state why it does not rely on body burden measurements, which is the norm in dioxin research.[55] Short of that, IOM committees should clearly state—when referring to "exposed populations"—which exposures have been verified by body burden measurements and which have not. The reader would then be able to decide which studies discussed by the IOM committees have any validity.

## What Is the Subject of the IOM Reviews?

Given the IOM's acknowledgment that there is no information that any of the herbicides used in Vietnam is a risk to human health, what is IOM examining? If the only possible culprit is dioxin, that should be stated, and IOM committees should stop talking about associations with herbicides and talk about associations with dioxin. If there is a reason—from animal studies, mechanistic (biochemical and molecular biology) studies, or epidemiology studies with careful control of other risk factors—that an herbicide should be considered risky, IOM would provide a great service by identifying it.

55. IOM has issued a number of contracts to develop methods to estimate exposures to Agent Orange in Vietnam. I consider all those contracts to be a waste of time and money. Enough is known about the body burdens of dioxin in veterans to conclude that few—if any—ground troops were exposed.

## Cancer

IOM should re-examine its decision that there is sufficient evidence for associations between herbicides and soft-tissue sarcoma, non-Hodgkin's leukemia, and Hodgkin's disease, beginning with an examination of Hardell's exposure classification scheme. Hardell's own analysis showed that workers he had classified as exposed had the same low body burdens as found in people who were classified as unexposed. The IOM should ask experts on cancer mechanisms and cancer cause and prevention to review the Hardell and other studies about herbicides and those tumors.

IOM's conclusion about a link between herbicides and respiratory cancer depends on studies of highly exposed workers in which exposures have been verified by body burden measurements. Thomas Starr analyzed the relationships between dioxin exposures and cancer rates in those workers.[56] Although exposures varied over a 1,500-fold range, cancer rates did not increase at higher dioxin exposures, providing no support for an association.

The IOM committees should discuss all that is known about cancer rates in human populations highly exposed to dioxin and the capacity of epidemiologic studies to detect dioxin-associated cancers if they do occur. I am convinced that this task, if done with scientific objectivity, would weaken any interpretations that dioxin causes human cancers.

## Spina Bifida

In my testimony before the Senate Veterans' Affairs Committee, I assumed that the IOM conclusion was correct, that the spina bifida

56. Starr, "Significant Shortcomings."

cases seen in the Ranch Hand children had been caused by dioxin, and that there is a relationship between dioxin exposure levels and the occurrence of spina bifida. Based on those assumptions, I calculated the number of spina bifida cases to be expected in a population of about 37,000 people in and around Seveso, Italy, who were exposed to dioxin from a 1976 chemical plant accident, and who have the highest-ever measured dioxin levels. Twelve years later, an analysis was published of 15,000 births in the Seveso area after the accident.[57] I calculated that between seven and nineteen spina bifida cases would have been expected in the 15,000 Seveso births. There was none, indicating that there is no connection between maternal or paternal exposures to dioxin and spina bifida.

### Diabetes

It is clear that there is no causative association between dioxin and diabetes because very different levels of exposures to dioxin in the Comparisons and the Ranch Hands are associated with similar frequencies of diabetes. How are those data to be interpreted?

## It's Not Science: What Is It?

Rather than bypass its obligation to provide the Congress with scientific advice, the IOM should seize opportunities to revisit decisions of its committees that have evaluated the evidence that Agent Orange harmed U.S. troops. The 2002 update cannot be a vehicle for a scientific evaluation; it is already complete (or nearly so). The 2004 update, which, unless Congress enacts new legislation, will be the final update, could be the vehicle for scientific

57. P. Mastroiacovo et al., "Birth Defects in the Seveso Area After TCDD Contamination," *JAMA* 259 (1988): 1668–1972.

review. Whether revisiting the decisions does or does not cause revisions, applying scientific criteria to its decisions would refurbish IOM's reputation as a scientific organization.

## The Lesson To Be Drawn from Agent Orange and, Maybe, a Different Lesson To Be Drawn from Dioxin

The absence of dissent from the IOM report provides an important lesson about the power of government. When government, either Congress and its agent, the IOM, in the case of Agent Orange, or the Executive Branch, through EPA, in the case of dioxin, decides that a risk exists, it can exert and maintain continued effort to convince the public to agree with it. Year after year, the government hires additional people to work on the risk. Year after year, those people produce more and more documents. With the passage of time, organizations that might oppose the government drop out because of expense or because they move on to other things. Few people remain to dissent, to say the risk is exaggerated or, even, nonexistent.

That's the way the world is. The amazing part is that anyone tries to thwart the government's risk assessments.

### Agent Orange

In the case of both Agent Orange and dioxin, the organizations that faced financial losses have gone on to other things. Agent Orange, except for probably adding more diseases to the list of diseases eligible for compensation, and certainly extending the lists of compensated veterans, is settled.

### Dioxin

For about two decades, EPA has produced assessments of the risks from dioxin that claim the chemical is a cause of human cancers

and other diseases and that current background exposures may be causing those effects. The EPA's Science Advisory Board (SAB) rejected key parts of EPA's 2000 dioxin reassessment.[58]

Importantly, the SAB includes members who have taken public positions on the risk or non-risk from dioxin; the SAB allows conflicts of interest. In my opinion, that's why the EPA's claims —as compared with the IOM's statements about associations between Agent Orange and diseases—have been rejected. Experts, on both sides, and experts with conflicts of interest, on both sides, produce a far more objective review of the scientific information than experts who are chosen for having no opinions.

Until recently, I thought that EPA would brush away the criticisms, say that it has the SAB's approval of all but a few details, and continue saying that dioxin in the environment causes human health effects. Now, I'm not so sure. Christopher Portier's characterization of the IOM conclusions as "political" will surely damage EPA's case because EPA depends on the same data considered by the IOM and interprets it similarly. Moreover, a new dissenting voice has arisen. The Agency for Toxic Substances and Disease Registry (ATSDR) in the Department of Health and Human Services pointedly disagrees with EPA's methods for estimating risks of cancer and other health effects from dioxin and rejects the EPA's suggestion that current exposures to dioxin may be causing adverse health effects.[59] I do not know what will result from ATSDR's disagreeing with EPA, but it may mark a crack in EPA's setting the government's dioxin agenda.

58. Science Advisory Board, Environmental Protection Agency, *Dioxin Reassessment—An SAB Review of the Office of Research and Development's Reassessment of Dioxin* (Washington, D.C.: USEPA, 2001). (EPA-SAB-EC-01-006 May 2001). Available at www.epa.gov/sab.

59. H. R. Pohl et al., "Public Health Perspectives on Dioxin Risks: Two Decades of Evaluations," *Human and Ecological Risk Assessment* 8 (2002): 233–50.