rupted or breached storage tanks, and the like.

To contaminate an area of 100 square miles (that is to say, an area no larger than that covered by a circle of 6 miles' radius) with a million curies of strontium-90 would require only a mechanism that could disperse 8 kilograms of freshly separated strontium-90. A chemical explosion in a liquid storage tank could disperse many droplets of material that could quickly become dust as, warmed by the radioactivity, they evaporated. An explosion involving chemicals that could boil through self-generated heating could therefore be a very effective means of generating an aerosol of highly activated fission products.

If a fire were to accompany or follow such an occurrence, the rising hot air could carry fine particles of these materials to appreciable altitudes. Although many particles might be large enough to fall out at short distances from the fire zone, fine particles such as those in the 1-to-10-micron range could stay in the air for days. It would not require severe winds to carry these particles tens of kilometers from the area of the disaster. In addition, such a facility would almost certainly be situated on a large river or other body of water. The contamination of the surface waters near the facility might even result in the spread of contaminants to bodies of water outside the range of airborne contaminants through connected lakes and streams. As wind, rain, or melting snow leached surface contamination from the soil, additional contamination of the surface water could then be expected periodically. Medvedev discusses scientific studies of water-carried radioisotopes that suggest just such periodic and uncontrolled additions of contaminants to lakes and streams.

Such an accident would require only physical mechanisms that have already been seen on an industrial scale. One can easily conjure up horrifying images of people attempting to fight fires or reach victims while extraordinarily radiotoxic materials settled around them. The circumstance, however, would more likely be the result of negligent handling of dangerous materials than of some exotic feature of nuclear waste.

There are a number of criticisms that should be noted. The book was written in Russian and translated into English, and it contains a number of glaring errors that the author clearly did not make. There are many typographical errors, some of which will be confusing to the layperson. The book comes with a jacket that makes some mystifying references to Three Mile Island, which is likely to make many technically sophisticated readers hostile and to mislead many less sophisticated readers. Unfortunately, the publisher's sloppy and inappropriate handling of such details gives the book a less credible appearance than it might have had and could be quite embarrassing to the author.

Medvedev's book is a substantial contribution toward informing the technical and lay public about the incident in Chelyabinsk. It would be interesting to see what an exhaustive and critical examination of "laundered" Soviet scientific publications on nuclear safety and engineering might reveal. Medvedev's story is far from complete and unambiguous, but it is honest and well referenced and provides a starting point for those who wish to dig further.

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The Dioxin Issue

The Pendulum and the Toxic Cloud. The Course of Dioxin Contamination. THOMAS WHITESIDE. Yale University Press, New Haven, Conn., 1979. x, 206 pp. Cloth, $15; paper, $4.95.

This book deals with the environmental and human exposure problems of one of the most toxic and teratogenic substances known—2,3,7,8-tetrachlorodibenzo-*p*-dioxin, or simply TCDD or dioxin. This material is a by-product in the manufacture of 2,4,5-trichlorophenol and consequently ends up in the herbicides 2,4,5-T and silvex and in the antiseptic hexachlorophene. The continued use of these products has been the subject of a great deal of scientific and public interest stemming from the defoliation operations in Vietnam, continuing through the tragic explosion in 1976 of a trichlorophenol plant outside Seveso, Italy (the main subject of the book), and culminating earlier this year in the emergency ban of 2,4,5-T by the Environmental Protection Agency (EPA). The basis for the ban is the alleged high spontaneous abortion rate in parts of Oregon subjected to frequent sprayings of 2,4,5-T for forest management.

In the first part of the book, Whiteside discusses the events that led to the confrontation between Dow Chemical, the major producer of 2,4,5-T, and the EPA. The author leaves no doubt about his position in this controversy. As he puts it in the conclusion, the issue of TCDD "symbolizes the encroachments of heedless technology upon the fundamental liberties of the individual, and, above all, touches upon our guardianship of the physical integrity of those yet unborn" (referring to the teratogenic nature of 2,3,7,8-TCDD).

These are strong words, and Whiteside has devoted his book to building an argument in support of them. Using the Seveso accident as the principal vehicle, his approach is to couple a discussion of the social, political, and scientific aspects of the accident with a summary of selected scientific and anecdotal evidence on the dangers of TCDD.

The account of the Seveso accident and its aftermath is a story of error, apathy, and neglect on the part of the manufacturer and the Italian government. Five thousand people were initially exposed to the "toxic cloud," and yet no mention was ever made that the fallout contained TCDD until the manufacturer was specifically asked by an Italian health authority nine days after the accident. Fourteen days passed before a physician representing Hoffman-La-Roche, the parent company that owned the plant, stated that contamination was serious enough to warrant evacuation. Finally, 16 days after the explosion, the first of the evacuees left.

On the evidence of Whiteside's account, the blame for Seveso must be shared by many. The manufacturer was guilty of poor practices; no holding tank was provided to capture the debris of an explosion and none of the plant workers knew about TCDD, its dangers, or even its presence in the reactor. The government attitude led to frustration and cynicism among the residents. Seven months were required to fence in the contaminated area. Schools were declared safe and then discovered to be contaminated. The cleanup of the area was done casually and included incidents leading to the additional spread of toxic wastes by spilling from trucks, dumping into sewers, or incinerating contaminated animal carcasses at low temperature, which only revolatilized the TCDD. Some cleanup workers assigned to wear protective suits were seen playing soccer in T-shirts and shorts in areas of high contamination. Accompanying all this were acts of terrorism, payoffs, and political maneuvering. The situation was well summarized by a local pharmacist who stated "everything finishes in politics. This tragedy has turned into a farce. A farce of cash considerations."

The Seveso disaster, according to Whiteside, underlines the hazards of the use of 2,4,5-T in the United States. Is there a scientific message for the United

States from the massive human exposure to TCDD in Seveso?

To answer that question, Whiteside returned to Italy in 1978, two years after the explosion. He found that attempts to conduct epidemiological studies had broken down. Clinicians at the local hospital, however, told him that there appeared to be no clear-cut effects on the health of the population—only a light scattering of short-term effects, no conclusive teratogenic effects, no hard data on increased spontaneous abortions, and no deaths. There is a higher incidence of infectious disease and a drop in the birth rate, but it is not clear that these effects can be ascribed to TCDD. The situation is confusing scientifically, but not for Whiteside. He goes on to summarize other scientific evidence in support of his position. Unfortunately, some of his choices are not discerning. For example, he cites a quoted Swedish study of hospital workers exposed to TCDD from hexachlorophene that has been discredited. The reports he cites of accumulation of TCDD in beef fat and human milk in the United States are extremely doubtful. Whiteside mentions a study that found 60 parts of TCDD per trillion in beef fat but fails to state that this was the only definite positive for 85 samples in the study. Furthermore, little confidence can be placed in the mothers' milk analyses he cites, which showed less than ten parts of TCDD per trillion. Only an extensive study involving adequate controls, blind samples, and replicate analyses will suffice at these low levels.

Whiteside argues that the potential harm to veterans from the use of 2,4,5-T in defoliation operations in Vietnam is additional evidence against its continued use. However, the use of Agent Orange in Vietnam is not analogous to the use of 2,4,5-T in the United States because the former contained about two orders of magnitude more TCDD and was used at a higher dosage and frequency and without regard to human exposure.

The account of the Seveso accident is presented well and shows clearly its human tragedy. The account could have been improved by the inclusion of photos and maps of the area. Rightly, Whiteside issues a warning to avoid the errors of Seveso and stresses the precedent-setting nature of 2,4,5-T with regard to regulatory control of toxic chemicals. However, to resolve the 2,4,5-T issues, a more scientific inquiry must be made into the effects of human exposure to TCDD. As a scientific review, the book has serious failings that may go unnoticed by the casual reader influenced by journalistic stratagems. Even the title cleverly contraposes chemical companies, represented by "the pendulum" (from a statement by Dow advocating a swing from "environmental extremism"), and the public, represented by the unsuspecting residents of Seveso exposed to "the toxic cloud."

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A Hemoprotein

Cytochrome P-450. RYO SATO and TSUNEO OMURA, Eds. Kodansha, Tokyo, and Academic Press, New York, 1978. xii, 234 pp., illus. $22.50.

Tsuneo Omura begins the introductory chapter of this book by stating that "cytochrome P-450 made a quiet debut . . . in 1955 when G. R. Williams first noticed a pigment with a peculiar carbon monoxide binding spectrum in rat liver microsomes." The quietness continued through 1962, when Omura and Sato showed that the pigment constituted one of two major heme proteins in rat liver tissue. In 1963 R. W. Estabrook, D. Y. Cooper, and O. Rosenthal reported that P-450 catalyzed hydroxylation of steroids and a variety of drugs in mammals. The report generated a burst of research activity that continues unabated. P-450 oxygenase systems were discovered in many mammalian tissues and shown to play a role in such diverse processes as drug detoxification, insecticide metabolism, carcinogen deactivation or activation, and steroid hormone biosynthesis and regulation. The liver microsomal P-450 system was found to rival the antibody system in versatility, catalyzing over a dozen types of reaction on hundreds of substrates with only a few different forms of the enzyme. This heavily funded research attracted scientists from many disciplines. Competition was fierce, and the contribution to the scientific literature was enormous. Even review articles tended to contain large quantities of new data. There was no time to look back. The researchers moved forward without leaving any unified summary of their progress for the benefit of students and scientists in other fields. Omura and Sato's book was written to begin to fill this gap.

The book comes at an excellent time in the development of knowledge of P-450 and its reactions. The range of reactions has been adequately described, the protein components have been purified, and the molecular and kinetic parameters of the proteins have largely been settled. Researchers are turning their attention toward such matters as the mechanisms of induction and catalysis of P-450. The involvement of Omura and Sato in P-450 research from its inception has enabled them to bring both historical perspective and considerable scientific expertise to this volume. They appear to have given credit where credit is due in numerous cases where the literature is deceptive concerning chronology. Perhaps the most ironic example of this deceptiveness is that Williams, cited above as the discoverer of P-450, never published his observation.

The task of making a coherent story out of the large P-450 literature in a reasonable length of time was handled by marshaling ten other prominent Japanese scientists to write sections of the book. Repetition, unevenness, and contradiction have essentially been avoided. The result is a readable recounting of the P-450 story, one that certainly will serve as the introduction the authors intended. Moreover, I think the book will be of value to researchers in the field because the attempt is repeatedly made to present and assess diverse sets of data in a uniform framework. One gains a sense of perspective from the book that is difficult to obtain from narrower reviews.

The book begins with a brief history of cytochrome P-450. Succeeding chapters treat physiological functions, molecular properties, oxygenase systems containing P-450, and mechanisms of catalysis. Detail is light except in the discussion of such procedures as resolution of P-450 from membranes and purification of P-450, where details help one recognize the substantial problems that have been surmounted. In each chapter the mammalian P-450 systems are contrasted with the more easily purified but remarkably similar systems from bacteria and other organisms. The least complete chapter is that on mechanisms of catalysis of P-450. The very important discoveries of the last five years concerning the activated form of oxygen are only briefly discussed, for instance. It can be argued, however, that the interpretation of these discoveries is still emerging and that discussion of them is best deferred.

The functions and physical characteristics of P-450 systems lend themselves to a multidisciplinary approach to a greater extent than most research problems. Thus, it is unfortunate that the