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says, NCI-sponsored regional cancer treatment centers were established in several of the areas surveyed. "It is impossible to determine the impact of migration toward these centers on the overall rates, but it might account for part of the reported increase." Lilienfeld also supports Rothman's criticisms and Peto's preference for mortality statistics.

Finally, the chemical industry claims that the proportion of cancers resulting from smoking has been underestimated, and points to recent studies that indicate nonsmokers might be harmed through exposure to neighboring smokers (*Science*, 2 May, p. 464). Schneiderman says his allowance for effects of smoking is liberal enough to account for this.

Harris, who has been calling attention to the Pollack, Horm, and Schneiderman data, admits that the meaning of all this is unclear. "The data are a long way away from being definitive or permitting conclusions," he acknowledges. He predicts that more reliable results will be available in 5 to 10 years, when NCI has tabulated the survey results through at least 1980. This will permit a look at data from identical geographical regions over a longer period of time. But the others say it will take even longer because the cancer rates often vary widely in a short period.

Peter Greenwald, an epidemiologist who oversees the New York State tumor registry, says that "with a slight trend—on the order of 2 percent a year—there will always be questions." Strong connections between the increase and past exposure to chemicals will be exceptionally difficult to draw. "To say that the incidence of cancer for all sites is increasing is to lump multiple diseases together for the purpose of making a sweeping generalization," Greenwald says. "I tend to look at cancer rates at each site, and then look for specific causes." It would probably take a large jump in the rate even at a specific site to be able to identify a cause. Endometrial cancer rose almost 70 percent during the 1960's, shortly after a 400 percent increase in the use of menopausal-type estrogens, he notes. Similarly, lung cancer among women has risen considerably after a big jump in smoking. No connection this clear seems on the horizon for chemicals and cancer at all sites.

If the statistics cannot relate cause and effect, they can certainly add to the rhetoric. Harris says a confirmed increase in the rate of cancer will have the effect of swinging the pendulum of public opinion back from its present position of anti-regulation toward more regulation. "If it looks like low-level exposure to chemicals is really taking a toll, the present regulatory pace is likely to change."

If the prediction is accurate, the stakes in this statistical contest are immense for both sides. Schneiderman perhaps overstates the stakes on the environmental side. "If the workplace contributes only trivially to the cancer burden or cancer itself is not really increasing as a problem," he told the occupational health conference, "then much of your work and some of mine is misplaced and we are wasting our time."

—R. JEFFREY SMITH

Continuing Confusion over Love Canal

EPA is still faced with reconciling the needs of courts with those of science

The task of bringing science to bear in solving the problems of Love Canal is still far from complete, and what has been accomplished to date is hardly an object lesson in how to apply science to public policy.

The controversy surrounding the chromosome aberration study commissioned by the Environmental Protection Agency (EPA) refuses to subside. With more studies of the health of Love Canal residents being planned, there is vigorous debate about what, if anything, such surveys can accomplish. Already apparent is a fundamental difference in approach between lawyers and scientists. The lawyers want quick results that can serve as evidence for law suits; researchers contend that environmental issues as complex as that of Love Canal defy almost any attempts to develop immediately useful data.

EPA's first attempt to bring science to bear on the Love Canal problem began last fall. Convinced that hundreds of families should be moved away from Love Canal, EPA attorneys asked the Department of Justice to seek a court order requiring Hooker Chemical Corporation to pay for the relocation of the families. It was Hooker that buried tons of toxic wastes in the abandoned canal in the 1940's and early 1950's. The Justice Department advised EPA to provide some evidence to the effect that continued residence in the Love Canal neighborhood was hazardous to health.

EPA officials decided that a search for chromosomal aberrations would fit the bill and, in January of this year, Dante Picciano of the Biogenics Corporation in Houston was commissioned to conduct a "pilot" study as quickly as possible.

Picciano, as it happened, was able to provide the evidence that EPA was looking for. The summary of his report, dated 14 May 1980, stated: "It appears that the chemical exposure at Love Canal may be responsible for much of the apparent increase in the observed cytogenetic aberrations and that the residents are at an increased risk of neoplastic disease, of having spontaneous abortions, and of having children with birth defects."

Before Picciano's findings could be submitted to any measure of peer review, they came to public attention, stirring new fears among the already distraught people of Love Canal and prompting renewed demands from them that they be relocated.

For more than a year, reports of excessive illness among Love Canal residents had been accumulating. Justice Department attorney Anthony Roisman calls the Picciano study the final straw that forced the policy-makers to a decision. Presidential aide Jack Watson took a personal interest in the situation, as did other high-ranking Executive Branch personnel. Steps were taken to provide funds for relocation of some 700 Love Canal families and, according to a number of scientists, the policy-makers began exerting considerable pressure for additional (and speedy) studies of the health of Love Canal residents.

Yet the Picciano study, despite its

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considerable catalytic effect on the politicians, came almost immediately under severe criticism from scientists, and in particular from two review panels convened by the EPA. One panel was chaired by David Rall of the National Institute for Environmental Health Sciences, and the other, by Roy Albert of New York University Medical Center.

Both review panels criticized the Picciano study for its lack of controls (see *Science*, 13 June 1980), and the EPA has now accepted the verdict of the Albert panel that the lack of controls makes it impossible to draw any conclusions from the study. Certain technical criticisms made by the Albert panel, however, have been disputed by other scientists, such as Marvin Legator of the University of Texas, Galveston, and Margery Shaw of the University of Texas Health Science Center. Shaw believes that anomalies dismissed as artifacts by the Albert panel were real aberrations as claimed by Picciano. Picciano also has defended his study and explained why it was conducted without controls (see Letters, *Science*, 15 August 1980).

Quite apart from the controversy that has entrammeled the Picciano study, the EPA's original choice of a chromosomal aberration survey may not have been particularly well advised. As a tool for demonstrating health effects, chromosome studies are notoriously difficult to interpret. No more than a handful of specific diseases has been shown to be associated directly with a known chromosomal aberration. And past experience makes cytogeneticists extremely wary about drawing hard and fast conclusions. Thalidomide, for instance, does not produce chromosomal aberrations, whereas aspirin, which does, is not known to cause birth defects in humans although it does in lower animals. The fact that the Love Canal residents have been exposed to unknown amounts of chemicals adds to the difficulty of interpreting a chromosome study. Some cytogeneticists doubt if anything of value can be learned from such a study in the short term.

Nevertheless, if the people of Love Canal are willing—and it is not certain that they are—another, "more definitive" and controlled chromosome study will soon be started under the auspices of the Center for Disease Control (CDC) in Atlanta. It is likely that Michael Bender of Brookhaven, in collaboration with a group at the Oak Ridge National Laboratory in Tennessee, will conduct the study.

What will it prove? Bender, who says he is willing but "reluctant" to be involved, believes that the only reason for a follow-up cytogenetic study at Love Canal is "humanitarian," to give the residents more information. He does not think it has the potential of being of any real value unless it is conducted as part of a long-range epidemiological study. Picciano agrees: "The only value of another cytogenetic study will be its long-term academic value," he says. "Besides, you don't need a cytogenetic study to know something's wrong up there at Love Canal. The trees don't have any leaves. The kids play with rocks, and when they throw them against a wall they explode."

According to Renata Kimbrough of CDC, "A second chromosome study will not resolve the Picciano controversy, nor will it prove that exposure to the dump is causing broken chromosomes. And if it is negative, that won't prove that there is no harm. The real problem is that we don't yet have the scientific tools to answer the kinds of broad questions that are being asked of us in situations involving dump sites and other environmental problems." To complicate matters further, Love Canal residents have threatened to boycott future studies or to give false information if they do participate.

In addition to a second chromosome study, plans are also under way to "assess the health" of the citizens of Love Canal by offering each an ordinary physical exam. "It would not be a study of much epidemiological value," according to Kimbrough but, if handled properly, could produce interesting baseline data for following the people for the next 10 or 20 years. The health assessment study will be conducted jointly by CDC and the State University of New York at Buffalo if they can agree on what should be included. Negotiations are not going smoothly.

In the continuing debate about what to do at Love Canal, two things are apparent. First, everyone is acutely aware that Love Canal is not only a problem in its own right but foreshadows problems to come. There are thousands of other toxic waste dumps throughout the country. Second, it is clear that scientists approach the issue from a decidedly different vantage point than do lawyers and policy-makers.

Where the scientific community seeks certainty and studies that measure up to the most rigorous standards, attorneys can willingly settle for much less. Roisman of the Justice Department explains that from a legal viewpoint, it is not necessary to prove beyond any doubt that exposure to chemicals at Love Canal caused chromosome aberrations that can be linked directly to disease. What Justice wants to show the court in its suit against Hooker is that such a chain of cause and effect is possible. "The laws we're seeking to implement all have to do with the idea of endangerment," Roisman says. "We need to show that there is risk."

"The real problem is that we don't yet have the scientific tools to answer the kinds of broad questions that are being asked of us. . . ."

A recent decision by the U.S. District Court in Arkansas set a precedent that the Justice Department thinks would apply to the Hooker case. The issue in the Arkansas case had to do with the hazards of exposure to minute quantities of dioxin. The Court did not require proof that citizens were being harmed before granting relief. Rather, it only required evidence that the presence of dioxin in the soil "gives rise to reasonable medical concern for the public health." Acknowledging the uncertainties involved, the Court said, "These concepts of potential harm, whether they be assessed as 'probabilities and consequences' or 'risk and harm,' necessarily must apply in a determination of whether any relief should be given in cases of this kind in which proof with certainty is impossible."

Despite the legal perspective, scientists remain concerned about the quality of research that will be used in future efforts to deal with environmental issues. At the very least, cytogeneticists would like to get together to devise a protocol that everyone can agree to, should additional chromosome studies be done. They plan to thrash it out when the American Society of Human Genetics meets in New York next month. Shaw says, "I think it is our civic duty to make sure these things are done right. The present situation is such a God-awful mess."—BARBARA J. CULLITON