

---

**SCIENCE & TECHNOLOGY**


---

intractable social problems as crime, poverty, and war be interpreted as the natural consequence of chaotic systems?" the author asks. "Could an understanding of dreams benefit from insights granted by chaos theory?"

What is clear, though, is that chaos theory has the potential to help clarify the philosophical notions of "free will" and "determinism"—or whether individuals are locked into the chaotic "patterns" of history.

"The future is determined by the present," Kanigel concludes. "But tomorrow hangs on the knife edge of today, needing but the barest breath of free will or circumstance to direct it one way or the other."

---

**RESOURCES & ENVIRONMENT**


---

### *Trash To Ash*

"Burning Trash: How It Could Work" by Allen Hershkowitz, in *Technology Review* (July 1987), Mass. Institute of Technology, Building W59, Cambridge, Mass. 02139.

The United States is running out of space for its trash. Each day, U.S. towns and cities generate 410,000 tons of solid waste. Each year, several major landfills are closed because they are full. Many dumps leach toxins into the groundwater, and only half of the nation's 9,244 municipal landfills have valid operating permits.

Hershkowitz, chairman of the New York State Department of Environmental Conservation's Advisory Board on Operating Requirements for Municipal Solid Waste Incinerators, sees resource-recovery plants as a solution to the "garbage crisis." Such facilities "create steam that can be used to heat or cool buildings or to generate electricity."

Already in 40 U.S. states, some 70 resource-recovery plants are operating (or are about to start), 20 more are under construction, and 100 are being planned. They are not cheap: A small plant burning 50 tons of trash per day, such as the one in Batesville, Arkansas, can cost \$1.2 million; a 4,500-ton-per-day plant in Broward County, Florida, will cost \$570 million when completed. In New York City, the sanitation department estimates that to build eight waste-to-energy plants capable of incinerating 70 percent of the city's garbage will cost \$3 billion. Of course, in each case, selling the electricity generated (anywhere from 10 to 100 megawatts) offsets much of the capital investment and operating expense.

According to Hershkowitz, trash-burning generators have performed well in Norway, Sweden, West Germany, and Switzerland. The Japanese have combined waste-to-energy conversion with extensive recycling programs. In Machida City, for example, residents recycle roughly two-thirds of the city's waste—more than 95 percent of their newspapers, 50 percent of their glass bottles, and 70 percent of their steel and aluminum cans. In the United States, some 8,000 communities have recycling programs as well, although even the best ones—such as those in Davis, California, and Camden, New Jersey—reduce volumes of waste by less than one-third.

The greatest drawback to high-volume incineration, adds Hershkowitz,

---

**RESOURCES & ENVIRONMENT**


---

is the pollution that it produces. The plants tend to spew toxins (e.g., lead, dioxin, hydrogen chloride gas) into the air, especially when burning plastics and metals. Yet equipping incinerator flues with scrubbers, "baghouses" (fabric filter systems), and "electrostatic precipitators" (which capture metal particles from the smoke), as the Japanese have done, can cut the pollution by as much as 95 percent.

Hershkowitz has little doubt that a carefully regulated waste-to-energy effort could be a boon to a majority of U.S. communities. What is lacking today in the United States, he says, is not the necessary technology, but a commitment to a changeover in disposal systems.

### *Calculating Risks*

"Environmental Epidemiology: Separating Politics and Science" by Michael Gough, in *Issues In Science And Technology* (Summer 1987), The National Academy of Sciences, 2101 Constitution Ave. N.W., Washington, D.C. 20418.

Proving a "cause-and-effect" relationship between low-level exposure to a hazardous substance and adverse health effects is a difficult task.

Cancer and birth defects are common among human beings. Only 30 chemicals have been shown to cause cancer in humans. In fact, none of the agents classified as carcinogenic to humans by the World Health Organization have been shown to cause cancer at low levels of exposure.

This presents a problem for the courts, says Gough, project manager at Environ Corp., a Washington D.C.-based consulting firm. When individuals who have been exposed to a hazardous substance become ill or produce a child with birth defects, they often sue for damages. But in order to grant compensation, U.S. courts require "proof" that a given substance has directly harmed a person. When no proof exists, the courts turn to epidemiological studies to determine the likelihood that the person was injured by low-level exposure to the substance.

Yet such studies are often unreliable, Gough contends. One cannot always distinguish "exposed" and "nonexposed" individuals, or determine their degree of exposure. While many veterans of the Vietnam War have sought compensation from the Veterans Administration for "health effects" (e.g., cancer, nervous disorders) due to exposure to the herbicide Agent Orange, no study so far has linked such exposure to any one disease. Two of Agent Orange's ingredients—dioxin and 2, 4, 5-T—do cause tumors and birth defects in animals. Yet in humans, epidemiological studies have related dioxin only to chloracne, a skin rash, and 2, 4, 5-T to soft tissue sarcomas and lymphomas. A study of the 1,200 Air Force participants in Operation Ranch Hand, who sprayed 90 percent of the Agent Orange used in Vietnam, found no significant evidence of adverse health effects due to Agent Orange exposure.

Although studies by the National Research Council of 46,000 veterans exposed to radiation during two atomic bomb tests in the 1950s turned up evidence of an above-average rate of leukemia, the increase in cancer levels was so small that the Office of Technology Assessment concluded that even a large-scale survey of all 220,000 atomic test veterans would not produce reliable results.