

LIVING DOWNSTREAM

A Scientist's

*Personal Investigation of Cancer
and the Environment*

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habitants of Normandale are not the residents of Cape Cod nor the women of Long Island. They are not positioned to reject the results of a county investigation and insist on a multi-million-dollar federal study. They have no friends in Congress. They are not armed with fax machines and university connections. They are unlikely to invite world-renowned scientists to convene proceedings in the parking lot of the A & W root-beer stand.

The citizens of Cape Cod and Long Island have struggled mightily to bring scientific attention to the link between cancers and environmental contamination in their communities. Still, the resources they command are starkly different from those among Normandale's residents. My meetings with the breast cancer activists of Long Island have taken place on college campuses and convention hotels. I have spoken with the cancer activists of Cape Cod in a beachfront conference center. When I met with a community leader in my own hometown, we held our discussion in the back room of an auto repair shop and towing company.

The Massachusetts report concerning the alleged cancer clusters on Cape Cod is more than five hundred pages long. It is considered preliminary. A ten-year, million-dollar, state-of-the-art investigation is in the works. The two reports detailing the state and county investigations into cancer rates in Pekin and the Normandale subdivision together total eight pages.

Said a man from Normandale who lost his wife to ovarian cancer, "I think the state has a way of putting things to the side or overlooking what's the real truth."

FIVE



war

When my father, at age sixty-nine, wrote his memoirs on a manual typewriter and sent copies to all surviving members of his family, he did so to commemorate the fiftieth anniversary of the Allies' victory in the Mediterranean theater. The significance of this event is emphasized throughout the text. It was his defining moment.

I have often imagined my father as a soldier in Italy. His two desires: to stay alive and to avenge the capture of his brother, my Uncle LeRoy, held as a prisoner of war in Germany. His one fear, which the Allied victory in Europe very nearly realized, was to be sent to the other theater—the blood-soaked Pacific.

My father firmly believes his life was saved by excellent typing skills. This was not a lesson to be lost on his daughters. The ninth child of a poor Chicago family, he moved a dozen times before fin-

ishing school and enlisting. How exactly he learned to type a hundred words per minute *with no errors* I do not know. It is part of my father's mystique. Throughout my childhood, the sounds of rapid, flawless typing filled my parents' bedroom. According to legend, his remarkable talent with the typewriter saved him for two reasons: first, because he was selected to work in correspondence at a U.S. Army office safely away from the front and, second, because he was therefore privy to orders about upcoming troop deployments. Thus forewarned, he deftly reenlisted in the right unit at the right moment and kept himself out of harm's way. His skills as a tank destroyer (motto: Seek, Strike, and Destroy), for which he was trained, would go untested.

With these stories, I was encouraged to spend time practicing penmanship, dictation, and typing at my father's big desk. Like him, I am near-sighted and left-handed. Neither were allowable excuses for sloppy work. But if I became more attracted to the sounds of the words than to the speed with which I could produce them, it was both for my plain lack of clerical talent and for the irrelevance introduced into the whole endeavor by electric, self-correcting machines—and, later, computers. Still, until I read his error-free autobiography while sitting at my own big desk, I did not realize how deeply my father's stories had influenced me or how much I am like that nineteen-year-old army clerk furiously typing up casualty reports. My own work as a writer is a legacy of a war ended years before I was born.

World War II is mentioned throughout the chapters of *Silent Spring*. Carson's references are casual, and they seem designed to remind already-aware readers that the technologies developed for wartime purposes had changed chemistry and physics forever. The atomic bomb was only the most arresting example. More intimate aspects of the human economy were also changed. The multitude of new synthetic products made available after the war altered how food was grown and packaged, homes constructed and furnished, bathrooms disinfected, children deloused, and pets de-flea'd. Carson described this transformation almost offhandedly, as though the connection between lawn-care practices and warfare was perfectly obvious.

Carson made at least two other points about World War II.

First, because many of these new chemicals were developed under emergency conditions and within the secretive atmosphere of wartime, they had not been fully tested for safety. After the war, private markets were quickly developed for these products, and yet their long-term effects on humans or the environment were not known. Second, because wartime attitudes accompanied these products onto the market, the goals of conquest and annihilation were transferred from the battlefield to our kitchens, gardens, forests, and farm fields. The Seek, Strike, and Destroy maxim of my father's antitank unit was brought home and turned against the natural world. This attitude, Carson believed, would be our undoing. All life was caught in the crossfire.

When *Silent Spring* was published, the victory days of the Second World War had not yet reached their twentieth anniversary. Compared to Carson's generation, those of us born after World War II are not as aware of the domestic changes wrought by this war. We have inherited its many inventions—as well as the waste produced in their manufacture—but we do not have a keen sense of their origins. In seeking explanations for the unprecedented cancer rates among our ranks, we need to examine them.

Taped above my desk are graphs showing the U.S. annual production of synthetic chemicals. I keep them here to make visible a phenomenon I was born in the midst of but am too young to recall firsthand. The first consists of several lines, each representing the manufacture of a single substance. One line is benzene, the human carcinogen known to cause leukemia and suspected of playing a role in multiple myeloma and non-Hodgkin's lymphoma. Another is perchloroethylene, the probable human carcinogen used to dry-clean clothes. A third represents production of vinyl chloride, a known cause of angiosarcoma and a possible breast carcinogen. They all look like ski slopes. After 1940, the lines begin to rise significantly and then shoot upward after 1960.

A second graph shows the annual production of all synthetic organic chemicals combined. It resembles a child's drawing of a cliff face. The line extending from 1920 to 1940 is essentially horizontal, hovering at a few billion pounds per year. After 1940, however, the line rockets skyward, becoming almost vertical after 1960. This kind

First, many of these compounds are themselves synthesized from synthetic chemicals that are highly reactive. By accident or on purpose, these industrial feedstocks are routinely released, dumped, or spilled in the general environment. While PVC plastic is, biochemically speaking, quite lethargic, the vinyl chloride from which it is manufactured exerts striking effects on the human liver. Second, inactive synthetic substances can shed or off-gas the smaller, more reactive molecules from which they are made. Third, new reactive chemicals can be created if these substances are subsequently burned—as when perfectly benign piles of vinyl siding are shoveled into a garbage incinerator, and poisonous dioxin rises from the stack. The incinerator itself, in this case, acts as a de facto chemical laboratory synthesizing new organic compounds from feedstocks of discarded consumer products.

Through all of these routes, we find ourselves facing a rising tide of biologically active, synthetic organic chemicals. Some interfere with our hormones, some attach themselves to our chromosomes, some cripple the immune system, and some overstimulate the activity of certain enzymes. If we could metabolize these chemicals into completely benign breakdown products and excrete them, they would pose less of a hazard. Instead, a good many of them accumulate. In essence, synthetic organic chemicals confront us with the worst of both worlds. They are similar enough to naturally occurring chemicals to react with us but different enough to not go away easily.

A number of these chemicals are soluble in fat and so collect in tissues high in fat content. Synthetic organic solvents, such as perchloroethylene and trichloroethylene, are an example. They are specifically designed to dissolve other oil- and fat-soluble chemicals. In paint, they work well to carry oil-based pigments. As degreasing agents, they work well to clean lubricated machine parts. As dry-cleaning fluids, they excel at dissolving human body oils and greasy fabric stains. They also all work splendidly to dissolve human body oils still on our skin and can thus easily enter our bodies upon touch. In addition, they are readily absorbed across the membranes of our lungs. Once inside, they take up residence in fat-containing tissues.

Many such tissues exist. Breasts are famous for their high fat content and often serve as repositories for synthetic organic chemi-

cals circulating within the female body. But organs less renowned for fat content also collect these chemicals. The liver, for example, is surprisingly high in fat. So is bone marrow, the target organ for benzene. And, amazingly enough, because nerve cells are swathed in a fatty coating, so are our brains. Consider that many solvents have been used as anesthetic gases due to their ability to affect brain functioning. Chloroform is one.

Its medical uses long since discontinued, chloroform continues to be used as a solvent, fumigant, and ingredient in the manufacture of refrigerants, pesticides, and synthetic dyes. U.S. annual production of chloroform is currently about 600 million pounds, and it is found in nearly half of the hazardous waste sites on the Superfund National Priorities List. As we shall see in Chapter Nine, trace amounts are also formed when drinking water is chlorinated. Chloroform is classified as a probable human carcinogen. Its residence time in the body is actually quite brief. DDT, for example, has a half-life of at least seven years, while that of chloroform is a mere eight hours. (Half-life is the time required to convert half the body's burden of a given substance into excretable by-products.) The problem, then, with chloroform is not so much biological persistence but the fact that we are continuously exposed through multiple routes. All human beings, according to the U.S. Agency for Toxic Substances and Disease Registry, receive at least low levels through water, food, and inhalation.

As noted earlier, in the last half of the twentieth century, cancers of the brain, liver, breast, and bone marrow (multiple myeloma) have been on the rise. These are all human organs with high fat content. In the last half of the twentieth century, the production of fat-soluble, synthetic chemicals has also been on the rise. Many are classified as known, probable, or possible carcinogens. We need to ask what connections might exist between these two time trends.



First synthesized in 1874, DDT languished without purpose until drafted into World War II, and it proved its mettle by halting a typhus epidemic in Naples. My father arrived in this occupied city not long after. According to his wartime account, Naples lay in ruins, its peo-

toms of shoes can remain impregnated in carpet fibers for years. Some researchers now believe that infants and toddlers experience significant exposure to pesticides by crawling on carpets and ingesting house dust—perhaps even more so than by ingesting pesticide residues on food.

Several studies have linked childhood cancer to home pesticide use. Childhood cancer in Los Angeles was found to be associated with parental exposure to pesticides during pregnancy or nursing. In a 1995 study in Denver, children whose yards were treated with pesticides were four times more likely to have soft tissue cancers than children living in households that did not use yard chemicals. In another case-control study, researchers found statistically significant associations between the incidence of brain tumors in children and the use of several household pesticidal products: pest-repelling strips, lindane-containing lice shampoos, flea collars on pets, and weed killers on the lawn. All together, these findings may represent the beginning of an explanation as to why brain cancer in children under age fourteen has risen sharply during the past twenty years.

Of course, the postwar boom in synthetic organics was not limited to pesticides. Industrial products manufactured from fossil fuels also exploded onto the scene. In this case, World War II simply accelerated a process set in motion years earlier.

Historians of chemistry date the twentieth-century rise of the petrochemical industry back to the near extermination of whales in the nineteenth century: lack of whale oil for lamps created a market for kerosene, one of the lighter fractions of petroleum. Another petroleum derivative, gasoline, found purpose with the advent of the automobile. With the blockades against imported materials during World War I, the chemical industries of all warring nations were stimulated to invent new products. Germany, for example, developed artificial fertilizers when its supplies of Chilean saltpeter were cut. The same manufacturing process proved quite useful for producing explosives—as the fertilizer-derived bomb that destroyed the Oklahoma City federal building in 1995 illustrates.

With a large supply on hand for making dyes, Germany turned to chlorine gas to serve as a wretched weapon of chemical warfare in

the trenches of France. Chlorinated solvents were also introduced during this time. After the war ended, new chemical products in the United States were protected by high tariffs, the war's losing parties surrendered their chemical secrets to the victors, and considerable wealth and prestige accrued to the chemical industry. By the 1930s, petroleum began to outpace coal as the source of carbon for new chemical inventions.

The cliff face of exponential growth in synthetic organic chemicals, however, did not begin until the 1940s. The all-out assaults of World War II created instant demands for explosives, synthetic rubber, aviation fuel, metal parts, synthetic oils, solvents, and pharmaceuticals. The innovations in chemical processing developed in the wake of World War I—such as the cracking of large, heavy petroleum molecules to produce many lighter and smaller molecules—were perfected and tested in large-scale production. When the war ended, the resulting economic boom, housing boom, and baby boom created unprecedented consumer demands as wartime chemicals, aided by skillful advertising, were transferred to civilian posts. Fearing a return to economic depression, national leaders encouraged the conversion of military products to civilian use. "In the United States," the historian Aaron Ihde has wryly noted, "peace did not prove catastrophic to an industry grown to monstrous proportions in response to the needs of war."

From an ecological point of view, World War II was a catalyst for the transformation from a carbohydrate-based economy—as it has been called by some analysts—to a petrochemical-based economy. For those of us born in the last fifty years, a review of petroleum's displaced, replaced, and discarded natural chemical predecessors is a fascinating exercise. I found myself amazed at how many products now derived from a barrel of oil were once manufactured from vegetation.

You may be excited to learn, as I was, that plastic existed before it was synthesized from petroleum. It was derived from plants, invented in the 1870s, and called celluloid. Clear plastic film derived from wood pulp with adhesive on one side was introduced in the 1920s as cellophane tape. Plant-derived substances were once used to make steering wheels, instrument panels, and spray paint for cars.

Thus, while the carcinogen vinyl chloride was actually first synthesized in 1913, its production did not begin to skyrocket until after World War II when research on the industrial uses of plant matter was replaced by an emphasis on petrochemistry. Automobile interiors would no longer come from cotton fibers or wood pulp, but from oil.

Guess, if you can, what formaldehyde and soybeans have in common. Imported from Asia in the nineteenth century, soybeans are a low-growing legume that produces round, yellow seeds inside of fuzzy pods. One of the oldest and simplest synthetic organic chemicals, formaldehyde consists of a single atom each of carbon and oxygen, plus two hydrogen atoms. These two substances could hardly be more different. Both happen to be deeply familiar to me, since soybeans cover the Illinois prairies and formaldehyde is the standard preservative of biological specimens destined for dissection. (Anyone who has ever confronted a pickled frog in a biology class would instantly recognize its distinctive odor.) Classified as a possible chemical carcinogen, formaldehyde is consistently ranked among the top fifty chemicals with the highest annual production volumes in the United States. In 1990 alone, 6.4 billion gallons were produced. Formaldehyde serves as an embalming fluid in funeral homes. It is also sprayed on fabric to create permanent press. In the 1970s, formaldehyde-based foams became popular for thermal insulation of houses. But nearly half of formaldehyde's annual production is used for synthetic resins to hold pieces of wood together as plywood and particle board. The subsequent evaporation of formaldehyde vapors from construction materials and furniture makes this chemical a significant contributor to indoor air pollution. As with chloroform, the problem with formaldehyde is not that it accumulates in our tissues but that we are exposed to small amounts of it almost continuously and from so many sources—from our subflooring to our wrinkle-free sheets.

Now the answer to the riddle: What formaldehyde shares with the soybean is an ability to act as an adhesive. Before formaldehyde was synthesized in such gargantuan quantities, soybean resins were used to hold particle board and plywood together. Soybean oil was also used in fire-suppressant foam and wallpaper glue, and as a base for paints, varnishes, and lacquers.

Other plant-based oils also played leading roles in industry before the war. Oils extracted from corn, olives, rice, grape seeds, and other plant parts were used to make paint, inks, soaps, emulsifiers, and even floor covering. The word *linoleum* echoes the name of its original key ingredient: linseed oil. Castor oil, from the tropical castor bean tree, was used to lubricate machine parts.

Countless examples of synthetic substitutions have occurred in the last half century and have provided us with new exposures to known or suspected carcinogens. In the 1950s, for instance, synthetic cutting oils were introduced into machine shops. Used for cooling metal parts during both cutting and grinding, cutting fluids come into close association with machinists through both touch and inhalation. Synthetic degreasers, such as perc, are then often used to clean the parts once they are cut. These have become a common contaminant of hazardous waste sites and therefore of drinking water. Researchers have recently discovered that synthetic cutting fluids can expose workers to N-nitrosamines, a contaminant formed during their manufacture. By the 1970s, cancer among machine operators and its possible relationship to synthetic cutting fluids began receiving attention. In one study the researchers concluded:

Until now, N-nitrosamines have not been directly associated with human cancers because no population groups had been identified that were inadvertently exposed. Cutting fluid users have the dubious honor of being the first such population group to be identified.



The rapid birthrate of new synthetic products that began in 1945 far surpassed the ability of government to regulate their use and disposal. Between 45,000 and 100,000 chemicals are now in common commercial use; 75,000 is the most frequently cited estimate. Of these, only about 1.5 to 3 percent (1,200 to 1,500 chemicals) have been tested for carcinogenicity. The vast majority of commercially used chemicals were brought to market before 1979, when the federal Toxics Substances Control Act (TSCA) mandated the review of new

chemicals through the economy point out that declines in toxic waste releases have not always been accompanied by parallel declines in toxic waste production: the generation of toxic waste by TRI-reporting facilities remains high. Where, then, is the waste going? Without thorough materials accounting, which is not currently required, no one is exactly sure.

Nevertheless, under EPCRA, for the first time in history, any citizen can request from the Environmental Protection Agency (EPA) a list of the reported toxic releases in his or her home county. Access to this information is now acknowledged by our government as a fundamental public right.

In some communities, the TRI has served as a powerful tool for pressuring factories to reduce pollution. Its most important function may be the implicit recognition that a so-called private industry is engaging in a very public act when it releases toxic chemicals into a community's air, water, and soil. Conceptually, we all know the industries in our communities pollute the environment. We may even be able to see and smell the results. But very often, the picture does not come into focus for us until we actually stare at the list of specifics, as when the names and the numbers are printed in our local newspapers: how many pounds of which known or suspected carcinogens were released by which companies into the air we breathe or into the rivers we fish and from which we draw our drinking water?

The TRI's first report, released by the EPA in 1989, had just such an effect. It revealed that *billions* of pounds of toxic chemicals were being routinely emitted each year into the nation's air, water, and land. Nearly all who read the report were amazed. This was the first attempt to gather together routine toxic releases, and the sum was an unquestionably staggering amount. Said a representative from the Chemical Industry Council of New Jersey: "I'll be honest with you. [Our reduction in emissions] probably would not have occurred if that data had not become public information. It was something that caught everyone's attention, including the corporate leaders." A Monsanto spokesman was even more blunt: "The law is having an incredible effect. . . . There's not a chief executive officer around who wants to be the biggest polluter in Iowa."

In the first year of reporting, only about 5 percent of toxic releases in the country were reported under TRI, and yet the effect of

ending the silence about toxic releases was huge. Some companies who found themselves on the list of the worst toxic offenders immediately entered into voluntary programs to reduce their emissions. Several communities began using their local data to force more recalcitrant industries to follow suit. Concerned citizens who also happened to be computer wizards came together to provide technical support to communities wishing to access their local TRI data electronically (a task that can now be accomplished on a home computer or at almost any local library). Public Data Access, Inc., mapped the information and, by bringing TRI data together with death certificate data, correlated areas of severe environmental contamination with areas of elevated cancer mortality. The results are the black, white, and gray maps described in Chapter Four.

According to the most recent TRI, which is about the size of an average telephone book, 2.26 billion pounds of toxic chemicals were released into the environment in 1994. Of these, 177 million pounds were known or suspected carcinogens.



In a favorite photograph of myself as a child, I am hanging determinedly onto a tricycle, wearing a goofy expression and my father's army hat. The determination came from trying to salute my father, the photographer, while simultaneously pedaling. It is 1962. The setting is the concrete patio on the south side of our house. A construction worker before the GI Bill returned him to the typewriter as a college student, my father poured this patio himself and laid the brick walkway leading out into his 1.5 acres of former cow pasture.

After the war, my father married a farmer's daughter with a degree in biology and another in chemistry. He built his house on Pekin's east bluff and planted lines of silver maple and white pine in the sod. Before the trees grew up to form a wall around the borders of his property, the patio offered a spectacular view. To the east, cows grazed. Although afraid of them, I liked to stand at the fence and watch them eat—their purply tongues and black plumes of flies, the ripping sounds of the grass.

Just beyond, the bluff's pastures unrolled into what was once—and I am guessing here—hill prairie. Here lay vast fields of corn and

soybeans. I liked the corn—each stalk a green man waving his arms. In September, the soybeans turned brilliant yellow and then deepened into an orange-brown far richer than my burnt sienna crayon.

“What color would you call soybeans?” I inquired of Aunt Ann, who farmed two counties east from us.

She didn’t miss a beat. “At six dollars a bushel, I would call them gold.”

My father drove west to work every morning. Looking through the patio screen from my tricycle, I could see the smokestacks, cooling towers, and distillation chambers of the river valley’s three dozen industries. I liked the steam clouds, trails of smoke, and mysterious shimmering vapors. I was especially fond of the pink-and-white-striped towers, which reminded me of giant candy canes. These stacks belonged to the ethanol distillery and the coal-burning power plant just upriver. At night, they became lighthouses—great blinking columns warning planes away. To my sister and me, my father referred to this scene as “progress, girls, progress.”

Tazewell County, Illinois, is home to two distinct cultures, one emblemized by the lone figure on his tractor and the other by picket lines of striking plant workers. Our house was situated in the transitional zone between the two.

Among farmers, Tazewell is known as the birthplace of Reid’s Yellow Dent, a famous strain of field corn that became the ancestor of many hybrid seed lines. Among industrialists, Tazewell County is known for the 127-acre Pekin Energy Company, one of the nation’s largest producers of ethanol, and as the manufacturing site and proving grounds for Caterpillar tractors, backhoes, and bulldozers. Caterpillar’s management offices are headquartered across the Illinois River in Peoria. A hydrologist’s description of the area from 1950 is as good as any: “The Peoria-Pekin area is a highly industrialized district requiring an enormous volume of water. The industrial areas are surrounded by the fertile agricultural prairie lands of the corn belt.”

Settled before the prairie was sod-busted, Pekin began as a military fort. War and manufacturing have frequently danced together here. Distilling and brewing began as a means of transforming grain into a nonperishable cash commodity that could easily be shipped

east. Wartime needs for industrial alcohol then provided a huge new market and inspired new production technologies. One of Pekin’s distilleries was founded in 1941 expressly to provide the U.S. military with ethanol. In 1916, the U.S. Army ordered the first Caterpillar tractors, which it used to drag cannons, ammunitions, and supplies to the front. During World War II, Caterpillar machines were used to bulldoze airstrips, grade roads, clear bomb wreckage, and topple palm trees. By 1945, 85 percent of Caterpillar’s production was shipped overseas for military work. Collected photographs of “Cats” in action during both world wars and the Korean War are still a hot item in the local bookstore.

Other photographs from the turn of the century show child laborers posing in the sugar-beet fields. The black smoke of the sugar factory forms a dramatic backdrop against the little white faces. The sugar works later become Corn Products, which produced Argo cornstarch and Karo syrup. In 1924, a starch explosion incinerated forty-two workers. In 1980, Corn Products became Pekin Energy.

In September 1994, I drove along the Illinois River banks to pass by where those old beet fields must have been—less than two miles from the house I grew up in. The floodplains are now a landscape of docks, stacks, rail yards, conveyers, elevators, hopper bins, pits, lagoons, coal piles, tailings ponds, settling tanks, power lines, and scrap heaps—all that I had seen at a distance as a child. A union billboard announced, “You Are Now Entering a War Zone,” a comment not on the environment but on labor’s latest showdown with management at the nearby Caterpillar plant.

There are some places in this world that prompt one to ask, “Where did all this come from?” The fish, vegetable, and flower markets of New York City always bring me to this question. Tazewell County is another kind of place. Spend some time on the Pekin docks. Watch the barges of coal, grain, steel, chemicals, and petroleum products. “Where is all this going?”

There are partial answers. The grain elevators and the mills ship corn and pelletized animal feed south to New Orleans and from there to Asia and Europe. The coal-fired power plant called Powerton sends electricity 165 miles north to Chicago via high-power lines. In

1943, its smoke prevented landings at an airport forty-one miles away. In 1974—the year I turned fifteen—this plant was named the worst polluter in the state of Illinois. Trace Chemicals formulates pesticides. I do not know where they end up. The brass foundry makes huge cylinders, called bushings, for draglines, drills, and crushers used in strip mines. Caterpillars end up everywhere. In 1986, I looked out the window of a bus heading south along the Nile River in eastern Sudan and found myself face to face with Caterpillar's familiar logo—a giant capital C—painted on a billboard near a military installation.

About the other industries lining the river valley I know less. I do not know what goes on at Airco Industrial Gases, the Sherex Chemical Company, the Agrico Chemical Company, or the aluminum foundry. I know that Keystone Steel and Wire makes nails and barbed wire out of scrap metal. In 1993, the company faced charges for polluting the sand aquifer below its facilities with TCE and another synthetic degreaser, 1,1,1-trichloroethane, a suspected carcinogen. The promises it made to clean up and switch to less toxic chemical technologies have, so far, kept Keystone off the Superfund's National Priorities List.

Like a film of gasoline on a pond's surface, an emotional blankness coats my words here. There are, of course, many ways of expressing the relevance of the historical past to the personal present. Surely there is one that could describe the private thoughts of an East Bluff girl returning home from Boston and passing by the hospital where, years before, she was diagnosed with a type of cancer known to be caused by exposure to environmental carcinogens. Surely there is a language able to explain why such a woman would now drive along Distillery Road, breathing the acrid air, searching for nineteenth-century sugar-beet fields and twentieth-century hazardous waste sites.

A silence spreads out. I cannot make her speak.

It is not the silence of resignation or paralysis. It is the fear that speaking intimately about this landscape—or myself as a native of this place—would make too exceptional what is common and ordinary. I feel protective of my hometown. Its citizens are not unusually igno-

rant or evil or shortsighted. And, away from the river, the city itself is lovely. Between the fields and the factories are nice, old neighborhoods, beautiful parks, the county fairgrounds, and reasonably good schools. There is nothing unique or even unusual about Tazewell County, Illinois. As true everywhere else, its agricultural and industrial practices—from weed control to degreasing parts—were transformed by chemical technologies introduced after World War II. As true everywhere else, these chemicals, many of them carcinogens, have found their way into the general environment. As true almost everywhere else, no systematic investigation has been conducted to determine whether any connection exists between the release of these chemicals and the rates of cancer here.

“We know the emissions are present, and the cancer, but we don't know if the two are related,” said a state toxicologist quoted in the local paper in March 1995. This article concluded:

The impact of tons of toxic emissions on the health of industrial workers and the public never has been systematically studied and may be impossible to determine. . . . Health statistics in Peoria and Tazewell counties are troubling, but the connection between emissions and health problems is not clear.

There is nothing special or unusual about the toxic release inventories for Tazewell and Peoria Counties. Of seventy-eight regions in Illinois, the Pekin-Peoria area ranks only thirteenth in TRI emissions. Nonetheless, I cried when I first read through these inventories. Hundreds of pages of computer print itemize the toxic emissions for area industries during the years since 1987, when this information was first compiled. In 1991, for example, large manufacturers in Peoria and Tazewell Counties legally released 11.1 million pounds of toxic chemicals into the air, water, and land. Among the known and suspected carcinogens released were benzene, chromium, formaldehyde, nickel, ethylene, acrylonitrile, butyraldehyde, lindane, and captan. Captan is a carcinogenic fungicide prohibited for many domestic uses in 1989. In 1987, according to the TRI, 250 pounds of captan ended up in the Pekin sewer system. In 1992, 321 pounds were released into the air.

Tips of all kinds of icebergs are revealed in other right-to-know documents. For example, I have a partial record of pre-TRI toxic re-

leases in Tazewell County dating back to 1972. The carcinogens catch my eye first—PCBs, vinyl chloride, benzene—but the list also includes other frightening and curious items: printing ink, jet fuel, asphalt sealer, dynamite, scrubber sludge, fuel oil, antifreeze, fly ash, coal dust, herbicides, furnace oil, and “explosive vapors.”

In addition, I possess a twenty-four-page list of facilities in Tazewell County with permits to discharge wastes into particular rivers and streams (“local receiving waters: Farm Creek . . . local receiving waters: Illinois River,” etc.). I have also obtained a thirty-four-page list of each and every facility—from the local crematorium to the auto body shop—permitted to deal in any way with hazardous materials. Right-to-know legislation has given me access to a hefty off-site transfer report, a document particularly revealing because it shows the flow of toxic wastes coming into Tazewell County. I know, for example, that the Sun Chemical Corporation of Newark, New Jersey, sent 250 pounds of friable asbestos to the Pekin Metro landfill for disposal in 1987. Tazewell doubled the amount of hazardous waste it generated and shipped off-site between 1989 and 1992, but, as one of the state’s top receiving counties, it still received four times more waste than it produced.

The spill report for Tazewell County details chemical accidents. Here is the first entry as it appears on the list:

DATE: 6/11/1988

STREET: RTE 24

MATERIAL SPILLED: METHYL CHLORIDE

AMOUNT SPILLED: 2,000 LBS

WATERWAY/OTHER: AIR RELEASE

EVENT DESCRIPTION: WEIGH TANK/WHILE PREPARING FOR INSPECTORS, VALVE INADVERTENTLY OPENED/EXACT CAUSE UNDER INVESTIGATION

ACTION TAKEN: TEMPORARILY EVACUATED AFFECTED BUILDING FOR TWO HOURS . . . SHUT VALVE TO STOP RELEASE

Route 24 is an old highway. To the west, it follows the Illinois River valley for some miles before shooting across the plains to the

Mississippi River town of Quincy. To the east, it connects Pekin to the Indiana border, passing four miles south of my grandparents’ farm in Forrest. I can tell you about every small town between here and there, describe every moraine, name every creek.

Methyl chloride is classified as a probable human carcinogen. It causes mutations in bacteria and kidney cancers in mice. It also causes birth defects and degeneration of the sperm-carrying tubules in rat testicles. Used in the manufacture of silicone products, fuel additives, and herbicides, methyl chloride is synthesized by attaching a chlorine atom onto a molecule of wood alcohol. By 1981, annual production reached 362 million pounds per year. Domestic consumption expands approximately 6.5 percent per year. Methyl chloride’s long-term effects on human health have never been studied directly.

Amid a flooded sea of information, an absence of knowledge. Amid a thousand computer-generated words, a silence spreads out.



Seek. Strike. Destroy. Of all the unexpected consequences of World War II, perhaps the most ironic is the discovery that a remarkable number of the new chemicals it ushered in are estrogenic—that is, at low levels inside the human body, they mimic the female hormone estrogen. Many of the hypermasculine weapons of conquest and progress, are, biologically speaking, emasculating.

This effect occurs through a variety of biochemical mechanisms. Some chemicals imitate the hormone directly, while others interfere with the various systems that regulate the body’s production and metabolism of natural estrogens. Still others seem to work by blocking the receptor sites for male hormones, which are collectively called androgens. In 1995, fifty years after its triumphant return from the war and entry into civilian life, DDT again made headlines when new animal studies showed that DDT’s main metabolic breakdown product, DDE, is an androgen-blocker.

Our enzymes quickly convert DDT into DDE. But because the next step is much slower (recall DDT’s seven-year half-life), we accumulate DDE as we age—much as a fine stream of sand grains gradually forms a heap at the bottom of an hourglass. DDE molecules can

cross the human placenta and can also accumulate in breast milk. Thus, those of us too young to have been sprayed by DDT directly nevertheless have accumulated DDE in our bodies through at least two routes: from our mothers (both before and after birth) and our consumption of milk, meat, eggs, and fish. Animals, like the humans who eat them, lack the biochemical hardware needed for efficient conversion of DDE to something excretable.

For boys and men, the consequences may include physical deformities such as undescended testicles, lowered sperm counts, and testicular cancer. No one knows what effect DDE exposure has on the reproductive development of girls or women; no research has been done. The only thing we know for a fact is that DDE is biochemically different enough from anything else in the human body—male or female—that it is not completely metabolized as are our own natural sex hormones. This is one reason why, more than two decades after DDT's forced retirement in the United States, we still have DDE molecules floating around in our tissues.

Much of the concern about hormone-disrupting chemicals has been focused on their possible role in contributing to birth defects, reproductive failures in wildlife, and infertility in humans. At times, these discussions seem nearly to eclipse the quieter, but longer-running conversations about the possible contributions of estrogen-mimicking contaminants to cancer. Certain breast cancers, for example, are notorious for growing faster in the presence of estrogen, which is why prescribing antiestrogenic drugs is standard chemotherapeutic protocol. Many other cancers—those of the ovary, uterus, testicle, and prostate, for example—are also known to be, or suspected to be, hormonally mediated. Thus, identifying pollutants that interfere with hormones is important to public dialogue about human cancers of all kinds.

The relevance of endocrine disruption for cancer is not a new subject. Rachel Carson mentioned it explicitly in *Silent Spring*. Nevertheless, a mysterious event in a Tufts University laboratory a few years ago brought renewed attention to the topic.

The cell biologists Ana Soto and Carlos Sonnenschein were working out the details of estrogen's relationship to breast cancer

when something puzzling happened in their laboratory. Breast cancer cells growing in plastic dishes containing no estrogen started dividing rapidly, as though they were being hormonally stimulated. "This indicated that some type of contamination had occurred," Soto remembers. "We made an accidental discovery."

Soto and Sonnenschein traced the contamination to the plastic tubes they were using to store blood serum. Together, they purified the contaminant and identified it as nonylphenol, a synthetic organic chemical added during the manufacture of plastic to prevent it from cracking. Molecules of nonylphenol were being shed from the tubes into the serum.

In a series of follow-up experiments, the two researchers demonstrated that nonylphenol is estrogenic. It activates estrogen receptors within cells so equipped, which in turn alters the activity of certain genes and changes the rate at which these cells divide. Nonylphenol makes breast cancer cells—at least those growing in petri dishes—grow faster. Soto and Sonnenschein began testing other chemical aliens—certain common pesticides, detergents, and other types of plastics—and discovered estrogenic activity in a whole variety of petrochemically derived substances. Other researchers were inspired to do the same. Approximately forty such chemicals have so far been identified as capable of mimicking estrogen.

This flurry of attention has shed light on the biological activities of two ubiquitous but almost totally unknown groups of synthetic compounds: plasticizers and surfactants. Plasticizers are chemicals that are mixed with plastics to give them more strength and flexibility. Surfactants are added to, for example, detergents, herbicides, and paints to help the active ingredient stick to the surface of its target—dirt particles, weeds, or the wall of a house. Alkylphenol polyethoxylates (APEOs) are surfactants widely used in household detergents. Since their introduction in the 1940s, they have become widely disseminated in rivers, lakes, and streams via sewage systems. APEOs have been detected in drinking water in New Jersey. In 1994, in the wake of Soto and Sonnenschein's discovery, a team of researchers in England reported that APEOs can, in trace amounts, stimulate the growth of breast cancer cells and feminize male fish exposed to contaminated sewage. Fish collected from many U.S. rivers also display

hormonal abnormalities consistent with exposure to estrogenic substances in river-borne sewage. However, it is not at all clear at this point—either in England or the United States—whether the feminization of fish downstream of sewage outfalls can be totally explained by exposure to chemicals such as APEO surfactants. New evidence suggests that at least some of the problem may stem from exposure to natural and synthetic estrogens found in women's urine—and so researchers investigating the gender-bending potential of sewage are now turning their attention from washing machines to toilets.

Phthalates, the plasticizers with the nearly impossible name, turn out to be the most abundant industrial contaminant in the environment. At least two have now been identified as estrogenic, and traces of both have been found in food. One is used in plastic food wrap and the other in papers and cardboard designed for contact with liquid, dry, and fatty foods.

Some phthalates are known to be overtly carcinogenic. For example, DEHP—which stands for the even more impossible di(2ethylhexyl)phthalate—gives PVC plastic its flexibility. It is also classified as a probable human carcinogen and because of this, its use in baby pacifiers, plastic food wrap, and toys has been discontinued. Residues of DEHP have been found in food items, especially those with high fat content, such as eggs, milk, cheese, margarine, and seafood. Because DEHP, like nonylphenol, can leach from plastic containers holding bodily fluids, it has also been found in blood used for transfusions. In 1993, the yearly production of DEHP was 270 million pounds. According to TRI data, in 1991 alone 3.76 million pounds of DEHP were released into the environment or transferred off-site for disposal.

About half of the synthetic materials known to function as endocrine disrupters belong to a chemical group called organochlorines. Not all estrogenic materials are organochlorines, and not all organochlorines are estrogenic, but the overlap is impressive. Moreover, organochlorines are such a large group—around eleven thousand exist—and they tend to be so persistent in the environment, so reactive within human tissues, and so frequently associated with cancer that they merit special consideration.

Many of the chemicals we have already discussed belong to this group. Lindane, DDT, heptachlor, chlordane, PCBs, CFCs, TCE, perc, 2,4-D, methyl chloride, vinyl chloride, polyvinyl chloride, dioxin, and chloroform are all organochlorines. Benzene, formaldehyde, nonylphenol, and phthalates are not.

Organochlorines, which involve a chemical marriage between chlorine and carbon atoms, are not strictly a human invention. A few are formed during volcanic eruptions and forest fires and some by living organisms such as marine algae. For the most part, however, chlorine and carbon move in separate spheres in the natural world—and in the bodies of humans and other mammals. To force the two together, elemental chlorine gas is required.

Although it holds a rightful place in the periodic table of elements, pure chlorine *is* a human invention. It can be produced by passing electricity through salt water in a procedure that was first undertaken on an industrial scale in 1893. A powerful poison, chlorine gas became known to the world during World War I, but its manufacture grew slowly until World War II, then rose exponentially. About 1 percent of this production is used for disinfecting water and about 10 percent for bleaching paper, and the majority is combined with various carbon compounds, usually derived from petroleum, to make organochlorines.

In its elemental form, chlorine (but not the ion chloride) is highly reactive with carbon, which is why so many different combinations are possible. Like houses of different architectural styles, some organochlorines are very small and plain, and others huge and ornate. One of the simplest is chloroform, which consists of a single carbon atom with one hydrogen and three chlorine atoms attached to it like four spokes on a hub. Consisting of one chlorine, two carbon, and three hydrogen atoms, vinyl chloride is not much more complicated. The dry-cleaning solvent perchloroethylene is two carbon and four chlorine atoms, while the industrial degreaser trichloroethylene consists of two carbon and three chlorine atoms.

On the more elaborate side are chlorinated phenols. These consist of a hexagonal ring of six carbons with various chlorinated groups hanging off the corners. The pesticide lindane, for example, consists of a carbon hexagon with six chlorine atoms attached all around. The herbicide 2,4-D is a hexagon with chlorines attached to the second

and fourth carbon atoms and a carbon chain waving like a flag from the first carbon atom. DDT is more complicated yet. It consists of two hexagonal rings, each with one chlorine atom attached, yoked together by a single carbon atom from which dangles a chlorinated carbon tail.

And then there are the PCBs. PCBs are the elders of the group, and they are referred to in the plural for a reason. As their name implies, polychlorinated biphenyls comprise two rings of carbon atoms welded directly together, around which are attached any number of chlorine atoms. In fact, there are 209 possible combinations and therefore 209 different PCBs. Some of these chemical combinations are estrogenic and some appear not to be, but no one has worked this out definitively.

As a group, organochlorines tend to be persistent in air and water. When they evaporate and are swept into the wind currents, some fall back to the earth close to their origins, while others can circulate for thousands of miles before being redeposited into water, vegetation, and soil. From there, they enter the food chain. Diet is thus believed to be a major route of exposure for us.

Not all organochlorines are deliberately constructed. Whenever elemental chlorine is present, the natural environment will synthesize additional, unwanted organochlorine molecules. These reactions can take place when water containing organic matter, such as decayed leaves, is chlorinated. It can happen in pulp and paper mills during the process of bleaching or when chlorinated plastics are burned. It can happen during the manufacture of other organochlorines. The production of 2,4,5-T, the burning of plastic, and certain methods of bleaching paper all contribute to the birth of dioxin. A chemical of no known usefulness and never manufactured on purpose, dioxin has been linked to a variety of cancers and is now believed to inhabit the body tissues of every person living in the United States. Dioxin is a beautifully symmetrical molecule, consisting of two chlorinated carbon rings held together by a double bridge of oxygen atoms.



The development of industrial chemistry in this century has been driven by the exigencies of war. Out of this crucible came new chem-

icals of all sorts. Some, such as organophosphate nerve gas, seem to have been born from truly evil intentions; others, from admirable ones. But few were invented solely for the purposes to which they were turned after the war's end. And few were adequately tested for long-term health effects.

As the daughter of a World War II veteran, I am grateful that my father did not die in a typhus epidemic in Naples. But as a survivor of cancer, as a native of Tazewell County, and as a member of the most poisoned generation to come of adult age, I am sorry that cooler heads did not prevail in the calm prosperity of peacetime, when careful consideration and a longer view on public health were once again permissible and necessary. I am sorry that no one asked, "Is this the industrial path we want to continue along? Is this the most reasonable way to rid our dogs of fleas and our trees of gypsy moths? Is this the safest material for a baby's pacifier or for a tub of margarine?" Or that those who did ask such questions were not heard.

These questions are finally beginning to receive a hearing. In 1993, the American Public Health Association issued a resolution calling for the gradual phaseout of most organochlorine compounds and for the pursuit of safe alternatives. In doing so, it followed another august agency, the International Joint Commission on the Great Lakes. Citing rising rates of breast cancer within the Great Lakes basin, the commission recommended scrapping the current practice of regulating persistent toxic chemicals after they have been produced, used, and released. Taking its place would be a preventive strategy recognizing that all such substances are "deleterious to the human condition" and must no longer be tolerated in the ecosystem, "whether or not unassailable scientific proof of acute or chronic damage is universally accepted."

In the fall of 1994, the esteemed epidemiologist David Ozonoff addressed a group of five hundred breast cancer activists in Boston and expressed his support for these concepts:

The ability to make these chemicals [organochlorines] in high volume did not even exist prior to World War II. . . . They are not a legacy from the industrial revolution of the 19th century, but of the rise of the chemical industry of the 20th. They are

not woven into the warp and woof of our national fabric, but on the contrary, are recent and unwelcome newcomers.

I do not contend that all synthetic organic chemicals should be banned. Neither do I advocate a return to the days of celluloid and castor oil. From what I understand, celluloid was flammable and brittle, and I'm sure castor oil had its own problems. However, I am convinced that human inventiveness is not restricted to acts of war. The path that chemistry has taken in the last half of this century is only one path—and not even a particularly imaginative one.

Some solutions may indeed be found through the rescue of chemical processes abandoned years before—as in the quiet decision of many daily newspapers to switch to soy-based inks—while others may be sought through altogether new applications of knowledge. Chlorine-free methods of bleaching paper are possible and are already in small-scale commercial use both here and in Europe. Citrus-based solvents, ultrasonics, and old-fashioned soap and water can often replace chlorinated solvents used for degreasing operations and precision cleaning of electronic parts. New methods of embalming and different attitudes about the role of funeral services can reduce the use of formaldehyde in mortuaries.

Sweeping changes are immediately possible in the dry-cleaning industry. Most clothing tagged as “dry-clean only” can in fact be professionally cleaned with the use of water, special soaps, and reengineered washing machines that allow computerized control over humidity, agitation, and heat. (Pressurized carbon dioxide also holds promise as a nontoxic solvent for cleaning textiles.) The Boston area, for example, is home to one such wet-cleaning operation, a pilot project of the Toxics Use Reduction Institute. I recently delivered to this shop a down coat, a silk dress, a badly stained antique kimono, and a pile of my best wool, cashmere, and rayon suits. All came back clean, beautifully pressed, and odor-free. The white streak across the sleeve of the green blazer—the result of an encounter with a freshly painted doorframe—was gone. Best of all, the proprietor, who appeared about eight months pregnant, expressed to me her relief at not having to be exposed to perc.

Most of the perchloroethylene manufactured in the United

States is used by the textile and dry-cleaning industry. In 1992 alone, 12.3 million pounds of this organochlorine and suspected carcinogen was released into air, ten thousand pounds to rivers and streams, and nine thousand pounds to land. Thirteen thousand pounds were directly injected into underground wells. The recycling of perchloroethylene produces contaminated sludge and filters, which are subsequently deposited in landfills where they poison soil. Traces of perchloroethylene have been found in breast milk, cow's milk, meat, oil, fruit, fish, shellfish, and algae. Perc has been detected in rainwater, seawater, river water, groundwater, and tap water. More than 650,000 workers are thought to be exposed to perc on the job, and an estimated 99,000 New York City dwellers are exposed to elevated levels just from breathing—many because their office or apartment shares the same building with a dry-cleaner. A 1993 survey found that 83 percent of New York City apartments located above a dry-cleaning establishment had ambient perc levels in excess of state health guidelines.

It is time to start pursuing alternative paths. From the right to know and the duty to inquire flows the obligation to act.