Dow Chemical issues quarterly updates of its performance on a set of environmental goals it intends to achieve by 2015. One goal is to cut the transportation of hazardous chemicals by 50 percent. By 2009 the number of ton-miles (one ton of freight moved one mile) dropped from 1,400 million to 851 million since 2005 when measurement began. Walmart has asked its 100,000 suppliers to calculate the full environmental costs of each product it sells. It plans to tag store items with a simple sustainability index.

CONCLUDING OBSERVATIONS

In the previous chapter we described how industrial activity harms the environment and explained major regulatory programs to mitigate the damage. In this chapter we looked more deeply into the methods underlying this regulation. We began with a story about railyard diesel exhaust to illustrate one molecular-level danger to human health in modern industrial society. Then we explained how such a danger is evaluated and how a regulatory approach is then chosen to mitigate it. We also give some illustrations of how companies are greening their operations.

The discussion emphasizes the strengths and weaknesses of both science-based risk assessment and a range of regulatory approaches. Command regulation is the most powerful, effective tool in the regulatory arsenal. Market approaches are more flexible and less expensive but have permitted companies to pay and continue polluting. Voluntary regulation is inexpensive, but often accomplishes little. Finally, voluntary corporate action can bring slow and modest, but widespread change. As thousands of companies around the world set out to measure their environmental impact and reduce it, their actions may be sufficient to slow the growth of pollution, if only in a small way.

In sum, much progress has been made in protecting both ecosystems and human health. Notwithstanding, the sum of human action is so far inadequate to avert rising global damage. The consequences of this failure will fill future chapters.

Harvesting Risk

This is the story of a scavenger. Ascending on shrewdness, Amvac Chemical Corporation has expanded from a small Los Angeles pesticide company into a multinational corporation with revenues of more than $200 million.[1] It keeps expanding. In the last several years it has added five new product lines, two foreign sales offices, and two factories.

[1] Amvac operates as a wholly owned subsidiary of a holding company named American Vanguard Corporation and is the company's main business.

Amvac's growth is based on a singular strategic vision. It stands apart from agrichemical industry giants as they create and market new pesticides. It waits while the big companies build brand names and markets for these molecules. Then, when a product has aged or become less attractive to the original owners, Amvac offers to buy it. Once Amvac has the brand rights, it pushes sales in remaining niche markets or, sometimes, opens new markets by registering additional crop applications or exporting to foreign customers. In this way, as the global behemoths shed shrinking, failing, dangerous, or obsolete products,

the opportunistic scavenger captures fresh streams of revenue.

Amvac's goal is to acquire one or two niche product lines every year and in recent years it has done so. Big agricultural chemical companies discard pesticides for many reasons. As they integrate businesses after mergers, they may decide to drop redundant brands. When Novartis and AstraZeneca merged their agribusinesses in 2000, Amvac got two vegetable crop insecticides and a herbicide used in cranberry fields. Sometimes big companies cast aside products when sales are inadequate. In the 1990s DuPont created a soil insecticide named Fortress that effectively controls corn rootworms, the most destructive cornfield pests. But sales missed targets. So Amvac bought Fortress in 2000 and with it entry into the Midwest corn market. It built a new sales team and within a year Fortress sales that would have disappointed DuPont were adding materially to Amvac's revenues.

In some cases products have matured or become outdated. Larger firms at the forefront of advancing biotechnology are shifting their focus from chemical poisons to genetic lines of insect-resistant seeds. As they do, Amvac has acquired older pesticides, including some organophosphates belonging to a family of pesticides that is on the way out in the industry.

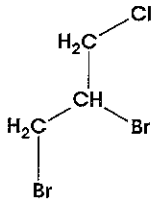
Organophosphate molecules are effective pest killers and still widely used, but they are being superceded by both biotechnology products and by pesticides that better target pests and pose less risk. Some organophosphates are exceptionally dangerous to human health in terms of both acute and long-term exposures. A few are so toxic that they defy safe use, leading to personal injury lawsuits and regulatory crackdowns. Even in these instances Amvac sees opportunity. Faithful to the logic of its niche strategy, it has acquired rights to some of the most poisonous brands even as bigger companies cease their production. Then, it has sought new markets for them while defending them against alarmed regulators. Here are several stories about Amvac pesticides.

DIBROMOCHLOROPROPANE

Dibromochloropropane, or DBCP, is a chemical soil fumigant that kills parasitic worms feeding on fruit and vegetable crops (see Exhibit 1). It belongs to an aging class of organochlorine pesticides developed after World War II. Most of these molecules, which include DDT, are used now only in a few poor countries. They are stable molecules that linger in the environment and accumulate in human tissue. Beginning in the 1960s, DBCP was used in the United States and around the world on cotton, potato, banana, and pineapple crops. Dow and Shell manufactured it until 1977, when it was discovered to cause sterility in men at formulating plants.[2]

EXHIBIT 1 Dibromochloropropane

Source: National Institutes of Health, http://ntp.niehs.nih.gov/ntp/htdocs/structures/2d/TR028.gif.



Chemical Formula: $C_3H_5Br_2Cl$

Regulators immediately banned DBCP in California. On the day of the ban, Dow and Shell suspended its production and marketing. Although the story of worker infertility got extensive media coverage, many farmers still wanted to use DBCP. So Amvac stepped in to fill the void and became its leading maker. Due to bad publicity, domestic sales had fallen, so Amvac supplied foreign markets. It replaced Dow and Shell as a supplier for Dole Fruit and other companies using DBCP on large banana plantations in Central America and the Caribbean.

By 1979 the EPA had gathered extensive data on DBCP and concluded it had no safe uses. The agency proposed a ban. Amvac disputed the evidence and finally persuaded regulators to allow an exception for Hawaiian pineapple crops. It agreed to promote safe application and to monitor local groundwater for contamination. In 1983 Amvac applied for a temporary exemption from the regulatory ban in South Carolina so that DBCP could be used in peach orchards. The EPA agreed, basing its decision on university research sponsored by Amvac. Outraged environmentalists stopped the exemption with a lawsuit.[3] Two years

[2] Helen Dewar, "Workers at Pesticide Plant Found Sterile in California Tests," *The Washington Post*, August 5, 1977, p. A3.

[3] Ward Sinclair, "The Return of DBCP," *The Washington Post*, February 1, 1983, p. A1.

later, Hawaiian wells for drinking water were found contaminated by runoff from pineapple fields and the EPA finally banned all applications of DBCP anywhere in the United States.

By this time evidence of DBCP's dangers was strong and before the end of the decade a substantial body of research backed up the agency's decision. DBCP causes sterility in both animals and humans. Studies showed that men who inhaled small concentrations produced fewer sperm and were more likely to father girls. With longer exposures their testicles atrophied and sperm production fell to zero.

DBCP is so dangerous that current regulations set safe inhalation exposure for workers at one part per billion over an eight-hour day. DBCP also causes cancer in rats and is classified as "reasonably anticipated" to be a human carcinogen. Like other molecules in the organochlorine family, it persists in the environment. After application it slowly evaporates from soil or surface water into the air, where it resides for up to three months before breaking down. In soil, it can linger for several years.[4]

DBCP bore a crop of lawsuits for Amvac. Villagers who drank contaminated water in Hawaii sued Amvac, along with Dow, Shell, and Dole Food Company, after researchers found unusual clusters of breast cancer, heart defects, learning disabilities, and infertility among them.[5] Amvac settled its part of the case for $500,000 in 1999. With the others, it was also named in multiple actions by Nicaraguan plantation workers charging that the companies continued to sell DBCP in developing nations after it was banned in the United States despite knowing it caused sterility, testicular atrophy, and other injuries.

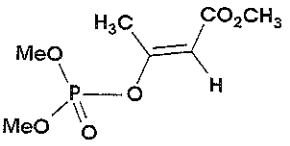
These workers opened a broad legal war against Amvac and the others but it has fizzled. The last of the banana workers cases were dismissed in 2010 after the discovery that attorneys had engaged in widespread fraud, recruiting plaintiffs by sending men to labs that faked sperm tests to show sterility.[6] Another case, by banana and pineapple workers in the Ivory Coast, alleged the companies used DBCP for genocide and crimes against humanity. However, because the workers could not prove the companies intended to commit genocide they lost the decision.[7]

MEVINPHOS

Mevinphos (see Exhibit 2) is an insecticide developed by Shell in 1954.[8] It protects fruit and vegetable crops against aphids, leaf miners, mites, grasshoppers, cutworms, and caterpillars. It belongs to the organophosphate family of pesticides, which disrupt transmission of nerve impulses by blocking the action of critical enzymes. Organophosphates are unstable and break down rapidly in the environment so growers can use them to combat infestations that come just before harvest. Their drawback is an extreme and broad toxicity. They poison any living organism with a nervous system, including humans, fish, and animals. Consequently, large agrichemical companies are moving away from organophosphates to newer molecules that not only are less toxic but also more narrowly target pests.

EXHIBIT 2 Mevinphos

Source: Environmental Protection Agency, *Report on Tolerance Reassessment Progress and Risk Management Decision*, EPA 738-R-00-014, September 2000, p. 4.



Chemical Formula: $C_7H_{13}O_6P$

[4] U.S. Public Health Service, Agency for Toxic Substances and Disease Registry, *Toxicological Profile for 1,2-Dibromo-3-chloropropane* (Washington, DC: Public Health Service, September 1992); and Environmental Protection Agency, "1,2-Dibromo-3-chloropropane (DBCP) (CASRN 96-12-8), Integrated Risk Information System, at www.epa.gov/iris/, last revised October 28, 2003.

[5] Malia Zimmerman, "Water Quality Lawsuits Target Chemical and Agricultural Giants," *Pacific Business News*, October 8, 1999, p. 4.

[6] Steve Stecklow, "Fraud by Trial Lawyers Taints Wave of Pesticide Lawsuits," *The Wall Street Journal*, August 19, 2009, p. A1.

[7] *Abagninin v. Amvac*, 545 F. 3d 733 (2008).

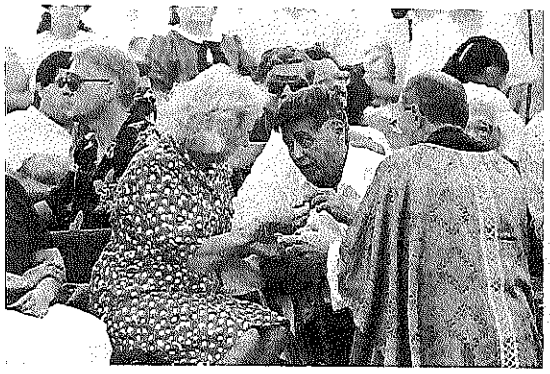
[8] Mevinphos is technically an alpha or beta isomer of 2-carbomethoxy-1-methyl-vinyl dimethyl phosphate. Exhibit 2 shows alpha-Mevinphos. It has been sold under the trade name Phosdrin in at least four formulations. See Department of Pesticide Regulation, *Mevinphos: Risk Characterization Document* (Sacramento: California Environmental Protection Agency, June 30, 1994), p. 5.

After their introduction in the 1950s, organophosphates such as mevinphos were second choice pesticides. Growers preferred to use organochlorines until concerns about the inability of nature to break them down turned the market toward the shorter-lived organophosphates. By the late 1970s mevinphos was being sold in large quantities. DuPont held the rights to it. Amvac manufactured some mevinphos at its Los Angeles factory under contract for DuPont.

As mevinphos was used more widely, concerns about its safety grew. Multiple reports of farmworkers sickened by contact with it alarmed regulators. In 1978 the EPA restricted its use, so that only certified applicators could spray it on fields.

In 1988 the leader of the United Farm Workers, César Chávez, held a 36-day hunger strike to protest the use of organophosphate pesticides, including mevinphos, on grapes. He believed their use recklessly endangered the health of field hands. In fact, subsequent research confirms multiple effects in exposed farmworkers. For example, after prolonged exposure they show deficits in coordination, information processing, and other neurologic symptoms.[9] Children of Latina women in agricultural communities show impaired behavioral development.[10]

A few months after Chávez's hunger strike, DuPont ended mevinphos production. Amvac, however, was willing to embrace it. DuPont sold its exclusive rights to Amvac, which continued to sell mevinphos even as the EPA was gathering further evidence of its dangers. In early 1993 the agency called mevinphos one of the five most dangerous pesticides. It had reports of 600 poisonings and five deaths over the previous decade and calculated that the rate of poisonings was 5 to 10 times higher than for any other product.[11] Before banning mevinphos, however, it allowed Amvac to suggest risk-reduction measures that might allay its concerns.[12]



César Chávez, president of the United Farm Workers, receives a small piece of bread from Ethel Kennedy, widow of former Attorney General Robert Kennedy. Her symbolic action ended a 36-day hunger strike in 1988 undertaken to protest the exposure of grape pickers to mevinphos and other pesticides. Source: © Bettmann/CORBIS.

Meanwhile, Amvac saw a new market opportunity. Large agrichemical companies had taken several other organophosphate insecticides off the market to placate the EPA. Apple growers in Washington were concerned that they would be unable to fight off ruinous late-season aphid infestations. Amvac believed that mevinphos could be safely used, even though regulators in Washington allowed pesticides to be mixed in open vats before spraying. Other states, for example California, required closed-vat mixing. Amvac negotiated with Washington's regulators, promising to train workers in the use of respirators and safe application.

That summer there were immediate reports of mevinphos poisonings in Washington orchards. In all, there were 26 documented cases. No one died, but seven workers were hospitalized. Martin Martinez, who later sued Amvac, was told to mix a concentrate of mevinphos with water, load a sprayer, and apply it. "My vision started to get blurry," he said. "I started to get nauseous. I began to vomit."[13] These are classic symptoms of organophosphate poisoning. He was hospitalized for seven days.

[9] Joan Rothlein et al., "Organophosphate Pesticide Exposure and Neurobehavioral Performance in Agricultural and Nonagricultural Hispanic Workers," *Environmental Health Perspectives,* May 2006.

[10] Brenda Eskenazi et al., "Organophosphate Pesticide Exposure and Neurodevelopment in Young Mexican-American Children," *Environmental Health Perspectives,* May 2007.

[11] David Holmstrom, "Control of Farm Chemicals Needs Overhaul," *Christian Science Monitor,* October 6, 1994, p. 7; and *Andrews Litigation Reporter,* "Settlement Reached between Farm Workers and Pesticide Maker," May 31, 2002, p. 1.

[12] Environmental Protection Agency, *R. E. D. Facts: Mevinphos,* EPA-738-F-94-020, September 1994, p. 2.

[13] Arthur C. Gorlick, "Orchard Workers File Lawsuit," *Seattle Post-Intelligencer,* September 13, 1995, p. B4.

Martinez and others had been trained. They were supposed to wear respirators, face shields, and chemical-resistant clothing. However, mevinphos is so toxic that even a slight mistake is very dangerous. Some poisonings took place in hot weather, when applicators shed articles of clothing. Absorption through skin is rapid. Ten drops of concentrate spilled on flesh is a lethal exposure for a 150-pound person. Inhalation is also dangerous. A 150-pound person who failed to adjust a respirator properly would begin to show effects such as dilation of the pupils after breathing little more than one ten-thousandth of an ounce.[14]

Once inside the body, mevinphos interferes with the regulation of nerve impulses, disrupting the central nervous system and major organs. One of the earliest symptoms of exposure is compromised reasoning ability, which compounds the danger because a worker loses the ability to appreciate an urgent peril. High exposure eventually leads to irregular heart beat, convulsions, unconsciousness, and death. Breathing air with only 10 parts per million of mevinphos over one hour killed 50 percent of rats in one study.[15]

Three orchard workers, including Martinez, sued Amvac alleging that mevinphos was a defectively designed product. It was so unsafe, they argued, that it should never have been marketed for orchard use. At one point, the case went to the Supreme Court of Washington, which handed down a ruling on a point of product liability law. It noted that a pesticide, by its nature, was a dangerous product. Its costs to society could be eliminated only by sacrificing the lethal qualities that made it effective. The question was, when was a pesticide too dangerous, too lethal?

The court ruled that a pesticide could be sold as an unavoidably unsafe product if its advantages greatly outweighed the risks posed by its use.[16] It would be up to a lower court to decide if mevinphos passed this test. However, Amvac ended the lawsuit by settling with the orchard workers for approximately $750,000. According to one of their lawyers, Amvac "was willing to sacrifice farmworker's lives and safety for profits. It had to be held accountable."[17]

Meanwhile, Amvac defended mevinphos before the EPA but was unable to convince the regulators it could be safely used. All pesticides must have EPA registration for legal use. With the agency prepared to cancel registration of mevinphos, Amvac voluntarily requested its withdrawal.

The EPA now classifies mevinphos as hazardous waste and bans any agricultural use in the United States. Nevertheless, Amvac continued to sell it in Mexico, South Africa, and Australia.[18]

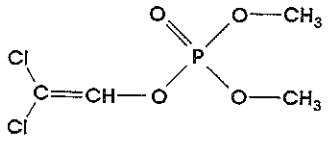
DICHLORVOS

Dichlorvos, or DDVP (see Exhibit 3), is another aging member of the organophosphate family abandoned by the big agrichemical firms but still sold by Amvac. It was synthesized in the late 1940s and first marketed by Shell in 1961. It targets a broad range of insect pests including flies, fleas, ticks, mites, cockroaches, chiggers, caterpillars, moths, and weevils. Like other members of the organophosphate family, it disrupts transmission of nervous impulses.

At first DDVP had many agricultural applications. It was used in silos, hoppers, and tobacco warehouses to protect stored crops. In feedlots it was sprayed over animals to control fleas and ticks. Farmers mixed it in feed to deworm horses and pigs. Canning and packing facilities applied it to control insects. It was sprayed over wide areas for mosquito control and used as the active ingredient in popular

EXHIBIT 3 Dichlorvos

Source: Environmental Protection Agency, *Interim Reregistration Eligibility Decision for Dichlorvos (DDVP)*, EPA 738-R-06-013, June 2006, p. 11.



Chemical Formula: $C_4H_7C_{12}O_4P$

[14] Based on a "no observable effect level" in humans of 0.025 mg/kg, see Department of Pesticide Regulation, *Mevinphos: Risk Characterization Document*, p. 1.

[15] Ibid., p. 1.

[16] *Guzman v. Amvac Chemical Corporation*, 141 Wn.2d 493, at 509–10.

[17] Co-lead counsel Richard Eymann, quoted in "Precedent-Setting Farm Worker Pesticide Poisoning Suit Settles," *Public Justice*, Summer 2002, p. 11.

[18] T. Christian Miller, "Pesticide Maker Sees Profit When Others See Risk," *Los Angeles Times*, April 8, 2007, p. A1.