The Woods Hole institution has made it clear that it wants the *Titanic* to remain where it is, unsalvaged, as a memorial to those who died. But although the vessel is protected from scavengers by the technical unfeasibility of large-scale salvage operations, there is the danger that entrepreneurs could come out with grappling hooks and cause considerable damage in attempts to snag artifacts from the debris. To forestall this, Representative Walter B. Jones (D–N.C.) has introduced a bill to designate the *Titanic* as a maritime memorial to be kept intact while the National Oceanic and Atmospheric Administration establishes guidelines for research, exploration, and salvage. It also directs the United States to negotiate with other countries a permanent international agreement to preserve the wreck.

The discovery of the *Titanic* has opened a new era for the many students of the disaster, as well as many potential legal questions. In fact, the day before the press conference—in which Ballard warmly praised the French-American cooperation—INFREMER filed suit in United States District Court in Washington, seeking to block distribution of photographs without its consent and claiming that Ballard was violating a copyright agreement. The Woods Hole institution says everything has been straightened out and that the photos, which were made under a Navy contract, are under no restrictions. Some confusion remains, though. The French announcement of the find described detailed agreements made between the two research teams in June, but the Woods Hole institution says it does not know of any agreements.

Ballard took off for a rest and could not be reached. His next project will be to take the *Argo* on its first scientific mission in December, exploring the mountains and hot vents of the East Pacific Rise.—**CONSTANCE HOLDEN**

The Rise and Decline of Temik

Once hailed as a miracle pest killer and still warmly regarded by farmers, it is being investigated, denounced, and threatened with federal controls

Temik and its pesticide cousin, Sevin, have been at the center of a lot of agony in the last year. Sevin was made in the factory at Bhopal, India that leaked a process gas in December, killing over 2000 people. Temik was implicated in the West Coast's watermelon crisis of July in which 998 people were poisoned. Temik also was the end product of the factory at Institute, West Virginia that leaked several gases in August, sending 135 people to the hospital but causing no serious injuries. Finally, the Environmental Protection Agency says Temik has turned up as a contaminant in ground water in 15 states.

This pesticide family, the carbamates, has come down in the world since their introduction in the late 1950's and early 1960's. They once were regarded as clean, narrowly targeted, even miraculous pest killers. Now they have fallen into the dark tradition of older pesticides. Temik is being reinvestigated, denounced, and threatened with new federal controls.

Temik's fall from grace makes an interesting tale. It deals with the consequences of asking too much of technology. It also hints at the clumsiness of institutions that are supposed to monitor such chemicals. For often they do not begin to face up to problems until extensive damage has been done, when the public is understandably scared. This leads to draconian measures, which in this case could mean removing a valuable and relatively clean pesticide from the marketplace.

The carbamates have a long lineage. The first to exploit a carbamate poison were the Egbo rulers of Nigeria, who used a water extract of the Calabar bean in witchcraft trials. (If you survived, you were demon-free.) The beans were taken to Scotland, sprouted, and studied during the mid 1800's. The toxin was identified in 1863, but the molecular configuration was not established until 1925. A chemist at E. I. du Pont de Nemours in 1931 invented the first insecticide based in the broad carbamate family, but it was overshadowed by more powerful toxins developed during and after World War II. The first modern carbamate insecticide was invented by Hans Gysin of the Geigy Chemical Company in Switzerland in 1947, but it, too, had limited use.

German researchers during the war became aware of the insecticidal power of chemicals related to the phosphoric nerve gases sarin, soman, and tabun. This led to the postwar development of the organophosphate pesticides, which also act on the nervous system. Meanwhile, Paul Müller in Switzerland had discovered DDT (a chlorinated hydrocarbon), a powerful stomach poison. Together, the organophosphates and DDT's family of toxins dominated the market through the late 1950's. They had flaws: they did not degrade quickly and accumulated in the food chain. DDT was banned in the United States in 1973, and many organophosphates have been phased out.

In 1953 Joseph Lambrech of the Union Carbide Company invented the first major carbamate, Sevin, known generically as carbaryl. Because it degraded rapidly and had very low toxicity in mammals, it became an immediate success. By 1971, 55 million pounds were produced annually in the United States.

In 1954 a group of scientists working with Robert Metcalf at the University of California at Riverside published an analysis of the means by which carbamates attack the nervous system, suggesting ways to increase potency. Capitalizing on this and the Swiss data, two scientists at Union Carbide—L. K. Payne and M. H. J. Weiden—in 1962 designed a new carbamate molecule closely modeled on acetyl choline (ACh), an organic substance that transmits impulses across insect and mammal nerve endings. Once ACh has carried a nerve signal, it is removed from the path by an enzyme, acetyl cholinesterase, clearing the way for the next signal.

The effect of organophosphate and carbamate pesticides is to frustrate the path-clearing work of the enzyme by mimicking ACh and "tricking" the enzyme into clinging to the synthetic rather than the true chemical. The nerve endings become loaded with signals, locked in permanent stimulation. This leads to uncontrolled movement, paralysis, and death. A crucial difference between the phosphate and the carbamate molecule is that the former locks into place firmly and refuses to let go, while the latter has a "spontaneously reversible" attachment. A person recovers slowly (weeks) from organophosphate poisoning, but

quickly (6 hours) from carbamate poisoning simply by eliminating the toxin in urine.

Union Carbide's new, potent molecule of 1962 was called Temik, or generically, aldicarb. It is at least 250 times more deadly for mammals than DDT and 850 times stronger than Sevin. It is one of the most toxic of all pesticides.

Every chemical needs a champion; Temik's is Richard Back of the corporate development office at Union Carbide. He proved his faith 15 years ago when he imbibed the company's flagship product—a stinger of Temik-and-water—at about one-tenth the lethal dose. (One milligram of aldicarb per kilogram of body weight was lethal for 50 percent of the rats tested. Back's dose was 0.1 mg/kg.) He was one of 12 volunteers in a toxicology study that included some uneasy fieldworkers. He recalls that it made him "weak and nauseous."

Back says aldicarb is a "remarkable acute poison without any chronic effects." In 20 years of study, Back says, no one has found a carcinogenic, neurotoxic, reproductive, or any other subtle risk to mammals from exposure to it. There appears to be no dissent to this view, except for some very recent work by researchers at the University of Wisconsin who claim to have found a correlation between low doses of aldicarb and suppression of the immune system in mice. Their data have not been confirmed.

Aldicarb is extremely powerful, though. For this reason Union Carbide (the sole manufacturer) decided in 1964 to distribute it only as a dust-free, granular material that can be dug into the soil. Its toxins are highly mobile in water and are taken up by roots and carried throughout a plant's system. Aldicarb was one of the first major "systemic" pesticides (hence the name "Temik"). It is so strong that two or three months after it has been applied near the roots it will kill an insect biting a leaf.

Crop trials began in the early 1960's. An early scare, known as the "Mrs. Kelly case," occurred in 1969 in Wenatchee, Washington, when a state employee gave his wife some experimental Temik for the roses at home. Three weeks after applying it, Mrs. Kelly ate a leaf of spearmint growing near the roses. She became extremely sick and required a shot of atropine sulfate, the antidote for nerve agents.

Carbide officials decided she was an atypical case, more than usually sensitive. But to be certain that people as a class of mammals were not more sensitive than rats, Back says he "persuaded the medical staff" to run the human test in which he drank a dose of aldicarb. Later, the data were used to convince the government there would be no harm in allowing residues in food crops.

A state chemist checks watermelons for pesticide after Independence Day weekend, when more than 998 people were poisoned. California officials believe two growers used aldicarb illegally and produced nearly all the tainted melons.

"The goal from the outset was to register it for cotton, I'm sure," says Richard Ridgway, an Agriculture Department researcher who ran some of the first tests on aldicarb in Texas. Its potency against the boll weevil "excited everybody" in 1964. But as time went by, Reynolds says, "What started out to be a dream began to turn a little more realistic." It became clear that "beneficial" insects that prey on pests also at times suck on crops to get water. Ridgway had hoped that aldicarb would kill only the destructive bugs, but field tests showed it killed a fair number of the helpful ones too.

H. T. Reynolds, who undertook early cotton studies at the University of California at Riverside, recalls that aldicarb "did make the plants look good—nobody knows why." However, boll worms also liked the look of treated plants and favored them with their eggs. "Based on our data, [aldicarb] didn't always work to the grower's advantage. We never did recommend its use in California." Reynolds adds, "That doesn't mean growers didn't use it."

Several researchers and many growers who have written to EPA about aldicarb describe its almost magical ability to make plants look healthy. Oranges from treated groves look bigger and brighter; leaves seem fuller and lusher; crops generally seem to thrive and come to fruit sooner. While no one has explained the effect, no one disputes it either. Unquestionably it has contributed to aldicarb's success.

Aldicarb is used as a killer of leaf pests and, more important, as a protection against nematodes, small worms that attack roots, often bringing viruses with them. Union Carbide has submitted reams of test results to EPA showing that it improves not just appearances but crop yields, with reported increases ranging from 7 to 50 percent, in some cases even more.

Aldicarb was first registered in the United States for cotton in 1970 and for potatoes in 1974—two of the biggest uses. It is used virtually everywhere in the world where citrus is grown. It is registered in 33 countries for potatoes and 28 for cotton. Wherever it is used, the active ingredient is dug into the soil at a rate of 10 pounds per acre for citrus and 1 to 3 pounds for most other uses. Small residues are allowed in many foods, including bananas, beans, beef, citrus fruit, lamb, milk, peanuts, pecans, pork, potatoes, soybeans, and sweet potatoes.

From the time of the Mrs. Kelly case until 1977, aldicarb had a fairly clean record, says Robert G. Haines, a former Union Carbide employee who helped register the pesticide. Then it began to turn up in water on Long Island, where it was used on nearly every one of 20,000 acres of potato farms. According to Haines, this problem was anticipated by a test in Arizona in 1971. Samples taken from a sugarbeet field there, Union Carbide found, showed that the toxic breakdown products of aldicarb penetrated 12 feet deep, enough to reach ground water in some areas. Haines writes, "It was at this time that EPA (now operating) learned that aldicarb moieties could go into the ground water."

Union Carbide dates the Long Island problem officially as beginning in August 1979. This was four years after aldicarb was introduced to the area, two years after EPA gave Long Islanders permission to use it in extra heavy applications (5 pounds an acre), and one year after New York had given farmers permission to add an extra 2 pounds per acre above the EPA limit. EPA went along with the extra-extra heavy dose in May 1979.

Well tests in December 1978 showed that aldicarb was leaching into the water. This was confirmed in August 1979, when Carbide notified EPA. The company eventually asked for a moratorium on the use of aldicarb in Suffolk County on

Long Island. Another heavy use area, Del Norte County, California, imposed a ban in 1983. Carbide has sampled more than 17,000 wells on Long Island alone and found 2300 to exceed EPA's health advisory level for aldicarb in drinking water (10 parts per billion). Haines says that 6000 wells have been fitted with carbon filters at Carbide's expense.

Summarizing the problem in 1980, Back wrote: "Union Carbide believes portions of the ground water on Eastern Long Island contain aldicarb residues due to a unique set of circumstances which favored greater leaching than might normally be expected." Among these were high rainfall, clean sandy soils, a shallow water table, and heavy aldicarb use. In its official scientific assessment paper (1983), Carbide describes this as an "unusual combination of environmental conditions."

But Long Island may not be unique. Stuart Cohen, leader of EPA's groundwater team, reports that ground water residues have been found in 15 states, with overlimit conditions in eight. Furthermore, as EPA official Hale Vandermer points out, very few samples have been taken in some of the high-risk states like Mississippi, Louisiana, and Alabama, heavy aldicarb users and the recharge source for Florida's ground water. Florida has tested over 1000 wells and already found over 500 to contain aldicarb. There are other suggestive numbers, Vandermer notes, such as Missouri's two strong positives (30 to 50 ppb) out of five samples. Oregon, which has a county with the same agriculture and water system as the one next door in California where aldicarb is banned, has not found any residues.

Carbide has two reasons for thinking the ground water problem is not serious. First, the levels are moderate. The highest reading ever found, Back says, was in a well on Long Island, at 500 ppb. Even that level is below the point that might cause a reaction.

Using his own aldicarb cocktail as a guide, Back calculated in 1980 that a 10-kilogram infant could drink a quarter-liter of water containing 2000 ppb of aldicarb with no effect. On a 24-hour basis, Back calculated that even with a ten-fold safety factor, the same infant could drink a lifetime's worth of Long Island water with a reading of 600 ppb. Typical samples in other states are in the range of 1 to 50 ppb. Because it thinks the risk is slight, Union Carbide, with the backing of EPA's science advisory panel, has asked to have the official aldicarb warning level relaxed from 10 ppb to 30 or 50 ppb.

The second reason for keeping cool, Back says, is that "in general, residues are going down." The worst Long Island well has dropped from 500 to 125 ppb, and Back predicts the crisis will be over in "another year or two."

Other scientists are not so confident. H. B. F. Hughes and K. Porter of Cornell University concluded in a July 1985 report that at present rates of decline, Long Island's aquifer could be contaminated for a century. John Harkin, who has been studying aldicarb residues in Wisconsin for several years, says he has become discouraged because the situation appears to be "very, very unpredictable." While readings are declining in many wells, they are rising in others, and not in any clear pattern. Furthermore, not all agree with Carbide that the toxins will degrade rapidly. Recent studies have found that in cool anaerobic conditions (as in northern aquifers), and in limestone water (as in Florida), breakdown takes much longer. To the extent that readings are declining, many think it is because aldicarb's use has been curtailed, and residues are being diluted.

Aldicarb improves not just appearances, but crop yields, with reported increases ranging from 7 to 50 percent or more.

As Carbide was coping with these problems and the disaster in Bhopal, it was hit on the 4th of July with what Haines calls "the great watermelon bust." A group of Californians became sick after eating watermelon at a holiday picnic. One of them consulted the Centers for Disease Control and called a press conference on Independence Day to give the diagnosis: aldicarb poisoning. Since then California epidemiologist James Stratton has received 1300 complaints, and among these he has confirmed 638 "probable" and 344 "possible" poisonings locally, and 360 probable cases out of state. One child had grand mal seizures; a middle-aged woman nearly died; and one stillbirth was associated with the poisoning.

It is "absolutely not" true that this could have come about through legitimate use of aldicarb, says Richard Back. (Carbide never asked for permission to use aldicarb on watermelons because its research shows the toxin can be concentrated in the fruit.) Growers have suggested that cotton fields recently converted to melon patches might have contained some residual aldicarb. Back says that is inconceivable. California has a criminal investigation underway and officials will not comment. The unofficial word is that two growers who should have known better used aldicarb illegally.

The widening file on aldicarb hints that its success could also be its downfall. Its tremendous popularity—the result of its lethality and strange invigorating power—may have propelled it to unmanageable abundance. What remedies are available?

Leaving aside the problem of running chemical factories more safely, an obvious environmental remedy would be to have a moratorium on its use. Haines likes the idea. He says, "Temik is like fire: it's a great servant but a lousy master," and he thinks it is getting the upper hand. In a column he writes, he urged Union Carbide to take aldicarb off the market, at least temporarily, to win public confidence. It might be possible to introduce it again later, he wrote.

Others, including Metcalf, author of early carbamate structural research, think aldicarb should be restricted to nonfood crops.

Union Carbide and the growers strongly resist these suggestions. The company proposes instead that EPA add new instructions to the pesticide label. These would impose new limits to restrict use of the chemical near drinking wells; they would warn against overirrigation; and they would reduce the levels of application. In addition, a Carbide spokesman says, state governments should inflict "some realistically stringent fines for misuse, not just $500."

EPA began a special review of aldicarb in 1984, due to be finished by the end of this year. Stuart Cohen calls it a "tweenie" chemical, in between the clearly dangerous and clearly benign. Aldicarb has many benefits and, until now, it has carried little risk. One virtue is its efficiency, for a single digging-in of aldicarb, growers say, takes the place of several messy spraying operations. And aldicarb is an unparalleled nematode poison. But, as Cohen points out, the places where nematodes thrive are the very places where soil qualities make it risky to use aldicarb. The problem is that "what makes a great nematicide also makes a great ground water pollutant."

EPA has received about 250 comments on its review of aldicarb. All but two or three are from users who want the agency to keep out of their way. As Cohen says, it will be the hardest case to decide this season.—**ELIOT MARSHALL**