effect, is a shrinking share of resources, says Telson. And "it will take more than a presidential request to see that Congress delivers the money."

One way to buffer R & D against the prevailing uncertainties would be to put it under a system of multiyear funding, but no strong hopes were held out that this will happen. As speaker at the wind-up lunch for the colloquium, Senator Harrison Schmitt (R–N.M.) did say that he was taking the lead in an effort to frame legislation requiring a comprehensive research and technology budget for R & D in order to counter the fragmentary approach to R & D matters.

If there was a surprise popped at the colloquium it was probably Keyworth's upbeat estimate of future U.S. prospects in high-technology competition with Japan. While Keyworth credited the Japanese with taking full advantage of technology transfer, particularly from the United States, and doing "some things very well," he went on to say that "the Japanese are concerned about their own future because they lack the very strengths that we have in abundance—creativity and flexibility." He quoted press reports that portrayed the Japanese as worried about the adaptability of their management and corporate finance systems and said that the society's emphasis on "community, obedience, and uniformity" made for highly efficient assembly lines but discouraged "far-reaching product invention."

When a questioner suggested that the Japanese have recognized their shortcomings in this respect and are taking steps to overcome them so that it would be wrong to be "complacent that the Japanese will defeat themselves," Keyworth replied rather starchily that he and his staff had given the matter considerable study including discussions with Japanese experts and he would "stand on my comments."

The reaction among those attending the meeting seemed to agree with those of AAAS executive officer William Carey who in remarks summing up the colloquium wondered "if the Administration was in the process of convincing itself that Japan Inc. was withering away," a view he characterized as "imaginative."—JOHN WALSH

Hawaiian Milk Contamination Creates Alarm

A sour response by state regulators

The analysis of milk samples at Albert Oda's laboratory was usually a routine matter. Every 6 months, colleagues of his in the Hawaii health department would collect some samples from local dairies to determine whether the milk was contaminated by pesticides. Roughly 9 million pounds of pesticides are used in Hawaii each year, and contamination is regarded as an ever-present threat but an unlikely occurrence. Oda says that the tests were always negative—until 21 January.

On that day, samples from several dairy farms and a milk plant on Oahu were shown to contain extraordinarily high levels of heptachlor,* a pesticide that causes cancer and liver disorders in mice and is considered a potential carcinogen in humans. Remarkably, health department officials reacted to this discovery as if nothing was seriously amiss. They allowed the milk to be sold and consumed. They sent the samples to a federal laboratory in San Francisco for confirmation. They waited. When the results were confirmed, they thought about it for awhile. They decided to collect more samples. When it was determined that these too contained heptachlor, still more samples were sought.

The public was finally informed 57 days after the initial discovery, when inquiries from a Honolulu newspaper forced the department to admit that milk supplies were contaminated. A limited recall was announced, and the remaining stocks were certified as pesticide-free. Within a few days, it developed that remaining stocks were also contaminated, and a more sweeping recall was issued. In this manner, department officials repeatedly certified milk and milk products, backtracked, and issued additional recalls.

After 11 successive milk recalls, public confidence in the dairy industry and state regulators has been shaken. George Yuen, a civil engineer who served as health department director for 7 years, felt compelled to take early retirement. And many of Oahu's 19 dairy farms are reeling in the face of enormous financial losses.

The parties involved are all anxious to blame someone else. The dairymen have sued one of the state's principal pineapple growers, the Del Monte Corporation, for $31 million, and another grower, Castle and Cooke Inc. (Dole), for unspecified damages, claiming that their cattle ingested the heptachlor in feed made from pineapple leaves. The state attorney general is weighing suits against the dairies and the pineapple growers. A citizen is suing the dairies and the state, seeking an injunction against the continued sale of contaminated milk. And there is a good chance that the entire country will foot the bill, through an obscure program in the federal Department of Agriculture, designed expressly to compensate dairy farmers for the loss of milk due to contamination by pesticides.

In the weeks after the contamination was revealed, health department officials sought vigorously to calm public fears that milk consumed during the regulatory delay was harmful. They did so in large part on the advice of scientists at the University of Hawaii, several of whom argued that the threat to public health was less serious than the potentially adverse consequences for the dairy industry. The medical consequences of the heptachlor exposure—if any—will not be manifest for years, but several other experts are concerned that infants in particular will suffer a heightened risk of leukemia or liver disorders. Studies of infant mortality during the period of exposure and potential liver enlargements in the subsequent period are being organized at a children's hospital and a state research center.

To understand the state's approach to the milk contamination, it is necessary to appreciate the significance of heptachlor to the vitality of the pineapple industry and therefore to the state's economy. Left to the rigors of nature, the pineapple

*In mammals, heptachlor is quickly metabolized into heptachlor epoxide, and this is the substance which the article refers to when describing either contamination or health risks.

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is vulnerable to the effects of the dreaded mealybug wilt, a withering of the roots caused by a toxin excreted by the mealybug. In a typical infestation, mealybugs attach themselves as parasites to the fruit and generate a substance known to pineapple agronomists as "honeydew." Mealybugs would engorge themselves and perish in a sea of honeydew were it not for the ant. Ants love honeydew, and so they cherish the mealybug by fending off its predators, transporting it from plant to plant, and consuming the excess secretion.

Pineapple growers discovered in the 1940's that wilt could best be controlled by pesticides that eliminated the ant, and since then have sprayed millions of pounds of DDT, mirex, and heptachlor on their crops. Each of these products was banned during the 1970's as a persistent environmental poison and a potential carcinogen in humans (see box). But during the federal hearings on heptachlor in 1978, the state of Hawaii and the Pineapple Growers Association of Hawaii intervened jointly to obtain an exemption for its continued use on the state's principal source of agricultural revenue. Despite a judgment by the National Academy of Sciences that heptachlor "may be carcinogenic in humans" and data indicating that fat cells of virtually every U.S. citizen contain heptachlor, the attorney representing the growers and the state said that his clients "do not concur or accept . . . that heptachlor use to control ants on pineapple poses a significant risk of exposure to man or the environment."

During the 1970's, the state's arguments on behalf of heptachlor and the growers' spraying operation were vigorously supported by agricultural scientists at the University of Hawaii. Protocols for heptachlor use were developed in consultation with faculty members; applicators were trained by the university's extension service. University biologists were the first to think of mixing pineapple leaves and other materials to form a wholesome diet for dairy and meat cattle, a practice that the university has studied and refined over the last 15 years. More recently, university engineers devised a machine that would cut the leaves close to the ground and gather them up into "green chop" for the feed. The Green Feed Cooperative was formed with money pooled from the state's dairy farms to harvest the leaves with the machine.

When the growers ultimately received federal permission to continue using heptachlor until an alternative was developed, they were supposed to abide by a requirement that green chop would not be collected and fed to cattle within a year of the most recent pesticide spray-

Tolerance of Zero Not a Zero Tolerance

As a potential human carcinogen, heptachlor is not supposed to be present at all in milk or meat, according to regulations of the Food and Drug Administration (FDA) in Washington, D.C. In the 1960's, when alarms about the pesticide were first sounded, the agency set what it refers to as a tolerance level of zero for heptachlor in foods. The agency's scientists could not guarantee that contamination was nonexistent, however, because their instruments recorded the presence of heptachlor only in quantities greater than 0.3 part per million (ppm) on a fat basis. So the agency established that amount as an action level, which means that milk containing more than 0.3 ppm would be the subject of regulatory action to remove it from the market.

This is the requirement that Oahu milk producers violated. According to estimates made by Albert Oda, director of the state's health lab, and by the FDA, samples in January contained as much as 2.7 ppm of heptachlor, or more than nine times the maximum allowed (one sample was thought to contain 5 ppm, but there is some uncertainty about it). In March, they contained as much as 2.8 ppm, and in June, when more than half of the dairies had ceased production under state order, as much as 0.96 ppm.

The discovery of widespread contamination, as well as public fears that even state-approved milk might be unsafe, has prompted the FDA and the Environmental Protection Agency (EPA) to reassess whether the action level of 0.3 ppm is appropriate. If the regulators were to follow the same principle used in the 1960's—the limit of scientific detection—the action level for heptachlor could be lowered to 0.05 ppm, one-sixth of the current level, or even lower. In its review of the level, however, EPA is now required to weigh the benefits of such a reduction against the costs to industry.

The benefits would largely be those that accrue to infants, who are particularly vulnerable to the adverse effects of pesticides because of poorly developed immune systems. According to a study prepared for EPA in 1976, infants are routinely exposed to more than six times as much heptachlor as adults, due to enormous milk consumption. Children between 1 and 2 years old are exposed to four times as much as adults. When the National Academy of Sciences reviewed the hazards of heptachlor in 1977, it declared that, while human risk was essentially unquantifiable, "in general . . . the very young are more susceptible to environmental insults."

The costs of a sixfold reduction in the action level for heptachlor would be substantial, not only in Hawaii but throughout the United States. Although all but a few uses of heptachlor have been banned by the EPA, heptachlor still shows up in substantial quantities in meat, poultry, and dairy products. Roughly 10 percent of milk samples taken nationwide by the FDA between 1978 and 1982 were found to contain heptachlor, and about a quarter of these contained amounts higher than 0.5 ppm. Thus, massive quantities of milk would have to be removed from the market. A reduction of the U.S. action level to 0.15 ppm—the guideline set by the World Health Organization—would in contrast be far less costly.

Contamination of milk is thought to persist because heptachlor is purged from cattle over a long period of time. In addition, there is a chance that cattle are still ingesting contaminated feed—due to the growing of food crops in contaminated soil or to continued spraying in other countries. The Velsicol Chemical Corporation still manufactures heptachlor for export to the Caribbean, Asia, and Latin America, although it declines to reveal how much.

EPA officials say that the results of their review will be announced in several weeks.—R. JEFFREY SMITH

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ing. Heptachlor does not degrade significantly in a year, but it becomes more dilute as the plant continues growing. The purpose of the requirement was apparently to ensure that the resultant heptachlor levels in a single batch of milk would be less than the maximum permitted by federal Food and Drug Administration (FDA) regulations. Now, in two lawsuits against the growers, the dairymen claim that this regulation was not followed—that Dole and Del Monte illegally sold leaves that had been recently sprayed. The state's agriculture department recently examined this charge at the request of the federal Environmental Protection Agency (EPA), but forwarded its report to the state's attorney general and to EPA without official comment. The irony is that it was the dairymen themselves, acting through their cooperative, who physically cleared the fields, and the growers who merely let them in, possibly too soon.

The state is still uncertain how long the feed, and thus the state's milk and milk products, have been contaminated. Stored samples of chop that were harvested as long ago as April 1981 were recently shown to contain levels of heptachlor as high as those that appeared last January. Oda maintains that the state's monitoring program picked up no signs of heptachlor contamination in milk in June 1981, although he cannot explain the discrepancy between this result and the high level of contamination in the feed then. He says that he cannot recheck the milk data from last June because the gas chromatograph slides were discarded in accordance with standard office procedure. If Oda's results from last June are somehow incorrect, or if the sampling was not truly representative of the market, there is a considerable likelihood that Hawaiian citizens have consumed highly contaminated milk and milk products for a year, and possibly longer. Lower, but still significant, quantities of heptachlor have been found in chop samples more than 2 years old.

If the state is to be believed, none of this exposure is harmful. Governor George Ariyoshi, a Democrat, told the press shortly after the first recall that "we did not pull a dangerous commodity off the market. In most countries the milk that was withdrawn would have been acceptable." Actually, the World Health Organization's maximum tolerance for heptachlor in milk is one-half that in the United States, a fact that Ariyoshi did not then realize (the WHO standard is 0.15 part per million). George Yuen, the health department director who retired in the midst of the crisis, told a Honolulu newspaper that "emotionalism and hysteria" had prevented the public from understanding that the contaminated milk was safe. Melvin Koizumi, a deputy to Yuen for environmental health and services and like Yuen an engineer, told the press that he had not turned in his own milk in any of the recalls. He said that he told his children that "it was safe to drink, and I drank it."

Castle & Cooke

When pineapples on Oahu stopped bearing fruit, the remaining plant leaves were gathered up and mixed into cattle feed, leading to the milk contamination.

According to state senator Benjamin Cayetano, a Democrat who has chaired a series of hearings on the contamination problem, Hawaiian officials made these statements on the advice of scientists at the University of Hawaii. "As soon as this problem arose, the department of health looked to the university for guidance," he says.

One of those consulted was Noel Kefford, dean of the university's College of Tropical Agriculture. Kefford was first apprised of the problem a week before the public learned of it, when the university was called on to perform some tests of milk samples. Once the presence of heptachlor had been confirmed in the university's lab, Kefford's advice was that it not be disclosed to the public. In a letter he wrote to Roy Matsuura, the state milk commissioner on 15 March, Kefford said that "continued consumption of milk with the reported heptachlor epoxide residues would not appear to constitute an unreasonable hazard to the public, even those segments of the population judged to be most sensitive. More serious would be an announcement of this technical violation of a tolerance, and subsequent prohibition of the sale of milk from dairies and processors. No amount of explanation of the technical nature of the violation would expiate the damage done to the reputation of local milk as a wholesome food and, coincidentally, to the dairy industry." Later, when the story finally leaked out, Kef-

The state health department's record "suggests that more than contaminated milk should be recalled," declared the Honolulu Advertiser *on 24 March.*

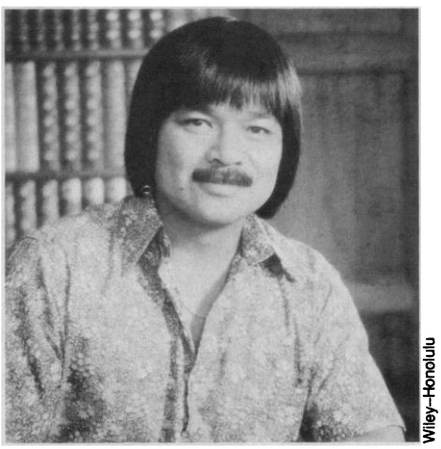
ford dismissed public fears about heptachlor contamination, saying that "the concern is about a regulation. We're following a regulation and that's what the story is."

An additional source of publicly comforting information was John Hylin, a university biochemist that Cayetano identifies as being "the state's ace in the hole in terms of expert knowledge." Hylin, who had previously testified at the request of the state and the pineapple growers during federal hearings on heptachlor, announced that "I do not believe that there is a health problem, for anyone in the population, from exposure to the milk." In an interview with *Science*, he dismissed the significance of studies indicating that heptachlor causes hepato-cellular carcinomas in mice, including a suggestive study conducted at the behest of the manufacturer, the Velsicol Chemical Corporation. "A great deal is made of a limited number of studies," Hylin says. He suggests that the true story of heptachlor's safety can be found in reports from the Council for Agricultural Science and Technology, a group largely funded by pesticide and chemical manufacturers.

The criticism raised by some of Hylin's peers in Hawaii is not that he is obviously incorrect, as no adverse effects of the exposure have yet occurred and none might turn up. It is instead that Hylin has a narrow viewpoint and could hardly be considered an impartial state adviser. Richard Stanley, a scientific colleague of Hylin's who also minimized the dangers of the contamination in public statements, noted pointedly in a telephone interview that the university was "a land-grant institution, with a major responsibility to support the state's industry."

Several experts with an altogether different point of view were not consulted when the state was deciding what to do. One of these is Leland Parks, a scientist at the Pacific Biomedical Research Center in Honolulu, which is affiliated with the university and funded in part by the EPA. Shortly after the contamination was revealed, Parks began testing samples of human breast milk. He discovered that the average level of heptachlor contamination had increased to four times the amount detected 3 years earlier, and in two samples the contamination exceeded the maximum amount permitted in milk sold to consumers.

"I'd like to study it more, but it appears that there is a relationship between exposure to the contaminated store-bought milk and the increase in human breast milk," Parks says. "There is a consistent increase. Now, I am less than comfortable with some of the data in the literature, but it appears that the margin of safety is becoming very thin for a small infant exposed to milk contaminated at or near the level it is being sold. There is enough information to make me and many others uncomfortable." Park says that he is worried about potential kidney damage or liver cell damage.



Wiley–Honolulu

Senator Benjamin Cayetano

Some experts evinced more concern for the health of the dairy industry than for the citizens of Hawaii.

Theodore Norton joined the University of Hawaii staff after serving as an agricultural chemist and assistant laboratory director at the Dow Chemical Company for 23 years. He agrees with Parks. "The safety margin doesn't look too hot," he says. According to his calculations, an 11-pound Hawaiian infant could easily be exposed to three-and-a-half times the amount of heptachlor per day deemed acceptable under the guidelines of the World Health Organization, a level set according to animal studies. Norton points out that infants might actually be more vulnerable than the animals, and that in any event there would be considerable variation from one infant to another. He suggests that the known presence of other harmful pesticides in mother's milk in Hawaii (such as dieldrin, chlordane, hexachlorobenzene, DDT, and DDE) could magnify the adverse effects of heptachlor. "I think the action level for heptachlor in milk [the maximum permitted for commercial sales] should be cut immediately to one-third its present value," Norton says, "although I would be satisfied if the state promptly told nursing and pregnant women to stop drinking milk from the stores."

Bernard Greenberg, dean of the School of Public Health at the University of North Carolina, says that the current standard for heptachlor contamination in milk "strikes me as being a rather high level for such a potent carcinogen." Citing clinical reports of an association between leukemia or neuroblastomas and exposure to heptachlor and chlordane (a pesticide that contains heptachlor), Greenberg has proposed to EPA that a surveillance program for infants be established on Oahu. He says that "a natural experiment has been foisted on the people of Hawaii" and it would be foolish to let the opportunity for observation slip by.

Senator Cayetano told *Science* that he is convinced on the basis of the hearings he chaired that some of those who were attempting to reassure the public "were more concerned about the health of the dairy industry than the people. This is understandable, but it is not acceptable." In a report issued on 31 March, the Senate health committee said that the state adopted essentially the same approach. The pattern of repeated milk sampling that delayed a public announcement "was directed more at showing declining levels of heptachlor contamination than ensuring that milk from all Oahu dairy farms was not contaminated," the report states. Although the state repeatedly had difficulty identifying which milk products were contaminated and which were not, products with confirmed contamination were frequently allowed to be sold.

Cayetano says that some of the problem is due to the nonchalance of health department employees and the fact that the director is not a scientist or physician. Hawaii is one of only a dozen or so states that does not require its top health official to have at least a medical degree. Although this requirement formerly existed, it was abolished by the legislature when Yuen was appointed. Governor Ariyoshi has hardly improved matters by appointing as a replacement George Clark, a former real estate salesman and state school superintendent.

Responsibility for the contamination of milk in Hawaii is obviously shared by both the public and private sector. At the core of the state's response, however, is a close relation between the pineapple growers and the dairies on the one hand, and the state and the university on the other. Through the university and the state, the industry was able to fend off public concerns that could have led to even greater financial losses. As it is, most if not all of the industry's loss could be repaid by federal funds that Hawaiian Senator Daniel Inouye is trying to get approved by Congress. No such bailout exists for the infants of Hawaii.

—R. JEFFREY SMITH