made others in biomedical research want one too. But you cannot clone Benno Schmidt, and you cannot mandate the kind of influence he has had on White House officials who were freely prepared to be receptive to him.

An attempt to do for all of biomedical research what the cancer panel has done for the programs of NCI was made in 1974 before legislation creating the present President's Biomedical Research Panel passed the Congress. The original idea was to mandate a permanent panel with the same White House access that the cancer group enjoyed, but it was stopped by threats of a presidential veto. So the present panel, whose only job is to issue a single, one-shot report, was put in place instead. Destined to officially dissolve by 1 July, its only hope of continuing on in spirit is to have its recommendation to expand the cancer panel accepted. It is not certain whether this recommendation will be adopted, but it most surely will come up when the Senate the House hold hearings on the panel's full report. The Senate hearings are already on the calendar for 30 April, the same day the report must go to the President.

In all of this, it might be noted that there already exist a number of advisory bodies to oversee the conduct of biomedical research. Every institute at NIH has an advisory council; the NIH director has an advisory council too. The former exist to review the scientific projects supported by the individual institutes; the latter is supposed to advise the NIH director on the way things are going overall. It is true that, in the past, these groups have not taken their policy-making responsibilities as seriously as they might, but there is no immutable reason might, but there is no reason that could not change. The authority is there.

The NIH director's advisory committee, long plagued by vacancies (*Science*, 31 October 1975), is not at full strength, and director Donald S. Fredrickson says he intends to make full use of the committee as a policy-making resource. In fact, an additional recommendation of the President's Biomedical Research Panel, one with which Fredrickson concurs, will be that the members of the director's committee, now appointed by the Secretary of Health, Education, and Welfare, be appointed in the future by the President. "To make the NIH director's advisors Presidential appointees would raise their visibility and lend a new tone to their work," one biomedical panel staffer observes. One foresees a situation in which one presidentially appointed committee on biomedical research is overseeing another. It hardly seems necessary to have both.—BARBARA J. CULLITON

Michigan's PBB Incident: Chemical Mix-Up Leads to Disaster

The hazards posed by the manufacture and distribution of dangerous toxic substances, and by their dispersal to the environment, are being pointed up by such stark episodes as the widely publicized Kepone poisoning incident in Virginia. Some of these episodes fail to attract national attention, however, and when the injury is not so much to human health as it is to farm animals the incidents may be little noted outside the regions where they occur.

A prime case in point is the episode that first came to light 2 years ago in Michigan, where, apparently as the result of a frightening and extraordinary mix-up of two chemical products, nearly 30,000 cattle plus thousands of other farm animals have had to be quarantined and destroyed. On hundreds of farms the livestock and poultry was contaminated with polybrominated biphenyl (PBB), a fire retardant closely related to polychlorinated biphenyl (PCB), one of the most notorious and widespread of all chemical contaminants. PBB has been employed in the manufacture of certain hard plastics, such as some that have gone into television cabinets and other products in which heat resistance is desired.

Disastrous as this Michigan episode has been—damages for livestock and poultry losses are variously estimated between something less than $75 million and $100 million or more—it could have been still worse had the nature and source of the contamination gone undetected even longer than actually was the case. Yet, except for a remarkable combination of circumstances and good luck, the cause of the disaster might remain a mystery even today.

Because of this, supporters of the pending toxic substances control legislation, which has already passed the Senate and now awaits further committee action in the House, point to the Michigan disaster as another strikingly clear demonstration that this legislation is critically needed. Also, the great difficulty many Michigan farmers have had in coping with and overcoming the PBB contamination is cited as compelling evidence that the farmers victimized in such episodes often need emergency help from Washington.

The most commonly cited hypothesis as to how the Michigan PBB disaster came about is as follows. Sometime during the summer of 1973, at the Michigan Chemical Corporation plant at St. Louis, Michigan, ten to twenty 50-pound bags of "Firemaster"—the fire retardant PBB—somehow were included in a truck load of "Nutrimaster," or magnesium oxide, a compound used to sweeten acidic feeds. The truck was bound for the big feed mill operated by Farm Bureau Services, Inc. (a part of the Michigan Farm Bureau), at Battle Creek.

Normally, the Firemaster, which resembled Nutrimaster in physical appearance, would have been packaged in bags lettered in red. But, because of a shortage of bags with pre-printed labeling the Firemaster, as well as the Nutrimaster, was packaged in plain brown bags on which the trade names were stenciled in black. How the Firemaster and Nutrimaster bags became mixed at the plant, if this is indeed what happened, is a mystery.

According to Roger Clark, an attorney for Michigan Chemical, the buildings in which Firemaster was manufactured and stored were several hundred yards from those where Nutrimaster was produced and stored. Also, it was the practice to load these products directly from the storage buildings onto trucks for shipment, with no need to move them to some common loading area where a mix-up could have occurred.

Yet, the fact is, a partially filled bag of Firemaster would be found at the Farm Bureau Services mill when an investi-

gation of the PBB poisoning incident got under way. Furthermore, Michigan Chemical was the sole manufacturer of PBB for sale in the United States (today, no PBB is produced in this country). And, although Michigan Chemical has not conceded that the hypothesis cited above is correct, a $270 million law suit brought against the company by Farm Bureau Services was settled last December for an amount exceeding $20 million.

In any event, there is no question at all but that Farm Bureau Services mixed 500 to 1000 pounds of PBB into feeds that were then widely sold and distributed to Michigan farmers. Besides the heavy primary contamination caused by this initial mixing of PBB into feeds, there was secondary contamination resulting from traces of the PBB remaining at the Battle Creek mill and at a number of other mills and grain elevators around the state. As events unfolded, farmers whose herds were afflicted during the early months of the PBB poisoning incident initially were unaware that their troubles were simply part of a pattern of affliction emerging almost statewide.

The discovery that PBB was the cause of the trouble was not made until the end of April 1974, which was at least 8 months after the presence of this highly stable and persistent chemical in livestock feeds had begun having its effect. Furthermore, after PBB was finally fingered as the malefactor, another year and a half would elapse before all of the contaminated livestock and poultry would be identified.

In the late summer of 1973, Frederic Halbert, a dairy operator near Battle Creek, happened to be the farmer who received what was no doubt the most heavily contaminated consignment of feed involved in the entire PBB episode. Halbert believes this feed contained the equivalent of four bags of Firemaster, or 200 pounds of the stuff, and that some of his cows each ate as much as a half pound of pure PBB.

It also happened that Halbert was no ordinary dairyman. He had earned a master's degree in chemical engineering and worked 3 years for the Dow Chemical Company before returning to the family farm in 1971. Except for these unusual circumstances, and for the fact that Halbert is exceptionally resourceful and persevering, there is no telling how long it would have taken to discover that PBB was responsible for the chemical plague that was descending on Michigan farms.*

Up until the last week in September 1973, the Halbert farm had had exceptionally good milk production, but in that week production began to fall and by mid-October it was off by 40 percent. And now the cows were eating much less and showing various symptoms of sickness such as loss of weight, abnormal hoof development, rheumy eyes, and runny noses.

But neither Halbert nor the veterinarians he consulted were able to pinpoint the trouble, although blood samples from sick cows were analyzed and the carcasses of several cows that died underwent autopsies. An obvious thing to do was to analyze the feed for chemical contaminants. But such a contaminant might be extremely hard to identify unless it were something such as dieldrin, DDT, or PCB—all frequently implicated in agricultural contamination problems—which the analysts would know to look for. So, not surprisingly, the early analysis of Halbert's feed turned up nothing.

Faced with ruin, Halbert did everything possible to press on with the investigation. He sought the help of scientists with the Michigan Department of Agriculture and those with the U.S. Department of Agriculture's National Animal Disease Center in Ames, Iowa. The first break in the situation came at Ames, where, partly by accident, a peculiar reading showed up in a gas chromatograph analysis of Halbert's feed.

An Unfamiliar Reading

The more common chemical contaminants that one might have suspected, such as those mentioned previously, show up as early emerging peaks on the chromatograph. But PBB—because of its exceptional stability—is revealed by a late emerging peak. Nothing showed up in the analysis of Halbert's feed until one day in late January 1974 when the researchers at Ames forgot to turn off the chromatograph during their lunch hour. By the time they returned, a wildly unfamiliar reading had appeared on the chromatograph. "Our machine is turning out the Rocky Mountain range," one of the researchers later told Halbert. Yet no one knew what the reading meant, or even whether it meant anything at all.

Although there was now more reason than ever for the scientists at Ames to continue the investigation, word came from Washington headquarters of the Animal and Plant Health Inspection Service that they would have to call it off because all of their center's funds were earmarked for other purposes. So Halbert, understandably frustrated and dismayed at having this bureaucratic obstacle placed in his path, had to turn elsewhere. A sample of his feed was sent to George Fries, a scientist in the pesticide degradation laboratory at the USDA's Agriculture Research Center at Beltsville, Maryland. By pure good luck, Fries happened to be one of the few scientists on this earth who knew how to recognize PBB on a gas chromatograph. A few years earlier he had obtained some PBB from the Michigan Chemical Corporation after seeing an ad in a journal saying that free samples were available for experimental work.

In a telephone conversation with Fries, Halbert mentioned the odd, late-emerging peak. Then, when Fries observed that PBB behaves in that way, Halbert inquired, "Does Michigan Chemical make PBB?" Why was he asking that?, Fries responded, quite surprised. Because, said Halbert, Michigan Chemical makes Nutrimaster.

So, with one quick intuitive thrust, Halbert had drawn the critical linkage between Firemaster and Nutrimaster. And, sure enough, by 29 April 1974, Fries had established, both by gas chromatography and mass spectrometry, that the feed sample contained PBB. Several weeks later, Farm Bureau personnel and federal Food and Drug Administration (FDA) investigators were to find the partially filled bag of Firemaster at the Battle Creek mill.

In May 1974, the FDA established the first so-called "action levels," or tolerance levels, for PBB contamination, and the Michigan Department of Agriculture began placing contaminated farms under quarantine—eventually, 500 farms were to be quarantined, but it would not be until the end of 1975 that all of them would be identified. For meat and dairy products, the maximum was put at 1 part per million (ppm); for feed, 0.3 ppm; and for eggs, 0.1 ppm.

But only 6 months later these levels were lowered to 0.3 ppm for meat and dairy products and to 0.05 for feed and eggs. Residues could now be routinely detected at the lower levels, and there was also the fact that many farm animals—though by no means all—had been found to manifest symptoms of PBB poisoning at levels below those first established. And, in truth, as the FDA freely acknowledged, those levels were based on analytical capabilities and not on toxicological data.

Between the time of the first deliveries of contaminated feeds to farmers in the late summer of 1973 and the time of the

*Halbert's key role in identifying the contaminant was described by Curtis K. Stadfeld in the January 1976 issue of *Audubon*.

first quarantining of contaminated dairy herds and other farm animals in May of 1974, several thousand Michigan farm families and their neighbors consumed meat, eggs, and milk that were contaminated with PBB, and in some cases heavily contaminated. The general public in Michigan was also exposed to PBB contaminated products, but to not nearly the same degree as the farm families. The milk marketed by Michigan dairies was never found to have as much as 0.3 ppm PBB, for this milk came from various uncontaminated as well as contaminated herds and was mixed and homogenized before being sold.

Whether PBB actually has harmed any of the individuals exposed to it is a question about which there was, and is, much uncertainty and debate. The Michigan Department of Public Health (MDPH) has never found any syndrome or signs of human illness clearly attributable to exposure to this compound. But the adequacy of the MDPH's medical and epidemiological evaluation has itself become a matter of dispute among experts. Walter D. Meester, clinical toxicologist at Blodgett Memorial Hospital in Grand Rapids, has sharply criticized the MDPH study, in part because 70 percent of the persons in the control group had detectable levels of PBB in their blood.

Certainly there is a presumption, derived from the limited testing that has been done with laboratory animals, that PBB might be bad for you. Several years ago, E.I. du Pont de Nemours & Company dropped the idea of using PBB in the manufacture of flame-resistant garments after discovering that this compound caused liver enlargement in rats. And rat-feeding studies initiated by state and federal agencies in October 1974 have shown that both PBB and PCB cause "dramatic alterations in normal biochemical and physiological processes," and that PBB is the more dangerous of the two. As an FDA official reported, "the weight of the evidence at this time indicates that PBB caused greater responses at lower levels than PCB and [its toxicity] may be up to five times [greater]."

And, valid or not, numerous complaints of illness brought on by exposure to PBB have been made. For instance, this past February, Hartley and Sharon Cole, who operate a resort business in Chippewa County in the Upper Peninsula, wrote a pathetic open letter to the Michigan legislature. Hartley Cole and four of the Coles' children, ages 5 to 10, were all sick and miserable, each suffering from one or more problems such as extreme lethargy, severe headaches, stomach discomfort, and stiff or swollen joints. These afflictions began sometime after the Coles started eating meat from some pigs that had been fattened on PBB-contaminated grain from the local Farm Bureau elevator. The pork that the family ate was only lightly contaminated, however, and the analysis of a fat sample taken from Cole himself turned up only 0.15 ppm of PBB.

Various studies are now under way to try to determine the short- and long-term effects of PBB on animals and humans. These include some testing to see whether the Firemaster contained trace amounts of dibenzofurans; these materials can be formed in manufacturing PBB or PCB, and they are more toxic than either of those compounds.

Whatever the consequences of human exposure to PBB are ultimately found to be, the impact of the PBB poisoning incident on the Michigan farm economy

Briefing

Clearinghouse for Chemical Carcinogens

Critics of the National Cancer Institute have complained that the institute has not always paid enough attention to the chemical carcinogens that may contribute to the development of as many as 80 or 90 percent of all cancers. One indication that this picture is changing is the formation of a National Clearinghouse on Environmental Carcinogenesis. Frank Rauscher, director of NCI, says that the clearinghouse is to begin operating sometime in May. Its goals are to accumulate information about potential carcinogens, to select the agents to be tested, and to disseminate information about them between government agencies and to the public.

Rauscher described the clearinghouse at the annual science writers' seminar sponsored by the American Cancer Society and held in St. Petersburg Beach, Florida, on 25 to 30 March. He mentioned it in responding to charges made by Sheldon Samuels, safety and health director for the Industrial Union Department of the AFL-CIO, that NCI was withholding the results of tests on 150 chemicals from the public. Rauscher replied that the information was not ready for release because the tissues from the animals treated with the suspect chemicals had not yet been examined to see if they contain cancer cells. He said that the current freeze on government hiring prevented NCI from hiring enough people to do the job. Samuels later softened his comments by saying that he does not think that the delay was deliberate.

In any event, Rauscher thinks that the clearinghouse is one way to keep the public informed. It is really a committee that will consist of about 30 members. There will be representatives from industry, labor, and the public in addition to those from NCI and the various government agencies involved in the identification and regulation of chemical carcinogens. These include the Environmental Protection Agency, the Food and Drug Administration, the National Institute for Occupational Safety and Health, and the National Institute of Environmental Health Sciences. The National Cancer Advisory Board and the office of the assistant secretary for health of HEW will also be represented. The cost of the operation should be about $50,000 per year—relatively modest by NCI standards—because the clearinghouse mainly involves coordination of existing activities.

The committee will be divided into four subgroups, each of which will deal with a different aspect of the problem of chemical carcinogens. These are selection of compounds to be tested, design of experiments (how to detect carcinogens rapidly and accurately is still a matter of some controversy), analysis of the data, and assessment of the relative benefits and risks of continued use of a particular agent. On the basis of the findings of the subgroups, the whole committee will then make a recommendation to the director of the Division of Cancer Cause and Prevention of NCI. The final report of the clearinghouse will be made public. The meetings of the committee and its subgroups will be open to the public.

In the past NCI has been criticized for not letting other government agencies in on what it is doing. Participation of the regulatory agencies in the clearinghouse could solve that problem. This is important because once an agent is identified as a carcinogen it will be up to agencies such as FDA and EPA to regulate—or abolish—its use.

Rauscher says that he sees two potential disadvantages to the clearinghouse. One is that information about a chemical that later proves innocuous may be released prematurely. The other is that he will be accused of seeking publicity—and money—for NCI. Nonetheless he thinks that the idea of seeking to identify carcinogens in as open a manner as possible is sound.—J.L.M.

has been made agonizingly clear. The loss of farm animals continues today, and a complete accounting will not be available for some time yet. But at last tally, the losses included 29,800 cattle, 5,920 hogs, 1,470 sheep, and about 1.5 million chickens. In addition, at least 865 tons of feed, 17,990 pounds of cheese, 2,630 pounds of butter, 34,000 pounds of dry milk products, and nearly 5 million eggs have been destroyed. Thousands of head of cattle have been hauled by Farm Bureau Services to a remote 20-acre burial site or "animal Auschwitz" in central Michigan.

By the end of 1975, settlements had been reached in 335 of the 650 claims filed against the Michigan Farm Bureau and the Michigan Chemical Corporation, with Halbert's claim having been one of the early ones settled. Altogether, $22.5 million was paid out.

Some of the claims and lawsuits that are still pending seek compensation for human injury, but most seek recovery of damages to farm animals. The problem presented by the majority of these latter cases is that the residues present in the animals are below the action level set by the FDA and observed by state authorities. (Halbert thinks that not more than maybe one-tenth of the cattle herds that have such residues actually show symptoms of PBB poisoning. Also, such symptoms are said to be easily confused with symptoms brought on by other problems, such as the iodine poisoning that can result from giving cows too much organic iodine to combat foot rot.)

By some unofficial estimates, as much as $50 million or more is at stake in such sub-action-level cases, and only a few have been settled. The Farm Bureau and Michigan Chemical are hanging tough in dealing with many of the claimants, especially those who can only show residues in amounts well below the action levels. For such claimants, the prospect is for a long legal battle which they can ill afford. Recently, several hundred angry farmers descended on Lansing to demand of Governor William G. Milliken and the legislature that the action levels be lowered drastically. But, with the state itself responsible for compensating farmers for any animals which might have to be officially condemned, Governor Milliken—conscious of the state's financial problems—has not been willing to have the state assume so large a liability.

Many farmers are scandalized at this posture on the part of state officials. Bumper stickers say, "Cattlegate Bigger than Watergate." One troublesome point of contention bears on the fact that, given the existing action levels, Farm Bureau Services and Michigan Chemical are insisting that settlements of claims involving animals with below-action-level residues should reflect the salvage value of those animals. The argument is made that to make a farmer sell a contaminated animal or the products derived from it is unethical.

But a counterargument is that some of the farmers themselves, knowing how much time and money it takes to build up a fine dairy herd, want to try to maintain their existing herds, culling out only the sicker or less productive animals. It is also noted that, in establishing the action levels, the FDA has drawn the official line between what is a threat to public health and what is not.

Some farmers such as Halbert who have had to live through the PBB episode, and some of the scientists and legislators who have tried to help them, believe that several important lessons can be learned from this episode. They speak of the following.

• *Rigorous premarket testing of chemicals is essential.* Certainly it is now clear that if PBB was to be manufactured at all, it should have been only after rigorous and extensive testing to determine its short- and long-term toxic effects. Its cousin relationship with PCB should itself have been enough to bring it under early suspicion.

Besides producing important toxicological data, the testing could also have revealed the compound's identifying characteristics, including its distinctive behavior and fingerprint in chromatograph analysis. Such information could have been cataloged for the use of any researchers called upon to discover and track it in contamination incidents.

• *Strict safeguards for handling and distributing hazardous chemicals should be mandatory.* Mix-ups such as the one involving Firemaster and Nutrimaster might be virtually impossible if products such as PBB were red flagged from the point of production all the way through to the point of use. No happenstance such as the temporary shortage of preprinted bags which apparently figured in the Michigan incident should be allowed to compromise the safeguards' effectiveness.

• *Federal technical assistance should be readily available in the event of chemical contamination incidents.* USDA scientists played a critical role in clearing up the mystery in the Michigan incident, but, had Halbert been less resourceful, this might not have been the case. In addition to seeing the scientists at the USDA's Ames laboratory called off the investigation just when the trail was getting hot, Halbert experienced some other frustrations which, while minor, he found discouragingly symbolic of the government's unresponsiveness. On one occasion, for instance, he was even denied a government bill of lading to ship a feed sample to a USDA toxicologist at Texas A & M University. Halbert ran up $5000 in out-of-pocket expenses to carry on the investigation—something many farmers would have been unwilling or unable to do.

The Animal and Plant Health Inspection Service maintains a network of emergency teams to cope with outbreaks of foreign animal diseases, such as hog cholera or African horse sickness. To prepare some teams to cope with chemical contamination incidents also seems called for. Halbert believes that, had the USDA arrived in force to help the Michigan Department of Agriculture, it would not have taken a year and a half to place all the more heavily contaminated dairy herds under quarantine.

• *Emergency farm relief loans are needed in chemical disasters.* A long delay in the settlement of claims can be ruinous for farmers, especially if during the time of waiting they must continue to feed their contaminated and unproductive animals to maintain proof of damages. None of the existing federal loan programs for farmers meets this particular need.

The toxic substances control bill which passed the Senate on 26 March is responsive to some of the foregoing needs, notably through its provisions for premarket testing and for regulation of the marking and distribution of hazardous chemicals. The Senate also recently approved a bill to make disaster relief loans available to farmers whose livestock or commodities are quarantined or condemned as the result of chemical contamination.

Senator Phillip A. Hart of Michigan has been one of the prime movers behind both of these pieces of legislation. The problems addressed in the disaster relief bill, as well as in the toxic substances bill, are truly national in relevance and scope, however. The USDA reports that, since 1968, there have been 24 incidents, involving 28 states, in which livestock or poultry have suffered chemical contamination. The losses involved are put at at least $97 million, an estimate which will probably be proved conservative once all the Michigan losses have been totaled up. These incidents, together with such problems as the PCB contamination of the Hudson River fishery and the Kepone poisoning of some Virginia chemical workers, may be enough to trouble even the more complacent guests at what has been aptly called the "chemical feast."

—LUTHER J. CARTER