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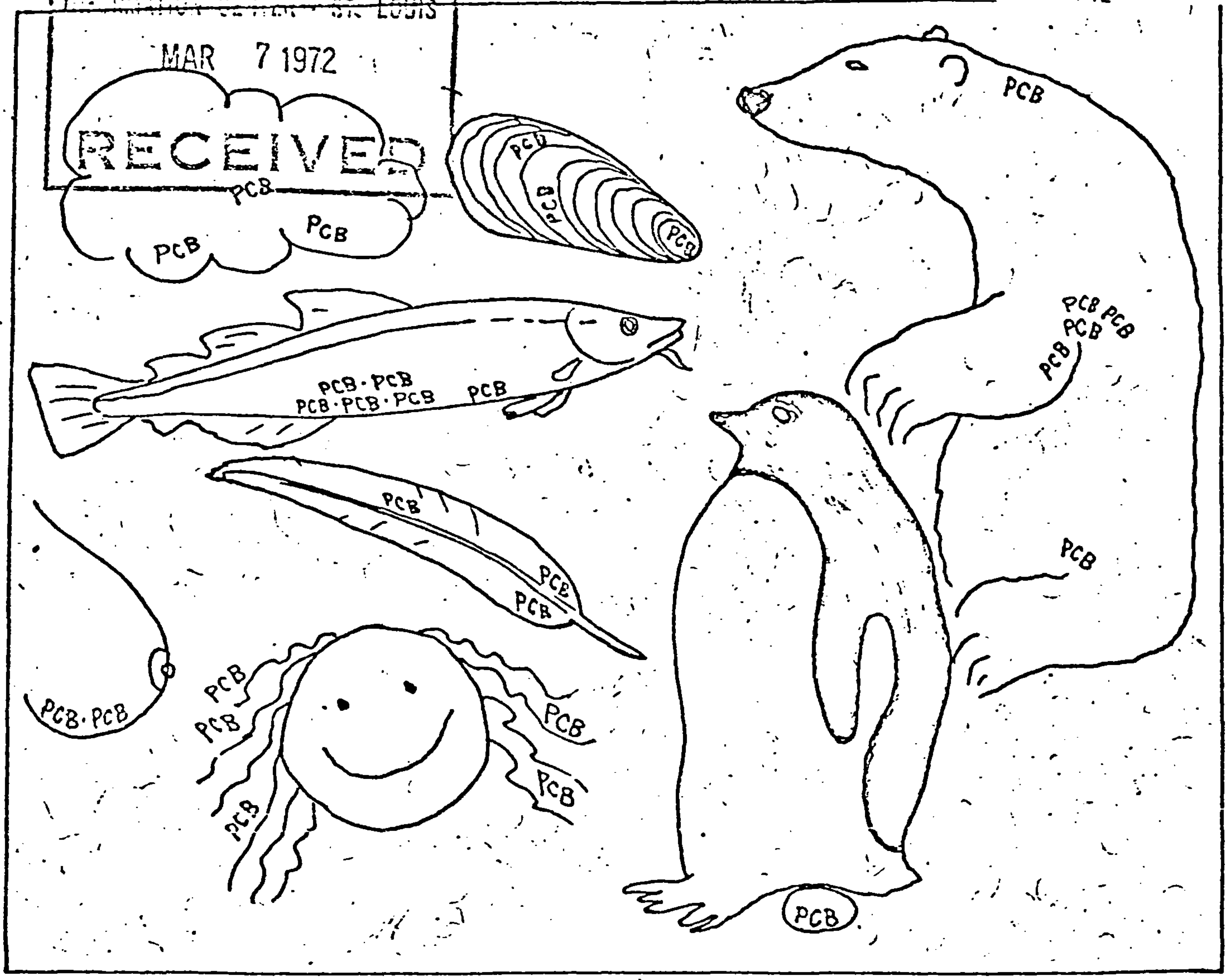

The ABCs of PCBs

by ELIZABETH N. LAYNE

IN 1966 A SWEDISH SCIENTIST named Sören Jensen, with the Institute for Analytical Chemistry at the University of Stockholm, detected the man-made chemical compounds known as polychlorinated biphenyls (PCBs) in fish taken from different parts of Sweden, in an eagle found dead in the Stockholm Archipelago, and in the hair of his wife, himself, and his baby daughter. Neither Jensen nor any other scientist had any idea what quantity of PCBs might be dangerous or possibly even fatal. He knew, however, that the compounds are a chlorinated hydrocarbon closely related to DDT, and that the high concentrations of PCBs in the dead eagle would have been close to a lethal dose if PCB toxicity were similar to that of DDT. Further, an examination of a sequence of eagle feathers from the Swedish National Museum of Natural History dating to 1880 revealed PCBs in one bird collected as far back as 1944.

Since Jensen's initial discovery of PCBs in the environment, scientists have been dismayed to find the chemical virtually everywhere they have looked for it—in rainwater in England, mussels in the Netherlands, seals off the coast of Scotland, porpoises in Canada's Bay of Fundy, sea lions in California waters, cod in the Baltic Sea, Adélie penguin eggs in the Antarctic, brown pelican eggs in Panama, osprey eggs on Long Island Sound, river water in Japan, coho salmon in the Great Lakes, tuna off the Galápagos and Hawaiian Islands, petrels and shearwaters from the Pacific Ocean, plankton far out in the North and South Atlantic, polar bears in Arctic Canada, trout in remote lakes in northern Quebec, in the air over cities in the United States, and in human milk samples and human fat.

PCBs have joined DDT as a truly global pollutant. But while DDT was deliberately cast into the environment, PCBs have leaked their way into the world's ecosystems. We know only sketchily how it has come about.

PCBs are not a single compound but a mixture of chemical compounds made up, like DDT, of chlorine, hydrogen, and carbon. They are available in this country—where they have been sold to industry for 40 years—as a colorless, odorless,

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syrupy liquid or as a resin. The sole manufacturer in the United States, Canada, and Britain is the Monsanto Industrial Chemicals Company of St. Louis, which markets them under the trade name Aroclor. PCBs are also made in France, Germany, Italy, Japan, and the Soviet Union. Like DDT, PCBs are described as insoluble in water, and highly soluble in oils and fats. They can withstand incredibly high temperatures (up to 1600°F), and are exceedingly resistant both to biological and chemical decomposition. The compounds are probably at least as stable as DDT and its long-lived breakdown product, DDE. In other words, PCBs have all the necessary characteristics for persistence and accumulation within the food chain.

The very qualities that make the compounds a threat to the environment are those that make them of great value to industry. Since the 1930s PCBs have been used primarily as coolant-insulation fluids in power transformers located in populated areas, where the danger of explosion from the intense heat produced by voltage changeovers presents a special hazard; and in what are called heat-transfer systems, in which PCBs are circulated through coils or tubes to conduct heat from furnaces to ovens or radiators. They have long been used in those black boxes called capacitors that sit on poles and regulate the flow of electricity through transmission lines, and in capacitors in fluorescent lights and air conditioners.

Theoretically PCBs cannot escape into the environment from these "closed system" uses, but systems can and do leak, and insulation fluids degrade and are discarded. To cite one recent example, a heat-transfer system leak in a fish meal plant last summer made it necessary to destroy 80,000 chickens and a like number of contaminated eggs.

It was not until about 1960 that Monsanto encouraged the use of polychlorinated biphenyls for a wide variety of "open" applications—to prolong the kill life of some pesticides, in sealants and synthetic adhesives, in paints, varnishes, and wax, in printing inks and carbonless copy paper, in automobile tires and brake linings, and in plasticizers, which is presumably why PCBs appear in many consumer plastics. All these new uses accelerated the release of PCBs into the environment through factory waste, abrasion, and trash incineration. Not long ago the federal Food and Drug Administration discovered PCBs in a variety of cardboard boxes used to package dried foods such as cereal. In addition, they found PCBs in some samples of shredded wheat and noodles packed in those boxes. Carbonless copy paper that went into the recycled paper from which the cardboard boxes were made is believed to be the source of contamination.

In response to mounting evidence of PCB pollution of the environment, Monsanto stopped selling the compounds for these "open" uses last year. And the Department of Agriculture has canceled registration for pesticides mixed with PCBs. What portion of total sales these uses represented is not known because Monsanto has not come forth with such information. However, the company did release some figures in November, under pressure from the scientific community and the government, that show production in the U. S. reached a high of 42,527 tons in 1970, more than double what it had been in 1960.

How directly lethal to life are PCBs? In Japan in 1968, more than 1,000 people suffered a severe skin acne and liver damage as a result of consuming a commercial rice oil used for cooking. In addition, there were two stillbirths out of nine pregnancies among the women affected. The rice oil had been heavily contaminated with PCBs used as a heat-transfer fluid in the food processing equipment.

Recent studies in the Netherlands indicate the culprit in such cases is probably a highly poisonous contaminant, chlorinated dibenzofurans, found in some PCBs manufactured outside the United States, rather than the PCBs themselves. Chlorinated dibenzofurans are "among the most poisonous compounds known," says Dr. Robert Risebrough, this country's foremost authority on PCBs in wildlife. The presence of these contaminants explains the high toxicity of German and French PCBs compared to those manufactured here.

Studies thus far indicate that American-made PCBs, free of chlorinated dibenzofurans, have a relatively low acute toxicity compared to DDT and to dieldrin. Interestingly enough, they are not highly toxic to insects but do have a synergistic effect with DDT and dieldrin. It is the shellfish that have been found to be more sensitive to PCBs than other forms of life thus far tested. However, it is perhaps significant that all testing in the United States and Canada is done with PCBs supplied by Monsanto. And an incident in 1963 suggests that at least some past batches of American-made PCBs may have carried the lethal contaminants. Professor E.L. McCune at the University of Missouri discovered his chickens were dying because of PCBs (Aroclor) used as a binder in an epoxy paint that had been freshly applied to parts of their feeding house. The symptoms shown by his chickens are now known to be characteristic of poisoning from chlorinated dibenzofurans.

BUT AS WITH SO MANY environmental pollutants, the possible long-term, sublethal effects of PCBs are what frighten scientists. Three separate tests in recent months—with rabbits, with mink, and with ring doves—have all had disturbing results. In the two studies using mammals, the animals were fed food saturated with American PCB concentrations of 10 to 15 parts per million, a level commonly found these days in Lake Michigan coho salmon. (The mink in fact were fed on salmon.) The first generations of both mink and rabbits failed to produce young. The second generation of ring doves, which had been fed the lowest dose of PCBs, produced an extremely high rate of embryonic deaths. In the light of these results, it is not unreasonable to surmise that PCBs pose a considerable long-range hazard to all animal life.

The extreme concern among scientists is that there is no clear evidence that the PCB contaminant, the highly poisonous chlorinated dibenzofurans, is not produced from the PCBs after they have entered the environment—or has not been widely present in batches produced in the past that now lie buried in dumps or in lake or river sediments. Dr. Risebrough, who suspects PCBs to be the cause of macabre birth defects and feather loss in young terns in a nesting colony in Long Island Sound, conjectures in a recent article in *Natural History* that the contaminants may be the agent causing the defects. Such speculation is prompted by recent experiments with chlorinated dioxins, a close chemical ally of the chlorinated dibenzofurans, which produced similar birth defects in birds in the laboratory. Risebrough grimly concludes that "these contaminants may, someday soon, result in an increase in the numbers of human defects as they work up through the food chain to the ultimate consumer."

Until it is known how much polychlorinated biphenyl has been produced and the major sources for release into the environment, we will be hindered in efforts to assess or reduce the potential hazards. Dr. Ian Nisbet of the joint scientific staff of the National Audubon Society and Mas-

sachusetts Audubon, and Dr. Adel Sarofim of MIT, who read a paper on PCBs at a December seminar of the National Institutes of Health, estimate that about one-half to three-quarters of all PCBs so far produced have escaped into the environment. Since dumping by industry must account for a large part of that quantity, Nisbet and Sarofim guess that a good many PCBs are still in dumps and landfills, where they have not yet come into circulation. Most of the remaining loose PCBs, they believe, lie in the shallows of estuaries, bays, and rivers. Here there is a danger they may be released into the food chain, where they pose a special threat to the thousands of aquatic organisms that use these waters as feeding and spawning grounds.

It is expected that the PCBs will be released slowly over a period of decades as the sediments in the dumps and in the shallows are turned over and leached out. The highest concentrations of the chemical so far found are in the waters in industrial, urban areas. Researchers in Great Britain last year discovered that approximately one ton of PCBs a year is being dumped in the ocean with the sludge from Glasgow sewage treatment plants. A similar amount enters the Irish Sea from Manchester's sewage and the Thames from sewage in London. Tests at one outfall in Los Angeles revealed an annual flow of 10 tons of PCBs. It is hardly surprising to learn that the main source of PCBs in the human diet is fish, or that a recent report to the Environmental Protection Agency noted: "It appears that the most serious chronic PCB contamination is in fish and fish-eating birds . . . which are the terminal carnivores of a complex mesh of food chains in the sea." Ospreys nesting in the vicinity of Long Island Sound have been elevated to the dread distinction of being "more contaminated with PCB than any other wildlife in North America." The eggs of the ospreys were found to contain levels three times higher than those that caused massive embryonic deaths in ring dove eggs.

Probably relatively few PCBs have so far worked their way down to the coasts. Despite curtailments of production or sales, Nisbet and Sarofim expect that much more will find its way down the rivers, into the estuaries, and out to sea. *The situation will inevitably get a lot worse than it is now.*

The incredible Borlaug blunder

by CHARLES F. WURSTER
and ROBERT VAN DEN BOSCH

THE SPECTACLE OF A SCIENTIST, competent in his own specialty, being drawn into fields where he has *no expertise—and exploited by forces he does not understand*—is a tragedy of modern science. This occupational hazard is particularly acute for some scientists with Nobel Prizes.

Dr. Norman E. Borlaug, a plant geneticist, won a Nobel Prize for his work in developing high-yield grains. Now, however, Dr. Borlaug is enmeshed in controversies where his splendid achievements are of little relevance and his expertise is nonexistent or 25 years out-of-date.

Last October 7th Dr. Borlaug testified at DDT cancellation hearings in Washington upon invitation of the U.S. Department of Agriculture. Under the rules of evidence, a witness must qualify as an expert in a subject before he can testify about it. When the USDA attorney asked Dr. Borlaug his opinion on the effects of DDT on wildlife, the hearing examiner barred the answer on the ground that Dr. Borlaug was not an expert in that subject. Dr. Borlaug testified that he last studied pesticides in 1944, when he was employed by a pesticide manufacturer. Most of his other testimony was irrelevant to the issues of the hearing.

From that hearing, Dr. Borlaug went directly to a press conference arranged by Montrose Chemical Corporation, the world's largest DDT maker. Without rules of evidence to inhibit him at the press conference, and at other forums, he has made unsupportable assertions about DDT and other pesticides, wildlife, cancer, insect control, hysterical environmentalists, and other subjects he was not competent to discuss in the hearing. His statements, of course, have been exploited for publicity purposes by the pesticide industry.

Dr. Borlaug does not understand the objectives of the environmental scientists he so vehemently attacks. No responsible scientist stands against all pesticides, fertilizers, and other chemicals, as he asserts. Nor have environmentalists attempted, through anti-DDT litigation, to stop the export of DDT to developing nations that cannot afford alternatives for malaria control.

The issue is *which* pesticides for *which* purposes. Excessive dependence on pesticides for insect control, espoused by Dr. Borlaug, is an ineffective, costly, and destructive method that is rapidly being replaced by sophisticated and effective integrated control techniques. DDT is incompatible with integrated control because it disrupts the beneficial balance of insect communities, often creates greater pest problems than it solves, is destructive to wildlife, and is a human health hazard. In short, most of the benefits Dr. Borlaug envisions are not attainable with DDT. But they can be achieved by safer means.

When a broadly toxic insecticide such as DDT is sprayed into the complex machinery of an interrelated insect community, most insects are killed. The field is stripped of its predatory insects and other natural controls, and is thus vulnerable to the rapid resurgence of the plant-eating pests. Often this leads to greater pest abundance than before spraying. And the development of pesticide-resistant strains of the pest insects makes matters still worse. The farmer, faced with nightmarish insect problems, finds himself addicted to more and heavier insecticide treatments, often at the urging of pesticide salesmen. With rising pesticide bills and falling crop yields, he is on a treadmill to economic disaster.

This sequence has occurred in many countries. In two regions of Mexico, near Dr. Borlaug's own laboratories, severe insect problems created by insecticides caused abandonment of the cotton industry and collapse of the associated economies. Excessive pesticide use could destroy the "green revolution" Dr. Borlaug himself has helped develop; his advocacy of this discredited approach is poor advice for a starving world.

Entomologists have developed effective, economical, and ecologically sound integrated control programs for a number