BY JOSEPH HIGHLAND

THE FIRST EVIDENCE that food supplies had become contaminated with polychlorinated biphenyls (PCBs) was reported in 1966, when fish from various Swedish waters were shown to contain these chemicals.[1] Since then, PCBs have been identified as contaminants in food supplies around the world. They have been found in pike taken from a lake in Finland, in mollusks and marine fish from Scottish waters, in a wide variety of fish caught in the St. John River system, in wildlife in California, and in trout and salmon taken from Lake Michigan.[2,3] More recent findings indicate that contamination by PCBs continues to be widespread. Within the last few months, striped bass caught in the Hudson River have been found to contain as much as 90 parts per million (ppm) PCBs, while pike caught in the Baltic Sea were shown to contain 0.31 ppm PCBs in their muscle and up to 190 ppm in their ovaries.[4,5] Moreover, plankton from the Baltic Sea, upon which many fish feed, contained levels of 25 ppm PCBs in their fat.[6]

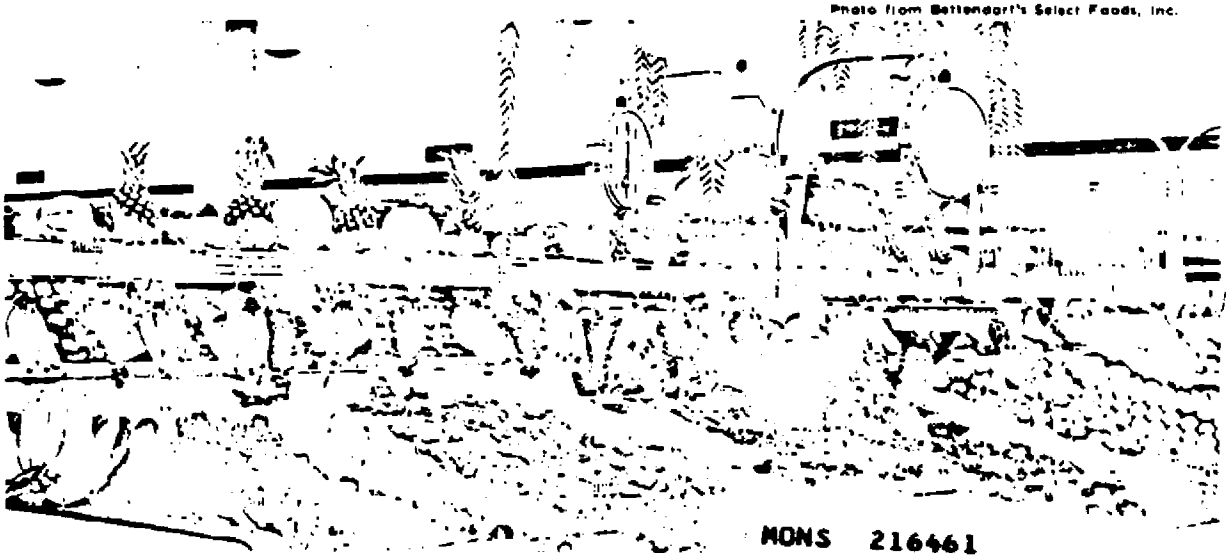
The federal government currently conducts three separate programs in which the contamination of foods by PCBs is measured: the FDA (Food and Drug Administration) Pesticide Surveillance Program, the FDA Total Diet Program, and the USDA (U.S. Department of Agriculture) Surveillance Program.

The FDA Pesticide Surveillance Program, which began in 1968, was developed to gather information on the levels of pesticides, as well as of PCBs, in foods and animal feeds based on a statistical sampling program designed to cover specific geographical regions of the U.S. The program is intended to assure the safety of the human food supply by screening and removing shipments of foods containing PCBs or pesticides in excess of established tolerances. Commodities covered under this testing program include dairy products, eggs, fish, animal feeds, fruits, vegetables, and processed foods.

In the FDA Total Diet Program, the levels of pesticides, PCBs, and trace heavy metals in sample diets are measured. Twice a month, a diet approximating that which would be consumed in a two-week period by a hypothetical fifteen- to twenty-year-old male is collected at retail stores in five regions around the U.S. The foods are prepared in the appropriate manner and then divided into twelve basic food composite classes, including meat, fish, poultry, and leafy vegetables. Each com-

JOSEPH HIGHLAND is director of the Toxic Chemicals Program of the Environmental Defense Fund in Washington, D.C.

Photo from Bettendorf's Select Foods, Inc.



PCBs IN FOOD

What IS acceptable?

posite class is then analyzed for contaminants.

The USDA Surveillance Program consists of periodic sampling and analysis of meats and poultry for chemical contaminants, including PCBs. Samples are taken from federally inspected slaughterhouses.

Levels of PCBs in Food

A summary of the findings regarding PCBs in the three survey and surveillance programs are listed in Table 1.[1,2,3] Although the data are incomplete, it is evident from this table that PCBs continue to contaminate our food. Results of the FDA Pesticide Surveillance Program appear to indicate an increase in the extent of contamination, while those of the USDA Surveillance Program indicate a decrease; this apparent conflict may be explained by the fact that different foods are sampled in these programs, and it is quite possible that contamination of some kinds of foods has decreased while it has increased in others.

The apparent decrease in the levels of PCBs reported in the FDA Total Diet Program Survey between fiscal year 1973 and the first half of fiscal year 1974 must be viewed with caution. During the first half of fiscal year 1974, the average PCB levels for milk and other dairy products, for eggs and egg products, and for animal feed ingredients were equal to or greater than those reported for fiscal year 1973.

Tests are being conducted by the FDA Pesticide Surveillance Program on food items such as fruits and vegetables to determine the amounts of PCBs in excess of established acceptable levels.

TABLE 1

COMPILATION OF DATA FROM FEDERAL SOURCES

FDA Pesticide Surveillance Program

Year	Number of Samples	Percent Contaminated	Levels of Contamination
1968-71	15,000	3.2	"detectable" (fish, specifically: 1-10 ppm)
Fiscal 1973	7,882	4.0	"detectable"
Fiscal 1974	1,723	5.4	"detectable"

FDA Total Diet Program Survey

Year	Number of Composite Food Samples	Percent Contaminated	Levels of Contamination
1968-71	900	6	trace — 0.36 ppm
Fiscal 1973	360	6	trace — 6.0 ppm
Fiscal 1974	360	4	trace — 0.05 ppm

USDA Surveillance Program

Year	Number of Samples	Percent Contaminated	Levels of Contamination
1971	4,175	4.0	trace — 15 ppm
Fiscal 1973 (Poultry only)	1,037	2.6	trace — 4 ppm
Fiscal 1974 (Poultry only)	574	1.0	1.25 ppm

Then why is there an apparent decrease between 1973 and 1974? In large part, this reflects an apparent decrease in the number of *fish* that were found to be contaminated with PCBs. In fiscal year 1973, 62.2 percent of the fish samples examined contained PCBs ranging from trace amounts to 123 ppm. In the first half of fiscal year 1974, only 35.3 percent of the samples checked were contaminated, and the levels found ranged from trace amounts to 9.7 ppm. However, the fish data reported for fiscal year 1973 included mostly freshwater fish, in which PCB contamination has been shown to be greatest, while during the first half of fiscal year 1974 the samples consisted mainly of marine fish. Since the samples are not comparable, the apparent decrease is probably a reflection of the difference in levels of PCB contamination between freshwater and marine fish rather than an indication

of a general decline in PCBs in fish.

In addition to these observations, numerous specific incidents of PCB contamination of food have been reported by the FDA and the USDA. In 1970, the Campbell Soup Company detected high levels of PCBs (26.8 ppm on a fat basis) in chickens grown in New York State. As a result, 140,450 chickens were destroyed. In July 1971, the Monsanto Company informed the FDA that large amounts of fish meal might have been contaminated with PCBs during the pasteurization process, due to a leak in the heating system at the company's East Coast Terminal in Wilmington, North Carolina. An investigation by the FDA revealed that the leak had begun in April 1971 and had continued through July 1971. Contamination of the fish meal was verified, and, as a result, over 123,000 pounds of egg products and 88,000 chickens were destroyed. That same year, the FDA was notified that high levels of PCBs (20 ppm) had been found in Swift and Company turkeys. As a result, approximately 1,000,000 birds were kept from market.[1] These incidents and the results of the federal surveillance programs demonstrate further that contamination of food by PCBs is not a new phenomenon; it is a continuing problem which has resulted in part from the continued indiscriminate discharge of PCBs into the environment, and it is one which must be eliminated because of the severe health hazards posed by these compounds.

"Acceptable Dietary Intake"

The FDA has calculated what is termed an "acceptable daily dietary intake" for PCBs in the human diet – or a level of PCBs which, if ingested for an extended period of time, would be toxicologically insignificant. Even if the validity of such a concept is assumed, the basis for establishing such a level must be evaluated. In this connection, the FDA's final environmental impact statement for rulemaking on PCBs[8] indicated that both animal and human toxicological data were used to establish an allowable dietary intake for human beings.

According to data then available (1973), long-term studies of dogs and rats showed "no-effect levels" (the dose levels below which the effects looked for were not observed) of 10 ppm for three commercial types of PCBs (Aroclors 1242, 1254, and 1260) fed in the diet. Employing the standard 100-to-1 safety factor used in applying results of animal experiments to human health standards, a no-effect level for human beings, based on data derived from the dog experiments, was calculated to be an intake of 0.0025 milligram per kilogram of body weight per day. From the data on rats, a figure of 0.003 milligram per kilogram of body weight was obtained. On the basis of the tests in dogs, the allowable level of PCB intake in a man weighing 70 kilograms (about 155 pounds) was figured to be 0.175 milligram per day (70 kilograms x 0.0025 milligram).

It appears that the metabolism and excretion of PCBs, especially of Aroclors with high chlorine content, are even slower than for some of the most persistent pesticides, such as dieldrin and DDT.

The human toxicological data used in determining the allowable daily dose were derived from investigations of human PCB poisonings in Japan. In 1968, over 1,000 Japanese persons experienced PCB poisoning after consuming rice oil contaminated with Kanechlor 400.[9,10] In addition to causing headaches, swelling of eyelids, temporary loss of vision, and many other symptoms, PCBs stored in the adipose tissue (connective tissue containing stored cellular fat) of pregnant women were passed through the placental wall to the fetuses. As a result, nine of the ten live-born babies had unusually grayish, darkened skin, and most were born underweight.

The outbreak was interpreted by the FDA to have the following implications for PCB intake standards:[8]

"Since 2,000 milligrams was reported to be the average total dose causing an effect in the Japanese, it is possible that 200 milligrams total dosage PCBs (applying a safety factor of 10 to 1) may be tolerated over a much more protracted period of time without overt adverse effect if daily exposure is held to minimal levels. This would permit ingestion of 4 micrograms [0.004 milligram] per kilogram body weight per day in a 70-kilogram man. Since the lowest total dose producing an effect in man in the Japanese incident was 500 milligrams, a similar analysis leads to an allowable protracted ingestion of 1 microgram [0.001 milligram] per kilogram body weight per day as derived from a 70-kilogram man."

On the basis of these data, the FDA arrived at an allowable dose of PCBs (for a 70-kilogram man) of 70 to 280 micrograms per day – or 0.07 to 0.28 milligram per day – compared to the 0.175 milligram-per-day permissible level established on the basis of the dog experiments. The validity of these calculations is very questionable, however. Particularly suspect are the estimates that had to be made of doses received by individual Japanese, as well as the arbitrary assumption that a safety factor of 10 to 1 is sufficient to determine a safe level of intake for a "protracted period of time." In addition, the calculations fail to consider the potential long-term effects caused by stored PCB residues.

Furthermore, according to H. Blumenthal (acting director, Division of Toxicology, Bureau of Foods, FDA) in the time since these calculations were made, there have been two important experimental observations concerning PCBs which make the previously calculated allowable daily intake level obsolete:[9] First, recent studies by J. R. Allen and his colleagues on the effects of low-level exposure of nonhuman primates to PCBs must be considered.[11,12,13,14] The effects seen in these studies of monkeys are similar in appearance and persistence to the symptoms of the human poisoning in Japan. Moreover, these symptoms were documented at dietary intake levels as low as 2.5 ppm (equivalent to about 2.5 milligrams per kilogram of body weight). To date, a no-effect level for PCBs in monkeys has not been established. This would indicate that dogs and rats are not particularly reliable subjects for tests relating to primates, since they are not as sensitive as are primates to many of the toxic effects of PCBs.

Second, Allen's work indicates that the use of gross observations of toxicity are not reliable in the study of PCBs.[11] Allen observed that routine toxicological evaluations of rats which were fed 100 ppm Aroclor 1248 for one year revealed no abnormalities in growth, mortality, or hematology. However, more sophisticated tests showed that these rats experienced drastically altered fat and cholesterol metabolism as well as changes in liver size and structure. Therefore, even if an allowable human daily dosage for PCBs calculated from animal toxicological data were acceptable, the basis for the FDA's 1972 calculations would be seriously questionable.

The chemical nature of PCBs may help to explain in part why they are subacutely and chronically toxic. The

chemicals have a low solubility in water but are highly soluble in fat,[15] therefore, they tend to accumulate and concentrate in the body's fat stores rather than being rapidly metabolized and excreted. It appears that the metabolism and excretion of PCBs, especially of Aroclors with high chlorine content, are even slower than for some of the most persistent pesticides, such as dieldrin and DDT.[16] Thus, after ingestion, PCBs persist in the body for long periods of time and may thereby elicit chronic effects.

Excessive Intake Is Common

The FDA's acceptable daily PCB intake level of 75 to 210 micrograms per day for a 70-kilogram man seems debatable at best. As J. Wessel, scientific coordinator of the FDA, has pointed out,[1] "It is quite clear that the acceptable daily PCB intake of 75-210 micrograms per day could easily be exceeded by an adult consuming some of the heavily contaminated foods in his diet." Table 2, taken directly from Wessel's testimony,[1] illustrates this point clearly: Consuming a steady diet of combined foods from the list would produce consistent over-exposure to PCBs if each food had the maximum allowed concentration of PCBs (listed under the heading "Temporary Tolerance [ppm]").

As Wessel concludes, "Even when PCBs are present at the [permissible] tolerance level, it would be possible for an adult, with normal dietary habits, to exceed 175 micrograms [0.175 milligram] of PCBs per day." Furthermore, adults with "normal dietary habits" are not the only people who are vulnerable. Perhaps at even greater risk are those large groups within the population (such as sport fishermen or people who require special diets) who consume above-average quantities of PCB-contaminated foods, or nursing babies who ingest PCBs in their mothers' contaminated milk and who, for natural biochemical reasons, have a very limited capacity for metabolizing foreign substances such as PCBs. A. Kolbye, Jr., associate director for science, Bureau of Foods, FDA, and H. Blumenthal are clearly correct when they say, respectively:[17,2]

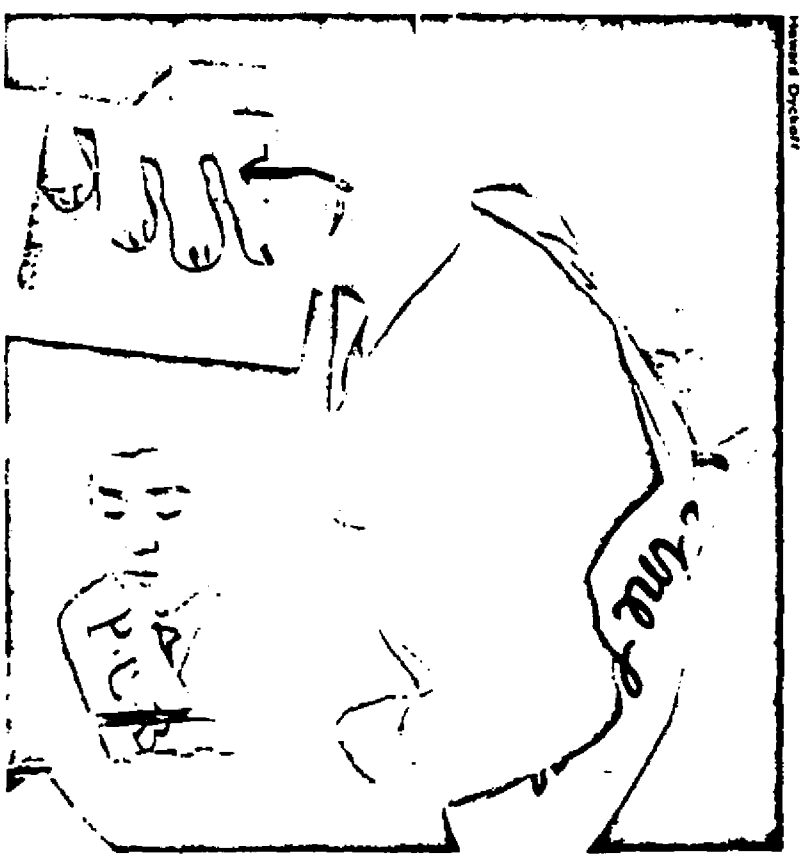
"Infants or young children could also readily exceed the tolerable daily exposure," and, "Thus, the best evidence indicates that children would be more susceptible to the poisoning caused by unmetabolized PCBs, since

TABLE 2

RELATIVE CONTRIBUTION TO ACCEPTABLE DAILY INTAKE (175 mcg/g) BY FOODS SUBJECT TO PCB TEMPORARY TOLERANCES

Type of Food	Serving of Food	Temporary Tolerance (ppm)	Equivalent Amount PCBs in Food	Relative Contribution to ADI
Milk	800 ml (3.5 cups)	2.5 (fat basis) 0.1 (whole product)	80 mcg	46%
Cheese	100 g (3.5 oz)	2.5 (fat basis) 0.6 (whole basis, assuming 25% fat)	60 mcg	35%
Poultry	200 g (7 oz)	5.0 (fat basis) 0.5 (whole basis, assuming 10% fat)	100 mcg	58%
Eggs	100 g (2 eggs)	0.5	50 mcg	29%
Fish	200 g (7 oz)	5.0	1,000 mcg	580%
Packaged Food	100-200 g (3.5-7.0 oz)	10.0 (Packaging)	10-60 mcg*	6-35%

*Based on 1971 FDA Survey that 10 ppm PCBs in packaging can result in migration of 0.1 - 0.6 ppm PCBs to packaged food.



Japanese doctor explaining the effects of PCB poisoning of rice oil victims in 1968.

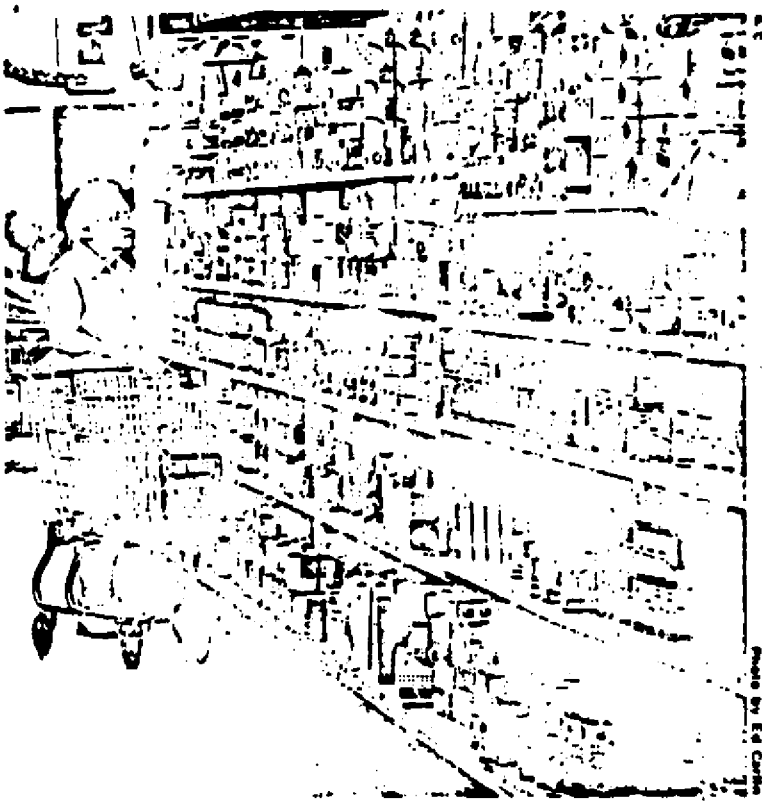


Photo by Ed Carlin

PCBs can escape from food packaging materials into food itself.

of photographs and lead-in excerpts, photo captions, and preparation of most graphs and illustrations which appear in Environment articles.

they have not developed effective ways of eliminating them from the body."

Need for Reevaluation

The FDA's temporary tolerances for PCBs in food are both inadequate and inappropriate; the acceptable daily dose calculated in 1972 is now obsolete in light of more recent findings. More importantly, however, the appropriateness of any "acceptable daily dose" for PCBs is highly questionable in light of new evidence demonstrating the carcinogenicity of these compounds in experimental animals.[18] Since there is at present no scientific evidence that *any* level of intake of a carcinogen is safe, the entire concept of an *acceptable* daily dose for carcinogenic substances such as PCBs is contradictory and scientifically unsupportable.

Our growing concern about the continued contamination of food supplies by PCBs reflects an ever-increasing awareness of the extreme health hazards posed by these compounds. Federal sampling and surveillance programs have continually demonstrated the presence of PCBs in our food supply, and the existing temporary tolerance levels for PCBs established by the FDA have been insufficient to protect the public health. A new regulatory posture is needed which takes into account recent evidence of chronic effects caused by low-level dietary intakes of PCBs and, even more importantly, the new evidence substantiating the carcinogenicity of these compounds in laboratory animals.[18] □

The USDA Surveillance Program consists of periodic sampling and analysis of meats and poultry for chemical contaminants, including PCBs.

The title of this article as originally submitted was "PCBs in Foods: A Look at Federal Government Responsibilities." The Publisher and Editors of Environment are responsible for the published titles and subtitles, selection

NOTES

1. Wessel, J.R., testimony on "PCBs in Paper Food Packaging Materials," Food and Drug Admin., Washington, D.C. (available from Hearing Clerk's Office, Docket No. 75N-0013).

2. Blumenthal, H., testimony on "PCBs in Paper Food Packaging Materials," Food and Drug Admin., Washington, D.C. (available from Hearing Clerk's Office, Docket No. 75N-0013).

3. Veith, G., "Baseline Concentrations of Polychlorinated Biphenyl and DDT in Lake Michigan Fish, 1975," Pest. Mon. Jour., 9:21, 1975.

4. Henley, R., "PCB in Fish Stirs New State Study," New York Times, Sept. 19, 1975.

5. Linko, R.R., et al., "Occurrence of DDT and PCB Compounds in Baltic Herring and Pike from the Turku Archipelago," Envir. Pol., 7:193, 1974.

6. Linko, R.R., P. Rantamaki, and K. Urpo, "PCB Residues in Plankton and Sediment in the Southwestern Coast of Finland," Bull. Envir. Contam. Toxicol., 12:733, 1974.

7. Cornelissen, P.C., testimony on "PCBs in Paper Food Packaging Materials," Food and Drug Admin., Washington, D.C. (available from Hearing Clerk's Office, Docket No. 75N-0013).

8. Food and Drug Admin., Supplement to the Final Environmental Impact Statement Rulemaking on Polychlorinated Biphenyls, 1975, p. 7.

9. Kuratsune, M., "Epidemiologic Study on Yusho, a Poisoning Caused by Rice Oil Contaminated with a Commercial Brand of Polychlorinated Biphenyls," Envir. Health Perspect., 1:119, 1972.

10. Kuratsune, M., "An Abstract of Results of Laboratory Examinations of Patients with Yusho and of Animal Experiments," Envir. Health. Perspect., 1:130, 1972.

11. Allen, J.R., "Response of the Nonhuman Primate to Polychlorinated Biphenyl Exposure," Federation Proceedings, 34:1975, 1975.

12. Allen, J.R., L.A. Carstens, and O.A. Barsotti, "Residual Effects of Short-Term, Low-Level Exposure of Nonhuman Primates to Polychlorinated Biphenyls," Toxicol. and Appl. Pharmacol., 30:440, 1974.

13. Barsotti, O.A., and J.R. Allen, "Effects of Polychlorinated Biphenyls on Reproduction in the Primate," Federation Proceedings, 34:238, 1975.

14. Barsotti, O.A., R.J. Morter, and J.R. Allen, "Reproductive Dysfunctions in Rhesus Monkeys Exposed to Low Levels of Polychlorinated Biphenyl (Aroclor 1248)," Food and Cos. Toxicol., in press.

15. Allen, J.R., D.H. Norback, and H.C. Hsu, "Tissue Modification in Monkeys as Related to Absorption, Distribution, and Excretion of Polychlorinated Biphenyls," Arch. Envir. Contam. Toxicol., 2:86, 1974.

16. Kimbrough, R.D., "The Toxicity of Polychlorinated Polycyclic Compounds and Related Chemicals," CRC Critical Reviews in Toxicol., Jan. 1974, p. 445.

17. Kolbye, A.C., Jr., testimony on "PCBs in Paper Food Packaging Materials," Food and Drug Admin., Washington, D.C. (available from Hearing Clerk's Office, Docket No. 75N-0013).

18. Kimbrough, R.D., et al., "Induction of Liver Tumors in Sherman Strain Female Rats by Polychlorinated Biphenyl Aroclor 1260," Ctr. for Disease Contr., Atlanta, Ga., in press.