July 21, 1969

Mr. James S. Nelson
Consultant, Product Safety
General Electric Corporation
Building 36
1 River Road
Schenectady, New York 12305

Dear Mr. Nelson:

Confirming our telephone conversation, I have enclosed a copy of the Dr. R. Risetrough report which appeared in Nature in December, 1968; the S. F. Chronicle news item; and our statement in response to the Chronicle article.

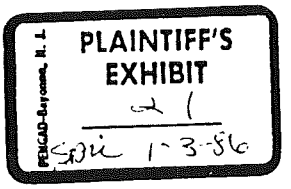
There are also enclosed a number of clippings concerning the DDT hearings in Wisconsin. Several of these clippings are on Dr. Risebrough's testimony in which he pointed out his conclusions that DDT was still the material of principal concern--rather than PCB--and that he had been misquoted in one or more news stories following the publication of the article.

Very truly yours,

Elmer P. Wheeler
Manager, Environmental Health

EPW:ju

b.c. J. G. Bryant
P. B. Benignus



IDS 003166

Polychlorinated Biphenyls in the Global Ecosystem

by

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Polychlorinated biphenyls are widely dispersed in the global ecosystem, and are powerful inducers of hepatic enzymes which degrade oestradiol. Together with other chlorinated biocides, such as DDT, they could account for a large part of the aberration in calcium metabolism which has been observed in many species of birds since the Second World War.

Declining populations of raptorial and fish-eating birds in Great Britain[1] and North America[2] have produced thin-shelled eggs since the period after the Second World War. A widespread change in the chemical environment which affected the calcium physiology of these species evidently occurred at that time. The chlorinated hydrocarbons, which came into general use in the 1940s, may now be the most abundant synthetic pollutants present in the global environment[3]. Thin eggshells have been found only in species which accumulate high concentrations of these compounds: relatively uncontaminated populations of these species continue to produce normal eggs[1,2].

Calcium metabolism in birds is intimately related to reproductive metabolism and is to a large extent regulated by steroids such as oestrogen and vitamin D[4]. The deposition of medullary bone, the chief source of calcium during egg and eggshell formation, is controlled by the steroid sex hormones[5–7], and hens deficient in vitamin D lay eggs with lower eggshell weights[8]. Steroids are hydroxylated and thereby degraded *in vivo* and *in vitro* by hepatic enzymes induced by exogenous, lipid-soluble substances, including the chlorinated hydrocarbons[9–14]. The relatively small amounts of chlorinated hydrocarbons required to produce this effect[9,11,13–16], and the discovery that small amounts of some of the DDT compounds are oestrogenic[9,17–22], have made irrelevant much of the parts per million approach to pollutant ecology based on toxicity data alone.

In both Great Britain[23–31] and North America[28] it was the decline of the peregrine falcon which initiated concern about the extent of the harmful effects of environmental contamination. In the United States the eastern population was extinct before competent observers were aware of a general, widespread decline[28]. Breeding peregrines persist in apparently normal numbers in British Columbia[28] and in the Arctic[27,28].

In 1967 we collected an unhatched, abandoned egg of a peregrine falcon in south-western North America, where a small remnant population remains (unpublished work of M. N. K., R. W. R. and S. G. H.). Analysis of this egg (Table 1) showed that it contained almost 5 mg of *p,p'*-DDE (dichloro-2,2-*bis*(*p*-chlorophenyl) ethylene). Unknown peaks present in the chromatograms of the extract of the egg were unidentified until polychlorinated biphenyls (PCB) were detected in European wildlife[29–31]. Positive confirmation of the identification was accomplished by mass spectrometry in Sweden[29]. The retention times of the unknown peaks in the peregrine extracts proved to be identical with those of several PCB compounds on *DC*-200 and *QF*-1 columns[3] and on a mixed *SE*-30:*QF*-1 column. Other species of birds and fish were subsequently analysed for PCB. The chlorine content of several extracts and standards was determined with a Dohrmann microcoulometric detector and a method of quantification of the PCB compounds was devised based on peak heights produced in the electron capture detector related to standard *p,p'*-DDE[3]. The DDT compounds are destroyed by nitration[32] and *p,p'*-DDT (1,1,1-trichloro-2,2-*bis*(*p*-chlorophenyl)ethane), DDD (1,1-dichloro-2,2-*bis*(*p*-chlorophenyl)ethane) and toxaphene are dehydrochlorinated by saponification with alcoholic KOH. PCB is not degraded by either procedure.

Table 1. CHLORINATED HYDROCARBONS IN NORTH AMERICAN PEREGRINE FALCONS

Sample	Dieldrin	Total DDT*	Percentage DDE	PCB	DDT/PCB
1. Unhatched egg†					
Baja California (wet)	0·11	102	97	10·2	10
2. Second year ♀ migrant from Arctic‡					
Breast muscle (wet)	NM	93	94	28	3·6
Breast muscle (dry)		206		64	
Brain (wet)	NM	85	98	21	1·7
Carcass (wet)	0·67	70	93	19·7	3·8
Carcass (lipid)	62·6	5,000		1,420	
3. Immature, California§					
Breast muscle (wet)	NM	14·4	90	9·4	1·5
Liver (wet)	NM	7·7	92	4·6	1·7
Brain (wet)	0·04	2·8	89	1·5	1·9
Brain (lipid)	0·50	30		19·3	
Carcass (wet)	0·11	20·2	92	10·6	1·9
Carcass (lipid)	1·6	300		160	
4. Adult, California¶					
Breast muscle (wet)	NM	127	87	88	1·8
Liver (wet)	NM	77	80	67	1·1
Brain (wet)	0·31	40·5	86	31·6	1·4
Brain (lipid)	3·7	505		415	
Carcass (wet)	1·7	85	87	63	1·3
Carcass (lipid)	50	2,600		1,950	
5. Immature** migrant from Arctic††					
Breast muscle (wet)	NM	2·3	81	0·16	14
Breast muscle (dry)		7·8		0·54	
Liver (wet)	NM	1·0	92	0·10	10
Brain (wet)	NM	0·43	83	0·037	12
Body fat (wet)	NM	50·3	82	3·2	16
Carcass (wet)	0·07	0·3	82	0·80	12
Carcass (lipid)	0·44	63·7		5·5	
6. Immature Arctic migrant‡‡					
Breast muscle (wet)	NM	1·9	89	0·6	3·4
Breast muscle (dry)		6·0		1·9	

Concentrations in parts per million wet weight, dry weight or lipid weight.

* DDT residues include: *p,p'*-DDT, *p,p'*-DDE, *p,p'*-DDD (*p,p'*-TDE), *p,p'*-DDMU, *o,p'*-DDT and *o,p'*-DDE. NM, Not measured.

† Chlorinated hydrocarbon contents of this egg were: 4,700 μg *p,p'*-DDE; 40 μg *o,p'*-DDE; 20 μg *p,p'*-DDT; 7·4 μg *p,p'*-DDD; 37 μg *p,p'*-DDMU; 8 μg dieldrin; 12 μg heptachlor epoxide. Concentrations were calculated by assuming a volume of 47·3 ml., the average value obtained by measuring eleven clutches of peregrine eggs from California in the Museum of Vertebrate Zoology, University of California, Berkeley, and by assuming a density of 1·0.

‡ Second year female, captured in October on the Texas coast during migration. Died in captivity shortly afterwards, no apparent cause of death. No body fat. Total body content of chlorinated hydrocarbons: 95 mg DDT, 10 mg PCB, 0·41 mg dieldrin, 0·18 mg heptachlor epoxide. Total body lipid, 7 g.

§ Plumage characteristics of both 3 and 4 were intermediate between those of typically resident California birds and the Arctic race *F. p. tundrius*, as described by White[33]. No. 3 was an immature female of the year trapped in the southern San Francisco Bay area in the winter of 1966. Observed feeding in the area for a week before capture. Died suddenly after eating a dead gull. Moderate body fat. Total body chlorinated hydrocarbon content: 13 mg DDT, 0·8 mg PCB, 0·07 mg dieldrin, 0·09 mg heptachlor epoxide. Total body lipid, 43 g.

¶ Adult female. Trapped in the southern San Francisco Bay area in the winter of 1966. Observed feeding in the area for a month before capture. Died shortly afterwards with an apparent cause of death and no body fat. Total body chlorinated hydrocarbon content: 52 mg DDT, 40 mg PCB, 1·0 mg dieldrin, 1·0 mg heptachlor epoxide. Total body lipid, 20 g.

* First year female trapped on the Texas coast in October. Last at Pt Mugu, California, the following January and was shot by a sportsman 3 weeks later. Abundant body fat. Total body content: 7 mg DDT, 0·6 mg PCB, 0·05 mg dieldrin, 0·17 mg heptachlor epoxide. Total body lipid, 110 g.

** First year female trapped on the Texas coast in October. Died shortly afterwards of heat prostration.

In Table 1 are presented the results of analyses of peregrine falcons which died from a variety of causes

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Table 9. PCB AND DDT IN THE GLOBAL ECOSYSTEM

Species	N	Total DDT (μg)	Total DDT (p.p.m.)	Percentage DDE	PCB (μg)	PCB (p.p.m.)	DDT:PCB
White crappie (1)*	5	—	1·83 (W)	6	—	0·004 (W)	475
Black crappie (2)*	5	—	2·10 (W)	6	—	0·003	650
Bluegill (3)*	5	—	5·5 (W)	6	—	0·005	1,200
Adelie penguin (4)							
Eggs	6	0·78 (0·56–1·04)	0·128 (L)	74	< 0·044 μg/egg		> 18
Western grebe (5)							
Breast muscle	2	—	26·4 (W)	5	—	0·093 (W)	270
Fulmar (6)							
A	1	—	0·41 (W)	76	—	0·08 (W)	5
B	1	—	3·4 (W)	80	—	0·34 (W)	10
C	1	10,475	17·5 (W)	96	3,900	6·5 (W)	3·7
Pink-footed shearwater (7)	1	2,000	3·0 (W)	93	277	0·42 (W)	7·2
Sooty shearwater (8)							
A	1	—	12·3 (W)	94	—	1·2 (W)	
B	1	—	10·3 (W)	86	—	0·9 (W)	10
C	1	1,265	2·3 (W)	85	NM		12
Slender-billed shearwater (9)	1	—	32·0 (W)	92	—	2·1 (W)	15
Ashy petrel (10)	8	2,156 (1,644–2,826)	59·3 (W)	95	389 (293–482)	9·8 (W)	5·5
Brown pelican (11)							
Eggs, Panama	6	59 (18–183)	11·5 (L)	81 (47–78)	23·1 (18–30)		1·55 (0·97–3·2)
Eggs, Baja California	2	53 (47–50)	10·0 (L)	81	10·4 (0·0–11·7)	—	6·5, 4·0
Frigate-bird (12) eggs, Panama	3	9·6, 8·7, 30·0	—	88	8·4, 5·7, 84·0	—	1·1, 1·5, 0·4
Brown booby (13) eggs, Panama	4	27·8 (16·4–24·5)	8·2 (L)	89	12·2 (6·5–18·9)	4·8 (L)	1·7
Brandt's cormorant (14) eggs	17	326	—	91	118	—	2·9
Pelagic cormorant (15) eggs	2	128 (125–130)	—	90	62 (48–75)	—	2·1
Cinnamon teal (16)	1	4,340	10·9 (W)	70	—	0·91	12
White-tailed kite (17)							
Eggs, clutch *A*	4	11·4 (9·8–12·9)	0·76 (W)	77	6·4 (5·5–7·8)	—	1·8
Unhatched egg *B*	1	5·1	0·34 (W)	82	0·84	—	6·0
Unhatched egg *C*	1	5·3	0·33 (W)	73	3·6	—	1·5
Clutch *D*	2	8·3/egg	—	82	4·3/egg	—	1·9
Clutch *E*	2	10·2/egg	9·0 (L)	57	4·0/egg	—	2·6
Clutch *F*	4	31·0/egg	—	80	3·8/egg	—	8·5
Cooper's hawk (18)	1	8,500	23·2 (W)	90	—	6·3	4·0
Golden eagle (19) egg	1	150	2·0 (W)	93	17·5	0·23 (W)	8·5
Osprey (20), Baja California	6	127 (30–264)	85 (L)	83	(7·3, 3·0, 103) (24, 7·0, 19)	—	8·5, 10·1, 1·8, 11·2, 9·7, 11·2
Merlin (21)	1	433	2·9 (W)	94	65·4	0·30 (W)	12·7
American kestrel (22)							
Whole body, adult	1	5·1	0·014	39	3·7	0·031	1·4
Eggs, two clutches	6	2·4/egg	0·20 (W)	93	1·0/egg	0·09 (W)	2·3
Black-crowned night heron (23)							
Egg	1	541	—	60	330	—	1·6
Egg	1	869	—	99	23	—	38
Western gull (24)							
Eggs, San Francisco Bay, three clutches	4	803 (632–1,123)	—	85	805 (580–1,310)	—	1·0
Eggs, Farallon Is., ten clutches	10	412 ± 102	—	89	130 ± 55	—	3·0
Eggs, Baja Calif., seven clutches	7	335 ± 230	—	97	45 ± 30	—	9·1, 10·3, 5·0, 12·3, 10·6, 10·7, 10·3
Forster's tern (25) eggs	2	635 (593–732)	—	89	114 (91–137)	—	5·8
Caspian tern (26)							
Eggs, San Francisco Bay	2	1,269 (1,210–1,322)	—	89	805 (660–950)	—	1·7
Eggs, San Diego Bay	5	1,430 (901–2,430)	—	88	1,010 (550–1,600)	—	1·4
Red phalarope (27)	1	—	0·78 (W)	79	—	0·10	8
Common murre (28) eggs	6	1,045 (932–3,021)	151 (L)	90	553 (304–1,010)	45 (L)	3·3
Cassin's auklet (29)	1	—	5·8 (W)	98	—	0·16	36
Ancient murrelet (30)	1	—	0·75	90	—	0·15	5
Rhinoceros auklet (31)	1	—	2·7	97	—	0·36	8
Mourning dove (32)	2	12·0, 33·1	0·19 (W)	77, 93	Not detected	—	—
Barn owl (33)							
Eggs, one clutch	8	27·7/egg	1·25 (W)	95	10·4/egg	0·47 (W)	2·7
Eggs, one clutch	2	143/egg	6·6 (W)	96	14·1/egg	0·66 (W)	10
Meadowlark (34)	8	21·2, 418	0·18, 3·3 (W)	77, 93	2·5, 28·1	—	8·4, 15·0

Content in μg and concentrations in p.p.m. wet weight (W) or lipid weight (L).
Unless otherwise specified, analyses were of whole bodies. Endrin and dieldrin were identified on the basis of retention times on both *QF-1* and *DC-200* columns.

1. *Pomoxis annularis*, 291 g, Clear Lake, Lake Co., Calif., May 1963.
2. *Pomoxis nigromaculatus*, 212 g, Clear Lake, Lake Co., Calif., May 1963.
3. *Lepomis macrochirus*, 229 g, Clear Lake, Lake Co., Calif., May 1963.
4. *Pygoscelis adeliae*, Cape Crozier, Antarctica, October 1957.
5. *Aechmophorus occidentalis*, Clear Lake, Lake Co., Calif., May 1963.
6. *Fulmarus glacialis*. *A* and *B*: Monterey Bay, Calif., November 1, 1964. *C*: Point Reyes, Calif., December 1957. Fulmars breed in Alaska.
7. *Puffinus creatopus*. Breeds in Chile. Collected in May 1964, in the Gulf of California.
8. *Puffinus griseus*. Breeds in New Zealand and Chile. *A* and *B*: Monterey Bay, November 1, 1964. *C*: Gulf of California, May 1964. NM, Not measured, interfering peaks.
9. *Puffinus tenuirostris*. Breeds in Australia. Monterey Bay, December 1966.
10. *Oceanodroma homochroa*. Farallon Islands, Calif., May 1964.
11. *Pelecanus occidentalis*. Panama eggs were collected on Isla Pachesa and Isla Pachequilla, Gulf of Panama, February 1968. One egg contained 0·06 p.p.m. dieldrin and 0·06 p.p.m. endrin, another contained 0·16 p.p.m. dieldrin and 0·07 p.p.m. endrin (lipid weight). Baja California eggs were collected at Bahia de los Angeles, March 1968. One egg contained 0·24 p.p.m. dieldrin and 1·13 p.p.m. endrin (lipid weight).
12. *Fregata magnificens*. Isla Pachesa, Panama, February 1968.
13. *Sula leucogaster*. Isla Pachesa and Isla Pachequilla, Panama. February 1968. Two eggs were analysed for dieldrin and endrin. Dieldrin: 0·03, 0·13 p.p.m.; endrin: 0·06 and 0·611 p.p.m. (lipid weight).
14. *Phalacrocorax penicillatus*. Farallon Islands, May 1967.
15. *Phalacrocorax pelagicus*. San Mateo Co., Calif.
16. *Accipiter cooperii*. San Diego, April 1964. Adult male.
17. *Elanus leucurus*. *A*: Contra Costa Co., Calif., April 1968. *B* and *C*: Contra Costa Co., May 1964, two and three young raised, respectively. *D*: Abandoned, Contra Costa Co., May 1967. *E* and *F*: Destroyed nests, Contra Costa Co., March 1965.

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Table 3 (*continued*)

18. *Accipiter cooperii*. Balboa Park, San Diego, February 1964. First year female, died of trichomoniasis.
19. *Aquila chrysaetos*. San Luis Obispo Co., Calif., April 1966. Unhatched egg in nest where one young was raised. Egg also contained 4·7 μg of dieldrin, 1·9 μg of heptachlor epoxide, but no endrin.
20. *Pandion haliaetus*. Gulf of California, March 1968. One egg also contained 0·10 p.p.m. dieldrin and 0·25 p.p.m. endrin (L).
21. *Falco columbarius*. Immature, Utah, December 1967.
22. *Falco sparverius*. Adult was killed on road, Monterey Co., Calif., December 1967. Eggs from Davis, California, 1963.
23. *Numenius americanus*. Eggs from different clutches, San Francisco Bay, May 1967.
24. *Larus occidentalis*. Standard errors, 95 per cent confidence limits.
25. *Sterna forsteri*. San Diego Bay, May 1967.
26. *Hydroprogne caspia*. 1967.
27. *Phalacrocorax pelagicus*. Monterey Bay, November 1, 1966.
28. *Cepphus columba*. Farallon Islands, May 1967.
29. *Ptychoramphus aleuticus*. Farallon Islands, April 1966.
30. *Synthliboramphus antiquum*. Monterey Bay, November 1, 1966.
31. *Cerorhinca monocerata*. Monterey Bay, November 1, 1966.
32. *Zenaidura macroura*. San Diego, July 1963.
33. *Tyto alba*. Clutch *A* from Contra Costa Co., Calif., March 1968. Clutch *B* from Yolo Co., Calif., April 1968.
34. *Sturnella neglecta*. Davis, Calif., December 1967.

In these, however, the amount of DDT was very low; with a DDT: PCB ratio of 18, no PCB would have been detected. A larger amount of fat material from Antarctic organisms, which would contain more DDT, would therefore have to be analysed before concluding that PCB has not yet reached the Antarctic.

Individuals of species resident in industrial areas have, as expected, higher PCB levels than individuals of the same species from more remote regions. Analysis of ten eggs from ten clutches of the western gull from the Farallon Islands showed an average PCB content of 136 ± 55 μg (95 per cent confidence level). PCB content of four eggs from three clutches from an island in San Francisco Bay averaged 803 μg with a range from 580 to 1,310 (Table 3). Seven eggs from seven clutches in the Gulf of California contained 45 ± 30 μg of PCB. The DDT content of the eggs from the Farallons was not significantly different from that of the Baja California eggs.

Birds from the Gulf of California also contain dieldrin and endrin (Tables 2 and 3), but the number of analyses is as yet insufficient to compare their relative abundance with that of DDT and PCB. Despite the inability of the Shell Chemical Company to find any chlorinated hydrocarbons in the Gulf of California and at the mouth of the Colorado River[21], which drains into the Gulf, it is likely that some do enter from the Colorado River and from agricultural areas in western Mexico. A significant fraction, however, must come from the atmosphere[16], and air transport best explains the presence of PCB in remote areas. In extracts from the Gulf of California one PCB compound was present in relatively small concentrations. This compound is readily degraded by ultraviolet light irradiation in laboratory experiments, and may therefore be selectively degraded in the atmosphere. Although PCB is not soluble in water, it has a low but finite vapour pressure[22]. Incineration of materials containing PCB would greatly increase the rate of entry into the atmosphere. PCB is used in the manufacture of many industrial products, so the high amounts found in San Francisco Bay, Puget Sound[3] and San Diego Bay presumably result from direct discharge of industrial wastes into these waters and from local fallout.

The presence of PCB in the few land birds and freshwater fish analysed indicates that it is also distributed among continental ecosystems in North America. Peregrines could therefore acquire PCB, as well as the other chlorinated hydrocarbons, over all their global range. No PCB residue data are available for prey species from the Atlantic, but compounds which seem to be PCB have been isolated from seals[16]. A second year male peregrine spent the winter of 1967–68 on Isla Pacheca, Panama, where the pelican, booby and frigate-bird eggs of Table 3 were collected. The Cooper's hawk which was analysed, a species which also preys upon birds, contained high residues of both DDT and PCB (Table 3). Cooper's hawks have declined in eastern North America and in some regions have produced thin-shelled eggs[23]. Several species of raptors do not accumulate high amounts of the organo-chlorine compounds (Table 3), a result of the very low residue levels usually found in their prey. American kestrels and barn owls are common residents of California cities. The white-tailed kite, which was near extinction 40 years ago in California, is now abundant in areas where insecticide use is intense, yet because it preys primarily upon the short-lived and herbivorous vole, *Microtus*, the species accumulates very little DDT or PCB (Table 3).

Previous work[18] has shown that both DDT and dieldrin induce hepatic enzymes in the pigeon which, in an *in vitro* preparation, increase the metabolism of progesterone and testosterone. This work has now been extended to study the metabolism of oestradiol by enzymes induced by *p,p'*-DDE, technical DDT (Dupont) and PCB ('Aroclor 1262'). The experimental procedure previously described[18] was followed except that the chlorinated hydrocarbons were injected intramuscularly rather than given orally, and in the separation of oestradiol and its metabolites the solvent system used was the upper layer of a mixture of benzene:heptane:methanol:water 7:3:3:2. The strips were monitored with an autographic strip scanner. The profiles obtained for the various inducing agents are shown in Fig. 1. It will be noted that the profiles of the metabolites obtained after enzyme induction using DDE and DDT are identical, but that a different metabolite is produced by the enzyme induced by PCB. The amount of metabolites formed was calculated from the radioactivity of the peaks. The results obtained are given in Table 4.

Table 4. INCREASE OF OESTRADIOL METABOLISM BY PIGEON LIVER HOMOGENATES FROM BIRDS TREATED WITH VARIOUS CHLORINATED HYDROCARBONS

	Amount of polar metabolites formed in m*μ*moles
Control	20·3 ± 6·5
DDE (40 mg/kg)	76·2 ± 13·1
DDT (40 mg/kg)	93·1 ± 11·2
PCB (20 mg/kg)	160·0 ± 10·5

Each figure is the average with standard deviation of a group of four birds. In all cases 500 m*μ*moles of oestradiol-6,7-T (500 mc/mmole) was present in the incubation mixture. Incubation time 30 min, weight of microsomal fraction used 300 mg. All chlorinated hydrocarbons were injected intramuscularly into the pectoral muscle 7 days before death.

Body concentrations of 40 p.p.m. of *p,p'*-DDE significantly increased the rate of oestradiol degradation by the induced enzymes in the experimental conditions. On a weight basis the PCB preparation had an oestradiol degrading potential approximately five times that of *p,p'*-DDE or technical DDT. Both DDE and PCB, which are apparently the most abundant of the chlorinated hydrocarbon pollutants in the global ecosystem, have therefore the capacity to produce sublethal physiological effects in birds.

Studies on the activity of induced enzymes in the rat at various times after a single injection of DDT or dieldrin have been made by Ghazal *et al.*[18]. He found that it took 70 days for the activity to fall to half its maximum value in the case of DDT and 15 days in the case of dieldrin. Experiments with dieldrin on pigeons

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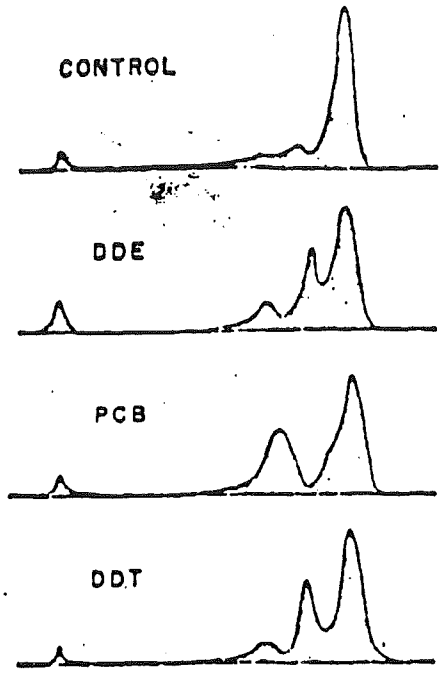


Fig. 1. Chromatographic separation of oestradiol and its metabolites. The large peak is unaltered oestradiol.

show that only a quarter of maximum activity remains after a month. Thus there is evidence that the effects of these induced enzymes can persist over a long period of time although more studies are needed to determine the steroid degrading potentials of livers of those species contaminated with chlorinated hydrocarbons. The profile of the metabolites should be some indication of the history of exposure to chlorinated hydrocarbons.

The reductions in eggshell thickness and eggshell weight increase the chances of egg breakage[21–24], and water retention, which affects hatching success[40–41], might be impaired. The environment in which birds now exist is therefore no longer the same as that in which they evolved; it is unlikely that any species has the genetic capacity to meet the selection pressures resulting from the abrupt environmental change which has produced the thin eggshells. The peregrine falcon is a species long highly revered and respected. G. H. Thayer[42] has described it as "the embodiment of noble rapacity and lonely freedom". An irony therefore exists in the fact that the peregrine may be the first species to be extirpated by global contamination.

This work was supported by the US National Science Foundation, the Bureau of Sport Fisheries and Wildlife and the US Public Health Service. Pure *p,p'*-DDE was supplied by the Federal Drug Administration, and samples of 'Aroclor' by the Monsanto Chemical Company.

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Tsunamis on the Moon?

by
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Scripps Institution of Oceanography,
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The spacing of the five annular mountain rings around Mare Orientale fits a dispersion curve for gravity waves on a 50 km "liquid" layer overlying a rigid basement.

The question whether the multiple ring-like mountain structures surrounding most of the lunar craters larger than 120 miles in diameter might be "frozen tsunamis", set in motion by the shock waves caused by impacting planetesimals, was first brought to my attention by R. B. Baldwin (personal communication). Baldwin points out that in several cases (including the giant Mare Imbrium) two or more rings can be made out

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A Menacing New Pollutant

By David Perlman
Science Correspondent

The peregrine falcon, a bird of prey that once abounded all over America, is bearing a bitter warning to man:

A newly-identified chemical pollutant has arisen on our planet: it threatens not only the existence of falcons and countless other birds, but its molecules are already entering the bodies of humans.

Its long-term hazards at low levels to the human species are wholly unknown — although in concentrated gaseous form the chemical is highly poisonous, and chemicals closely related to it are known cancer-causers.

In California the pollutant is widespread; in the San Francisco Bay Area, where many industries use many varieties of the compound, the chemicals have concentrated heavily.

The new pollution threat is a class of organic chemicals called polychlorinated biphenyls. Few laymen have ever heard of them, yet they

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IDS 003171

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Bay Scientist's Pollutant Warning

From Page 1

are a major boon to industry: they are used in making resins form the chemical is joints and plastics, electrical insulations and rubber tires, waxes, sealants and epoxy resins.

Despite their widespread use, in America they are made only by Monsanto Chemical Co., which markets many forms of the compounds under the trade name of Aroclors.

They apparently enter the biosphere and marine environment by vaporizing, venting from factory stacks, by waste discharge into waterways and even by the abrasive wearing of tires on freeways.

Their chemical structure is very similar to that of DDT, the potent and long lasting insecticide. Both DDT and the biphenyls are known as chlorinated hydrocarbons, and in the words of a Berkeley researcher they are now "the most abundant synthetic pollutants present in the global environment."

The Berkeley scientist is Dr. Robert W. Risebrough, a researcher at the Institute of Marine Resources in the University of California's Department of Nutritional Sciences.

Dr. Risebrough and a team of colleagues from Davis, San Diego and Cornell University in New York, have been alerting ecologists to the hitherto unsuspected prevalence of the biphenyl compounds and to their invasion of man's environment.

FALCON

They have published their findings in the British science journal Nature, in its American counterpart Science, and have discussed it at conferences on environmental poisons. Risebrough will be presenting more evidence on the problem at a La Jolla scientific meeting on the "Chemical Invasion of the Ocean."

In an interview with The Chronicle recently, Dr. Risebrough described the new pollution menace, and how he came upon it.

The tale is an ironic one, for it all started with the peregrine falcon. That bird, once described by an enamored ornithologist as "the embodiment of noble rapacity and lonely freedom," is now extinct as a breeding species in the eastern United States and southern Canada.

Its rapid population decline during the years right after World War II — when DDT was first introduced as a major pesticide — first served to alert ecologists that a new poison might be damaging the environment.

DDT

Investigations showed the falcon was succumbing by preying on birds that had ingested large quantities of DDT, a chemical that concentrates in animal fats. So the falcon, in a sense, was man's first messenger to carry the warning that DDT was befouling the world.

And just as Spartan kings slew their messengers who bore bad news, so the falcon is being slain today as it carries the news of the new chemical pollutant. Eighty percent of California's breeding peregrine falcons, Dr. Risebrough estimates, have now been destroyed.

It was barely two years ago that Dr. Risebrough, on an expedition to Baja California, found an unhatched, abandoned egg of a peregrine falcon. He analyzed the egg's contents, found DDT in it, and also found it contained another unidentified chemical.

PCB

Later that same chemical was found in the fat of European birds and Swedish scientists identified it as a polychlorinated biphenyl, which was to gain its scientific notoriety as PCB.

Dr. Risebrough and his colleagues then began an exhaustive hunt for PCB in birds and fish along the West Coast. They are still at it.

They have found, for example, that PCB is present in almost all birds of prey, but its quantities are largest in those birds that feed on fish or fish-eating birds. The material, like DDT, apparently starts concentrating in the lowest links of the marine "food chain" — the microscopic oceanic plants and animals — and becomes more and more concentrated as tiny fish eat plankton, bigger fish eat small fish, and birds eat bigger fish.

Peregrines preying on Pacific sea birds have now virtually vanished Dr. Risebrough reports. But small inland colonies of California falcons, which prey mostly on doves and songbirds, still appear to be reproducing normally.

In hundreds of analyses of birds and their eggs Dr. Risebrough and his colleagues have found only about a tenth as much PCB as DDT among birds from relatively uncontaminated areas. But in birds from the Farallon Islands the PCB quantities are higher — between a fifth and a half the DDT.

In birds and their eggs from polluted San Francisco Bay — falcons, gulls, terns and night herons — there is often more PCB than DDT.

Dr. Risebrough and his colleagues point out that all the chlorinated hydrocarbons, like DDT, cause enzyme changes in animal livers and that these new-formed enzymes break down many vital hormones, including sex hormones. In laboratory experiments with pigeons, using a biphenyl compound called Aroclor 1262, made by Monsanto, Dr. Risebrough's group has found that PCB is five times more powerful than DDT in its hormone-destroying activity.

The sex hormones, according to Dr. Risebrough, play an important role in calcium metabolism, and as a result of the pollution by PCB and DDT the eggs of birds like falcons are now far thinner and more fragile than they used to be.

HUMANS

The calcium-deficient eggs break prematurely and fail to produce hatchlings. Thus the decline of the falcon — the end of its evolutionary road. It had adapted over millions of years to its natural environment but it could not survive as a species in an environment altered by man's new chemicals.

And what of the effect of the biphenyl compound: in humans? The compounds have already been found ominously. In the milk of mothers analyzed by Dr. J. H. Enderson and Dr. F. A. Beland at Colorado College, and Dr. Risebrough is now hoping to test for their presence among nursing mothers here.

As Dr. Risebrough has written: "They are highly toxic to man when inhaled as vapors, and the more heavily chlorinated components have greater toxicity. No tolerance limits have been set for human food supplies and their cancer-causing properties remain to be determined."

FOOD

Dr. Risebrough and his colleagues have found evidence that the biphenyls, like DDT, are carried widely across the oceans by winds and water currents. Arguments that they can be used safely in

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cause they remain localized. Dr. Risebrough says, are "misleading, irrelevant and wrong."

How the PCB compounds may affect human food supplies and human lives are questions for future research. The one certainty now is that they can be found everywhere, that they have invaded the food-producing levels of the oceans, and that their presence is rising swiftly.

Officials of the Monsanto company in St. Louis were asked for comment on Dr. Risebrough's report last week. After three days of queries a company spokesman would only say that top Monsanto scientists and sales executives were studying it.

Dr. Risebrough's fellow-researchers attacking the PCB pollution problem include Dr. D. B. Peakall of Cornell; Steven G. Herman, a zoologist at Davis; Dr. Monte N. Kirven at the San Diego Natural History Museum, and Paul Reiche in the marine resources lab at Berkeley.

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Monsanto

FROM (NAME & LOCATION): E. V. John - St. Louis

DATE: February 2, 1970 CC

SUBJECT: Possible Customer Questions on PCBs

REFERENCE:

TO : Dr. Cumming Paton - CPATO

In reply to your memo of January 22, I am attaching information relative to questions 1, 2 and 3 to be used as back-up information for your salesmen.

E. V. John

EVJ/stw

Attachment

IDS 003174

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POSSIBLE CUSTOMER QUESTIONS ON PCBs

PUBLICITY

QUESTION 1

What articles have appeared on the PCB problem? Will you send me copies?

ANSWER

In the U.S., articles have appeared in the San Francisco Chronicle on Feb. 24, 1969, the San Francisco Examiner on Feb. 25, 1969, and the Hartford Times on Aug. 3, 1969. Numerous articles were generated by the Wisconsin "DDT Hearings" in May, 1969. At the hearings, witnesses discussed the problem of PCBs as "interfering substances" in their search for DDT in the environment. PCBs, they said, produced peaks on a gas chromatograph similar to the peaks produced by DDT. In no case was PCB indicted at the Wisconsin hearings.

Copies of the articles will be made available on request. Regional managers should contact E. V. John, Public Relations Manager, Organic Chemicals Division, in St. Louis and copies will be forwarded to the customer through the regional manager's office.

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--2 POSSIBLE CUSTOMER QUESTIONS ON PCBs

In addition to the newspaper articles mentioned above, there have been radio broadcasts. At the time of the San Francisco Chronicle and Examiner articles, radios in the San Francisco area also carried the story. In August, the sports editor of the Hartford Times syndicated a radio broadcast on the subject of PCBs, and in Dec., 1969, the Canadian Broadcasting Co. (radio) carried an interview they taped with a member of our medical department.

QUESTION 2

Were Monsanto's Aroclors specifically mentioned in these articles?
If so, which ones?

ANSWER

Monsanto's Aroclors were mentioned in some of the articles but only in the San Francisco Chronicle story in Feb., 1969, was Aroclor 1262 specifically mentioned by number. In several of the articles, Monsanto was also identified as the sole U.S. producer of polychlorinated biphenyls, marketed under the tradename of Aroclor.

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--3 POSSIBLE CUSTOMER QUESTIONS ON PCBs

QUESTION 3

What did the articles on the PCB problem say?

ANSWER

Since the outset of the "PCB problem", when the first article appeared in the U.S. press in Feb., 1969, the whole question has been closely interwoven with the question of DDT as a possible environmental contaminant.

The San Francisco Chronicle article carried a headline, "A Menacing New Pollutant." In rather sensational style, it identified PCB as a threat to birds and humans, highly toxic in a gaseous state and related to known cancer-causers. PCB presence in the environment is rising swiftly, the article stated.

The Examiner article called PCB a "plastic pollutant in the Bay and Mothers' Milk." This article called PCB an "alarming" new chemical pollutant that is playing a role in the declining peregrine falcon population, has been found in mothers' milk, and is the "latest addition to a growing list of chemicals in the ocean ---- the newest symptom of man's chemical invasion of the ocean."

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--4 POSSIBLE CUSTOMER QUESTIONS ON PCBs

These two articles quoted Dr. Robert Risebrough, a researcher at the Institute of Marine Resources in the University of California's Department of Nutritional Scientists, on the detrimental effects of PCBs. Later Dr. Risebrough said he had been misquoted in some newspaper stories.

The Hartford Times story called PCB pollution a "new puzzle." Less sensational than the San Francisco articles, the Times gave an account of PCBs being found in the environment and the studies under way to determine their biological effects. This article, says Dr. Risebrough, tends to clear PCB of blame.

Articles generated by the Wisconsin DDT hearings generally discussed PCB as an interfering substance discovered in scientists' search for DDT in the environment. Dr. Risebrough said at the hearings that there was no proof at the moment that PCBs alone can cause thin eggshells, one of the phenomenon that he had discovered in studying the declining population of the peregrine falcon.

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