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RECEIVED

MAR 19 1969

EDWARD M. KLINE, M. D.

March 17, 1969

Dr. E. M. Kline
NEW YORK OFFICE

Dear Ed:

I have been in telephone conversation with Dr. Emmet Kelly and Ed Wheeler, Medical Director and Industrial Hygienist respectively of Monsanto Chemical Co. in St. Louis. They are concerned over some recent technical and newspaper articles relating to the presence of polychlorobiphenyl products in widely dispersed fish and wildlife. The increasing interest in the effects of pesticides, especially chlorinated ones, on the ecosystem has raised the question of what adverse effects, even the pico-gram quantities of the polychlorobiphenyl compounds found in birds' livers and eggs and in fish livers, can have on the normal development of these species. At present, there is little to indicate whether these compounds have been dispersed atmospherically or have been waterborne.

The General Electric Co. purchases its chlorinated polyphenyls from Monsanto Co., modifies it, and uses it under the name of Pyranol. I believe the major application for this material in our Company is as a dielectric for certain types of transformers and capacitors. Dr. Kelly was not sounding a tocsin, but thought that the proper people in our organization should be alerted to the possibility that questions may be aimed at us, or that we may want to make some attempt to determine to what degree the Components using this material discharge it as either liquid or solid waste, or as an air contaminant.

I am attaching several articles on this subject which you may wish to pass on to the proper person or persons. One individual who is highly knowledgeable about the uses of Pyranol is A. Raab at the Laboratory in Pittsfield, Massachusetts. Dr. Raab may be a good person to contact first.

Best personal regards,

I. Matelsky
Industrial Hygienist
#116.20

IM:ejp
Attachments
cc: JW Loney, M.D.

PLAINTIFF'S EXHIBIT 1205

735881

GENP 001105

...is terminated and the completed chain released ... the ribosome-*m*RNA complex to which it is bound ... the *t*RNA molecule carrying the last amino-acid ...separated. There must be a mechanism for reading ... chain terminating codon (three codons UAA, UAG, ... UGA can code for chain termination) and cleaving ... last peptidyl-*t*RNA bond. In *Biochem. Biophys. ... Comm.*, 28, 773 (1967) he describes an experimental ...dure devised to give a rapid assay for chain termina... and in *Proc. US Nat. Acad. Sci.*, 58, 1144 (1967) ... reports the discovery of an enzyme required for ...ination.

The assay for termination employs the RNA from ... amber mutant of the coat protein gene of the RNA ...-phage *R*17. This mutant has an amber codon, ... at the position of the sixth amino-acid, a gluta... residue, in the *R*17 coat protein molecule. In a ... free system the mutant RNA directs the synthesis ... a small N-terminal peptide of the coat protein with ... sequence N-formylmet-ala-ser-aspn-phe-thr; the ... amino-acid in the coat protein is glutamine, but ...th the mutant RNA the amber codon causes pre...ature termination of synthesis and the release of the ...apeptide. The great virtue of this system is that ... unterminated peptide still attached to the peptidyl-...NA can be distinguished from the terminated peptide ...ased from the *t*RNA and the amounts of each ...ured. Furthermore, starving the system for any one ... the six amino-acids in the peptide arrests the trans...-ion machinery before it reaches the UAG codon so ...mination can be controlled.

Exploiting this procedure, Capecchi isolated a ...plex of ribosome, *m*RNA and pentapeptide attached by the phenylalanyl *t*RNA simply by starving for threonine. With this he has been able to define the conditions necessary for termination; incubating the complex under suitable conditions with or without threonine or supernatant enzymes showed that to get release it is necessary but not sufficient to complete the peptide by incorporating threonine and that release is not solely dependent on the transfer enzymes required to move the ribosome from the threonyl codon to the UAG terminating codon. Release does, however, depend upon the presence of a supernatant factor. This factor, with a molecular weight of between 40,000 and 50,000, sediments between 3·5*S* and 4·5*S*. Because its releasing activity is not affected by RNase, it cannot be an RNA-protein complex. Apparently the substrate of the release enzyme is the ribosome-*m*RNA-peptidyl *t*RNA complex so that it must act directly at the ribosome and not cleave the *t*RNA from peptidyl-*t*RNA already released into the supernatant, which was the other possibility.

Capecchi does not yet know whether the release enzyme works alone or in conjunction with other factors, in particular a hypothetical chain termination *t*RNA which reads the termination codon but does not carry an amino-acid. Many people, including Capecchi, have searched in vain for such a *t*RNA species, and although negative results can never exclude the possibility that such *t*RNA exists it is reasonable to think about alternative models in which the terminating codons are read either by the ribosome or the release enzyme or in which nonsense codons function simply because they cannot be read at all. Further characterization of the release enzyme could well decide the issue.

Chlorinated Hydrocarbons in British Wildlife

by

D. C. HOLMES
J. H. SIMMONS
J. O'G. TATTON

...oratory of the Government Chemist, ...don

Polychlorobiphenyl compounds have been detected in British wildlife. In birds' livers and eggs they are often in greater quantities than organochlorine pesticide residues. Polychlorobiphenyls are known to be toxic, and their detection in wildlife raises the question of the adverse effect they may have.

When wild birds' eggs or the livers of British wildlife are ...mined by gas-liquid chromatography (GLC) using ...tron-capture detection, peaks corresponding to such ...chlorine pesticides as BHC, dieldrin and DDT, and ... metabolites and breakdown products, often appear ... the resultant chromatograms. These peaks sometimes ...esent amounts which are significant from a toxicolo...al point of view, but the sensitivity of modern instru...nts also enables completely insignificant amounts to be ...tected. Analysts concerned with the determination of ...chlorine pesticides in wildlife, however, have long ...n aware that it is not unusual for an additional series ... as many as ten peaks, corresponding to unidentified ...mpounds, also to appear on these chromatograms[1-4]. ...tle is known of the structure and origin of these com...unds, but Roburn[3] established that they are organo-chlorine in nature, with a substantial chlorine content, and consequently possess electron-capturing properties.

On silicone or 'Apiezon' GLC columns, the series of peaks for these compounds normally begins at the point at which *pp'*-TDE and *pp'*-DDT are emerging from the columns and extends, in terms of retention times, to four or five times that of *pp'*-DDT, which is the last of the commonly occurring pesticides to emerge.

Before examination by GLC, samples have normally been subjected to a fairly rigorous clean-up procedure, such as that of de Faubert Maunder *et al.*[5], which includes a dimethylformamide–hexane partition and passage through a column of prepared alumina. Because these unknown compounds are similar in nature and properties to the organochlorine pesticides, they also pass through this and similar clean-up procedures; consequently, they

often interfere seriously with determinations of *pp'*-TDE and *pp'*-DDT in wildlife because of overlapping of the chromatographic peaks. Suitable procedures have been devised to overcome this difficulty of interfering peaks. One method is to effect a better resolution of these particular peaks by choice of a suitable stationary phase for GLC[6]. Another method, which also demonstrates the presence of these compounds in the sample, is the use of a preliminary thin-layer chromatographic treatment[7]. The cleaned-up extracts are examined on silica gel chromatoplates using a 1 per cent solution of acetone in hexane as mobile phase[8]. Spots corresponding to the compounds can then be found at R_F values between 0·8 and 1·0, whereas the commonly occurring organochlorine pesticides and their metabolites produce spots of lower R_F values. A similar separation can also be shown with reverse phase paper chromatography[9] whereby the unknown compounds move only a very short distance from the base line compared with the pesticides and their metabolites.

Gas-liquid chromatography using dual channel detection systems with separate electron-capture and flame-ionization detectors has also been used to demonstrate the presence of large amounts of weakly electron-capturing material, in addition to known pesticide residues, in the eggs of oyster catchers (*Haematopus ostralegus*)[9].

Experience in this laboratory has shown that these compounds occur most frequently and in the largest proportions in the livers, fat and eggs of birds, particularly terrestrial predators such as sparrowhawks (*Accipiter nisus*) and kestrels (*Falco tinnunculus*) and marine feeders such as guillemots (*Uria aalge*) and kittiwakes (*Rissa tridactyla*); they also commonly occur in freshwater fish. We have detected small amounts in human and animal fat samples, but less frequently and in much smaller proportions than in avian samples.

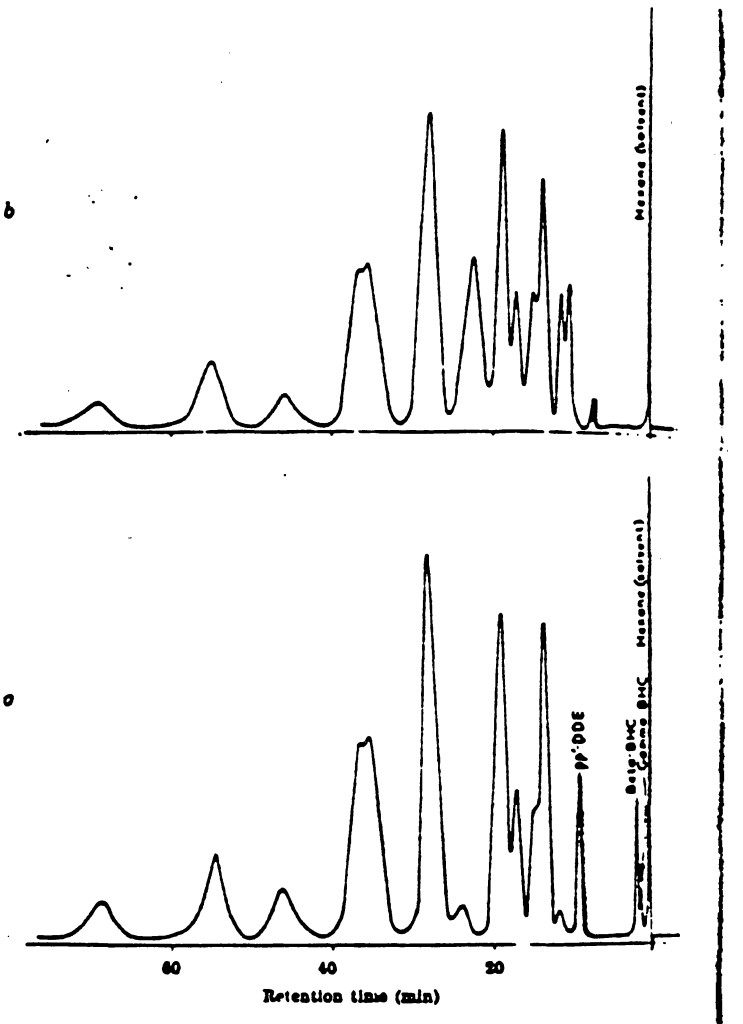

Fig. 1. Gas-liquid chromatogram of (a) extract of kestrel liver and (b) a commercial polychlorobiphenyl resin.

A similar series of chromatographic peaks has been observed by Holden[10,11] when examining extracts of seals and fish taken in Scottish waters. He found that the peaks given by the extracts of fresh and sea-water fish represented fairly low concentrations, but those given by extracts of seal blubber corresponded to much larger proportions, of the order found by this laboratory in birds' eggs.

Despite considerable curiosity about the identity of these compounds, little progress has been made in identifying them, but there has long been a general supposition that they were either further breakdown or condensation products of the organochlorine pesticides or possibly loose compounds of these with natural products such as protein matter.

Jonson, however, succeeded in identifying a series of such peaks as corresponding to polychlorobiphenyl compounds, in 200 pike taken in different parts of Sweden, and in an eagle[12]. We have now been able to show that the long retention time compounds occurring in British wildlife are also polychlorobiphenyl compounds.

Polychlorinated biphenyl has been in common commercial use for some time as a plasticizer in paints, resins and plastics. It also has electrical insulating properties and can be used for a number of other protective purposes. Commercial preparations of this material are usually graded according to the degree of chlorination, but all of them are substantially complex mixtures of polychlorobiphenyl compounds that could be expected to resemble the organochlorine pesticides in their chemical and physical properties. In the prescribed extraction and GLC conditions, these mixtures produce a series of chromatographic peaks of the type in question.

The compounds occurring in British wildlife correspond to the more highly chlorinated biphenyl compounds rather than the more lightly chlorinated types. These highly chlorinated biphenyls also occur to some extent in analogous polychloroterphenyl preparations which have commercial uses similar to those of polychlorobiphenyls. It is possible that some of the compounds with very long retention times occurring in British wildlife are highly chlorinated polychloroterphenyl compounds.

Fig. 1*a* shows the gas-liquid chromatogram of an extract from a kestrel liver. The peaks corresponding to *pp'*-DDE (0·43 ng), beta-BHC (0·33 ng) and gamma-BHC (0·03 ng) are labelled. The other peaks form the series referred to above and until now would have been regarded simply as "unknown organochlorine compounds" corresponding to any known pesticide or its metabolites. Fig. 1*b* shows the analogous chromatogram of a commercial polychlorobiphenyl resin. So far as retention times are concerned and apart from the pesticide peaks, there is exact matching for all but a few peaks in the two chromatograms.

The chromatograms shown were obtained by use of a silicone gum (*GE–SE 52*) column, but this precise correspondence between the retention times of the peaks of the unknown compounds and those from the polychlorobiphenyl resin has also been demonstrated on 'Apiezon

Table 1. RELATIVE RETENTION TIMES ON THREE DIFFERENT GLC COLUMNS (Excluding times for known pesticides)

	(Dieldrin = 1·00)				
	'Apiezon L' column		Cyanosilicone GE-XE 60 column		
GE-SE 52 column					
KLE	PCB	KLE	PCB	KLE	PCB
1·42	1·42	2·31	2·30	1·21	1·21
1·73	1·73	2·67	2·67	1·34	1·33
1·91	1·90	3·04	3·05	2·20	2·19
2·81	2·81	5·05	5·06	2·62	2·60
3·58	3·58	5·66	5·95	2·97	2·95
3·70	3·70	6·57	6·56	3·60	3·60
4·68				4·63	4·63
5·62				5·11	5·11
7·11					

KLE, Kestrel liver extract; PCB, polychlorobiphenyl resin.

and cyanosilicone columns. The actual retention times recorded for the peaks on these three types of column are given in Table 1.

Further confirmation as to the identity of these compounds has been obtained by a study of their behaviour on thin-layer chromatoplates, alumina and silica gel adsorption columns and reverse phase paper chromatograms. In addition, these compounds have been shown to resemble the polychlorobiphenyl compounds in their chemical inertness. Thus they are not easily modified by simple chemical reactions to produce readily identifiable shifts in their retention times on GLC as can be done, for instance, to *pp'*-DDT by hydrolysing it to *pp'*-DDE or to aldrin by oxidizing it to dieldrin.

A number of livers and eggs taken from birds in the British Isles or their coastal waters have been examined in this laboratory with results similar to those obtained for the kestrel liver referred to earlier. While the identification of these compounds in British wildlife may solve the mystery of these peaks on GLC chromatograms, it raises, however, many other questions. Why, for example, do these compounds seem to be accumulated, most frequently and in the largest proportions, in certain types of wildlife such as birds, seals and fish, and only at the most in very small proportions in man or his domestic animals such as cows or sheep? In this respect they seem to differ markedly from the organochlorine pesticides which seem to have invaded nearly all aspects of our environment and to which they bear a strong resemblance chemically and physically.

Some of the samples of birds examined in this laboratory have seemed to contain higher proportions of polychlorobiphenyl compounds than organochlorine pesticides. For example, the peaks on the chromatogram for the kestrel liver shown in Fig. 1 were estimated to be equivalent to about 12 ng of polychlorobiphenyl compounds. This must be contrasted against the organochlorine pesticide residues listed above. These total only about 0·8 ng of which 0·33 ng is beta-BHC, an isomer of BHC which is generally regarded as non-toxic to wildlife.

Great concern has often been expressed by conservationists about the effects of pesticides on wildlife, particularly birds. The identification of these other organochlorine compounds in wildlife prompts enquiries as to the possible toxic effects they may be having. That these compounds are toxic is generally agreed[13,14]; the polychlorobiphenyls are in fact regarded as an industrial hazard and threshold limits for them in air have been advised[15].

We thank the Nature Conservancy for samples of wildlife and Monsanto Chemicals Ltd. for samples of polychlorobiphenyl resins.

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Quasi-stellar Sources, Supernovae and Novae

by

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By considering the opacity of a surface layer of a star, the author concludes that quasi-stellar sources, supernovae and novae may be different manifestations of the same mechanism.

It is usually considered that the outbursts of novae and supernovae are fundamentally different processes, but I shall here propose a mechanism which can account for both phenomena, and which at the same time can account for other problems concerned with quasi-stellar sources (quasars). In particular, I suggest that these outbursts are likely to be anisotropic (as indeed they are observed to be for novae). Because the energy released during a supernova outburst is comparable with the stellar rest energy, an anisotropic outburst could mean that the star is accelerated to relativistic velocity in order to conserve momentum, thus affording a Doppler explanation of the large red-shifts of the quasi-stellar sources.

Consider the opacity of a layer, L, at the surface of a star. Let ΔR be the thickness and R the radius of L, and let L contain plasma at temperature, T, with electron and positive ion densities N_e and N_i respectively. L will be opaque to radiation of wavelength λ provided that τ is almost 1, where τ is the optical depth of L. A major contribution to τ is τ_{ff}, the optical thickness due to free-free absorptions. It is known that $\tau_{ff} \propto \lambda^2 T^{-3/2} N_e N_i \Delta R$ (ref. 1), where induced emissions are included. Suppose, now, that L is compressed or dilated without changing the total numbers of ions; that is, ΔR is varied under conditions which maintain constant $4\pi R^2 \Delta R N_e$, so that $\Delta R N_e =$ constant. Evidently $\tau_{ff} \propto N_e N_i \Delta R \propto N_i \propto 1/\Delta R$. Thus compression of L increases its opacity, while dilation reduces the opacity.

Of course, the total number of ions will not remain constant in practice, because the recombination rate is proportional to $N_e N_i$. If the percentage of atoms ionized is large, the density of unionized atoms, N, will therefore be proportional to $N_e N_i$. This means that the contribution to the opacity made by bound-bound and bound-free transitions within unionized atoms is also proportional to $N_e N_i \Delta R$. This effect, recognized to be important for stellar pulsation[1,2], further increases the opacity of L on compression.

Some consequences of this variable surface opacity will now be examined. Under equilibrium conditions the

Fractions and Multiples

fraction	prefix	symbol
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a

multiple	prefix	symbol
10	deka	da*
10^2	hecto	h*
10^3	kilo	k
10^6	mega	M
10^9	giga	G
10^{12}	tera	T

*To be restricted as much as possible.

Compound prefixes should not be used. Thus 10^{-9} metre is represented by 1 nm, not 1 mμm. The attaching of a prefix to a unit in effect constitutes a new unit, so that

$$1\ km^2 = 1\ (km)^2 = 10^6 m^2$$

not $1\ k(m^2) = 10^3 m^2$.

Where possible any numerical prefix should appear in the numerator of an expression.

Examples of Units Contrary to SI, with their Equivalents

physical quantity	unit	equivalent
length	ångström	10^{-10} m
	inch	0·0254 m
	foot	0·3048 m
	yard	0·9144 m
	mile	1·609 34 km
	nautical mile	1·853 18 km
area	square inch	645·16 mm^2
	square foot	0·092 903 m^2
	square yard	0·836 127 m^2
	square mile	2·589 99 km^2
volume	cubic inch	$1·638\ 71 \times 10^{-5}$ m^3
	cubic foot	0·028 316 8 m^3
	U.K. gallon	0·004 546 092 m^3
mass	pound	0·453 592 37 kg
	slug	14·593 9 kg
density	pound/cubic inch	$2·767\ 99 \times 10^4$ kg m^{-3}
	pound/cubic foot	16·0185 kg m^{-3}
force	dyne	10^{-5} N
	poundal	0·138 255 N
	pound-force	4·448 22 N
	kilogramme-force	9·806 65 N
pressure	atmosphere	101·325 N m^{-2}
	torr	133·322 N m^{-2}
	pound (f)/sq.in.	6894·76 N m^{-2}

Organochlorine Pesticides in Seals and Porpoises

by
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Seals and porpoises in Scotland and Canada, far from the sites of application of pesticides, can accumulate high concentrations of residues in their blubber. These chemicals are spreading through the long food chain which ends with seals and porpoises and obviously cannot be confined to their place of discharge.

THE presence of organochlorine residues in marine life in many areas of the world, including the Antarctic, has been reported recently[1-3]. In British waters the accumulation of residue in the eggs of sea birds[3] and the process of concentration of pesticides through certain food chains in the marine environment[4] have been studied. Analyses of various species of marine fish and mammals from Scottish waters during the past 5 years[5,6] have shown that organochlorine residues are now a normal occurrence, the highest concentrations being found in organs or tissues with the highest lipid content. Thus the muscle tissue of salmonids, the livers of cod and the blubber of seals act as storage sites for these residues.

The aquatic mammals, such as whales, seals and porpoises, have a relatively high proportion of the body weight in the form of subcutaneous fat (blubber). Seals feed chiefly on gadoids and salmonids, and porpoises chiefly on small gadoids and clupeoids. The process of concentration of pesticides through their food chain might be expected to result in high pesticide levels in the fat of these mammals, and samples analysed at this laboratory confirm this expectation. In recent years, specimens of the grey seal (*Halichoerus grypus*), common seal (*Phoca vitulina*) and porpoise (*Phocaena phocaena*) have been sampled from the coasts of Scotland. Samples of blubber were available for all the specimens examined, and in a few cases other organs were also available. As well as recognized pesticide residues, other electron-capturing substances have been detected by gas–liquid chromatography and, in order to establish whether such substances are as widely distributed as the pesticides, blubber samples from grey seals and harp seals (*Phoca groenlandica*) on the Canadian Atlantic coast have also been examined and the results of the analyses are reported here. Examination of samples of seal blubber from other areas is continuing in order to assess the variation between different regions of the marine environment.

All tissue samples from Scottish waters were frozen at −18° C until required for analysis. The Canadian samples were preserved in 10 per cent formalin, which showed no evidence of any influence on the analytical procedure, and in this and other cases involving fat it has not affected the efficiency of recovery of pesticide residues. Aliquots of the samples (5 g) were ground to a powder with anhydrous crystalline sodium sulphate (AR grade) and extracted in a Soxhlet apparatus with redistilled AR grade n-hexane (previously tested and found to be free of electron-capturing materials by gas chromatography). The hexane extracts were made up to known and 25 ml. aliquots were subjected to clean-up by the hexane–dimethylformamide partition method of Mr. Faubert Maunder *et al.*[7], followed by column cleaning using alumina containing 5 per cent water. The loss of pesticide residues from fat extracts so treated is up to 20 per cent, but, as is customary in pesticide analyses, no correction has been made for such losses in the results presented here.

The cleaned-up hexane extracts were analysed by gas–liquid chromatography on a Varian 'Aerograph 200' instrument employing two glass columns 5 ft. long × ¼ in. outer diameter. One column was packed with Chromosorb *W AW/DMCS* 80–100' mesh coated with 10 per

200 silicone oil, and the other with the same support and with 5 per cent *DC*-200 + 7·5 per cent *QF*-1 silicone. The oven temperature was 200° C, the nitrogen gas flow 50 ml./min and the column resolution dieldrin equivalent to 1,600 theoretical plates. There was no significant degradation of DDT on the columns. While complete separation of the common pesticide residues is possible on one or other of these columns, interference by polychlorinated biphenyl (PCB) residues[4,9] with *p,p'*-TDE and *p,p'*-DDT peaks necessitated a further critical stage. Aliquots (5 ml.) of some of the extracts were evaporated to dryness in a stream of cold filtered air, and the residues refluxed with 2 ml. of 2·5 per cent alcoholic potassium hydroxide for 15 min on a warm water-bath. After cooling, 5 ml. of *n*-hexane was added, with mixing, followed by 40 ml. of 2 per cent sodium chloride solution. The supernatant hexane layer was then analysed by gas–liquid chromatography. By this technique, quantitative conversion of *p,p'*-DDT to *p,p'*-DDE, and of *p,p'*-TDE to *p,p'*-MDE (= DDMU), is obtained, and the conversion products confirm the identity of the original residues. The residual peaks in the *p,p'*-DDT and *p,p'*-TDE positions, where present, can be subtracted from the values of the pesticides originally determined in these positions. Hydrolysis also destroys α and γ-BHC, where present, but polychlorinated biphenyls are unaffected. A cyanosilicone (*XE*-60) column[10] has also been used to separate *p,p'*-DDT and *p,p'*-TDE from PCB interference, confirming the latter.

The principal pesticide residues found in all samples examined were those of the DDT group, with dieldrin in much smaller quantities. Canadian seals contained lower concentrations of dieldrin than Scottish seals, while Scottish porpoises contained remarkably high concentrations of all pesticide residues (see Table 1). Interference on the *DC*-200 silicone column in the *p,p'*-TDE position caused by a non-hydrolysable residue was responsible for about 5 per cent of the total estimated *p,p'*-TDE in the Canadian and Scottish samples examined. In the *p,p'*-DDT position, the non-hydrolysable residue constituted about 10 per cent in the Canadian samples and about 5 per cent in the Scottish samples examined for this interference, the total amount of non-hydrolysable material being smaller in the Canadian samples. The values in Table 1 have not been corrected for this interference, for only a proportion of the samples were hydrolysed. Results from the various species of seals were not noticeably different in a given area, and have been combined in Table 1.

Table 1. CONCENTRATION RANGES OF ORGANOCHLORINE RESIDUES IN FAT OF SEALS AND PORPOISES (p.p.m.)
(Means in parentheses)

Area and type of sample	No. in sample	Dieldrin	*p,p'*-DDE	*p,p'*-TDE	*p,p'*-DDT
Scotland, adult seals (1965–66)	18	0·15–2·1 (0·79)	1·0–11·1 (5·7)	0·27–3·0 (1·2)	1·5–23·3 (7·8)
E. and W. Scotland, adult seals (1965–66)	6	0·06–0·39 (0·20)	1·2–7·0 (3·4)	0·17–0·83 (0·41)	1·7–7·7 (3·8)
E. and W. Scotland, seal pups (1966)	9	0·06–0·44 (0·18)	1·0–4·0 (2·5)	0·13–0·59 (0·32)	1·1–3·7 (2·3)
Canada, Magdalen Is., pups and adult seals (1967)	2	0·02–0·04 (0·03)	0·67–1·8 (1·2)	0·08–0·16 (0·12)	0·03–0·63 (0·36)
Canada, Cabot Straits, pups, immat. and adult seals (1967)	6	0·03–0·10 (0·07)	1·2–17·3 (5·9)	0·25–2·1 (0·78)	2·1–13·6 (5·5)
Scotland, Orkney, adult porpoise (1967)	1	0·59	1·1	0·55	2·2
Scotland, adult porpoises (1965, 1967)	3	4·6–18·0 (9·9)	9·6–15·3 (12·6)	5·2–14·3 (9·9)	13·1–25·7 (21·1)

Contamination by pesticides is greater in the seals on the east coast of Scotland (taken in an area roughly from Aberdeen to the Tay estuary) than in specimens from the west and north coasts, including the Orkney Islands. Seal pups from the Orkney and Harris (west coast) breeding grounds contained only slightly lower residues than adults from the same areas. By comparison, the Canadian samples from the Magdalen Islands (Gulf of St. Lawrence) contained very low levels of both dieldrin and the DDT group, while seals from the Cabot Straits (Gulf of St. Lawrence) contained little dieldrin but higher DDT group residues, similar to those of Scottish seals. Of the few porpoises examined, that from Orkney was the least contaminated, but the three taken on the east coast of Scotland had markedly higher contents of all the residues measured. One specimen contained a total residue concentration (dieldrin and DDT group) of 73·3 p.p.m. Analyses of a few tissues other than the blubber have been made, but concentrations in the blubber have always been found to be the highest (Table 2). Concentrations in other tissues seem likely to be consistent with their lower lipid contents.

Table 2. TOTAL DDT CONCENTRATIONS (p.p.m.) IN VARIOUS TISSUES

Sample	Blubber	Liver	Brain	Kidney	Spleen	Muscle
Grey seal	5·8	0·77	0·26	—	—	—
Grey seal	0·2	0·05	0·15	—	—	—
Grey seal	14·8	0·07	0·24	—	0·53	—
Grey seal	5·4	0·46	0·17	—	0·13	—
Grey seal	2·4	0·11	0·07	—	0·06	—
Porpoise	3·5	0·58	0·02	0·04	0·10	0·56

The proportion of blubber extractable by hexane was determined for some samples. Values ranged from 72 to 86 per cent (mean 80 per cent) for the Canadian seals, and from 88 to 98 per cent (mean 93 per cent) for Scottish seals samples on the breeding grounds off the west coast. (Values for other seal samples were not estimated.) Concentrations of pesticides in terms of extractable fat for these samples would thus be up to 40 per cent greater than the values in Table 1, but the general comparison is not significantly affected. The lower extractable fat values for the Canadian samples may possibly be a result of being preserved in formalin.

Concentrations of pesticide residues in the extractable fat of various organs and tissues of one porpoise show an important relationship (Table 3). While the concentrations of the DDT group in the original tissues vary widely, those expressed in terms of extractable fat are in much closer agreement, with the sole exception of the brain. A similar anomaly for tissues of trout was described by Holden[11]. It seems likely that a large proportion of the lipid fraction of the brain may not contain pesticides, and the brain lipid composition is known to differ considerably from that of depot fat.

Table 3. CONCENTRATIONS OF TOTAL DDT (p.p.m.) IN TISSUES OF A PORPOISE

Tissue or organ	Blubber	Muscle	Liver	Spleen	Kidney	Brain
Concentration in tissue	3·8	0·56	0·58	0·12	0·04	0·02
Percentage extractable fat	67·0	9·1	13·2	5·1	1·4	8·3
Concentration in extractable fat	5·6	9·2	4·6	2·4	2·9	0·27

The unidentified peaks on the chromatograms seem to be similar to those produced by polychlorinated biphenyls and, to enable comparison to be made, the ratios (*Rx*) of the retention times of all regularly occurring peaks (relative to dieldrin = 100) have been calculated for the operating column temperature of 200° C, these values being temperature-dependent. The *Rx* values of PCB compounds from commercial PCB formulations were also determined for both types of column (Table 4). At least seven PCB-type peaks were found, including those which interfere with *p,p'*-TDE and *p,p'*-DDT. Heptachlor epoxide and *p,p'*-MDE could not be confirmed on both columns and are not therefore recorded.

The most significant aspect of the results is that, although seals and porpoises inhabit an environment far removed from the site of application or discharge of pesticides, they can contain much greater concentrations of dieldrin and DDT group residues than those recorded for most other species, including man. Robinson and Hunter[12] found a mean concentration of dieldrin of 0·22 p.p.m. (range 0·10–0·73 p.p.m.) and a mean total con-

centration of DDT of 4·0 p.p.m. (range 1·0–11·1 p.p.m.) in samples of human depot fat in England in 1964. No evidence of any significant change was found during 1962–65.

Table 4. RELATIVE RETENTION VALUES (R_R) OF RESIDUES (DIELDRIN = 100)

DC-200 column			*DC*-200/*QF*-1 column		
Residue		Sample	Residue		Sample
PCB	= 68·5	63	PCB	= 68·5	70
p,p'-DDE	= 100	100	*p,p'*-DDE	= 84	83·5
Dieldrin			Dieldrin	= 100	100
PCB	= 121	125	*p,p'*-TDE	= 121	121
p,p'-TDE	= 129	128	PCB	= 123	122
PCB	= 148	149	PCB	= 146·5	—
p,p'-DDT	= 170	171	*p,p'*-DDT	= 147	147
PCB	= 174	175	PCB	= 224	221
PCB	= 205	205	PCB	= 282	278
PCB	= 282	287			
PCB	= 339	338			

The seals and porpoises from the east coast of Scotland were usually more seriously contaminated than those from the north and west coasts. This, at least in respect of seals, may be because, as is believed, the populations in the two areas come from different breeding sites. The seals south of Aberdeen breed principally on the Farne Islands, off the north-east coast of England, while the seals of north and west Scotland are primarily from the breeding grounds of the Orkney Islands in the north, and other islands off the west coast of Scotland. The sea off eastern Scotland is also likely to receive more contamination from estuarine discharges than that off north and west Scotland. Similarly, the two separate seal populations sampled off the east coast of Canada may inhabit areas with different levels of contamination. Pups contain pesticide residues in concentrations only slightly lower than in the parent population. Common seals in Holland have been found with concentrations of residue similar to those of seals on the Scottish east coast[14].

While the residue concentrations in subcutaneous fat are high, those of other tissues and organs are found to be much lower. This suggests that there is no risk of physiological effects, unless the metabolism of much of the fat in times of stress leads to a considerable increase in the concentration of the residue in circulating lipids, and thus in residue concentrations in other organs or tissues.

Grey seals on the coast of the Scottish mainland fe... primarily on salmon (*Salmo salar*) and cod (*Gad... morrhua*)[16]. The highest concentrations of pesticide... salmonids in the marine environment have so far be... found in sea trout (*S. trutta*) on the east coast with up t... 0·2 p.p.m. (dieldrin + total DDT) in muscle tissue[15], a... salmon from the same area would probably have similar contents. Cod examined from the east coast have contained up to 0·35 p.p.m. (dieldrin + total DDT) in muscle tissue (mean 0·12 p.p.m.) and from the west coast up to 0·56 p.p.m. (mean 0·22 p.p.m.), while cod livers contained up to 4·0 p.p.m. and 12·0 p.p.m., respectively. Grey seals are estimated to eat about 15 lb. of food daily, and thus an adult seal could consume its own weight in food in 20 days. Assuming a high proportion of the pesticide intake to be stored in body fat rather than to be excreted or metabolized, an increase of two orders of magnitude in pesticide concentration from food to body fat within a few years is feasible. This degree of accumulation of residue in an environment not deliberately contaminated and in species ecologically far distant from the target organisms of persistent pesticides, underlines the impossibility of confining such chemicals to the area of application.

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The North Pacific: an Example of Tectonics on a Sphere

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Individual aseismic areas move as rigid plates on the surface of a sphere. Application of the Mercator projection to slip vectors shows that the paving stone theory of world tectonics is correct and applies to about a quarter of the Earth's surface.

THE linear magnetic anomalies[1,2] which parallel all active ridges can only be produced by reversals of the Earth's magnetic field[3] if the oceanic crust is formed close to the ridge axis[4]. Models[4] have shown that the anomalies cannot be observed in the North Atlantic unless most dyke intrusion, and hence crustal production, occurs within 5 km of the ridge axis. The spreading sea floor[5] then carries these anomalies for great horizontal distances with little if any deformation. The epicentres of earthquakes also accurately follow the axis and are offset with it by transform faults[4,6]. The structure of island arcs is less clear, though the narrow band of shallow earthquakes suggests that crust is consumed along a linear feature. These observations are explained if the sea floor spreads as a rigid plate, and interacts with other plates in tectonically active regions which also show recent tectonic activity. For the purposes of this article, ridges and trenches are respectively defined as lines along which crust is produced and destroyed. They need not also be topographic features. Transform faults connect ridges and are lines of pure slip. They are always parallel therefore, to the relative velocity vector between two plates, a most useful property. We have tested this paving stone theory of world tectonics in the North Pacific, where it works well. Less detailed studies of other regions also support the theory.

Pesticides: Transatlantic Movements in the Northeast Trades

Abstract. *Concentrations of chlorinated hydrocarbons in airborne dust carried by the trade winds from the European-African land areas to Barbados range from less than 1 to 164 parts per billion. The lower limit of the average content of 1 cubic meter of air is* 7.8×10^{-14} *gram. The contributions of river-borne and atmospherically transported pesticides to parts of the marine environment are calculated approximately and compared. The amounts of pesticides contributed to the tropical Atlantic by the trade winds appear to be comparable to those carried to the sea by major river systems.*

The transport and distribution of pesticides through the world ecosystem have been attributed to a combination of atmospheric and hydrospheric (oceanic and fluvial) currents (*1*), yet their relative contributions remain unclear. The high concentrations of residues of pesticides found in shearwaters *Puffinus tenuirostris* and *P. griseus* from the Pacific Ocean and skuas *Catharacta skua* from Antarctica suggest that coastal areas are not the sites of ingestion (*1*).

Various lines of evidence indicate air transport: (i) the codistillation of chlorinated hydrocarbons with water (*2*), and (ii) their detection in air and rainwater (*3*) and in atmospheric dust originating in Texas and subsequently deposited in Ohio (*4*). These observations, however, are not sufficient to support the hypothesis that much of the pesticides present in marine organisms was atmospherically transported to the oceans from the continents.

Complementing such work is the observation that the mineral talc that is used as a carrier and diluent for pesticides occurs in the solid-mineral phases of rains, glaciers, and rivers and in dusts recovered from the atmosphere in concentrations much higher than expected from natural occurrences (*5*); its existence in airborne particulate matter over the sea (*6*) suggests a link with the global dispersion of pesticides.

Although talc is perhaps diagnostic of the presence of insecticides, its use as a quantitative tracer is not fully warranted; it is gradually being displaced in pesticides by water or light petroleum base. Furthermore, some insecticides are dispersed in Fuller's earth, a mixture of minerals not readily analyzed by x-ray diffraction.

Large-scale tropospheric transport from continents to oceans can best be approached by investigation of the three main zones of movement of air masses: the equatorial easterlies, the temperate westerlies, and the polar easterlies. Gram quantities of airborne particulate matter carried by the equatorial easterlies, the trade winds, over 6000 km from Europe and Africa across the Atlantic to Barbados were collected (*7*). Pronounced seasonal variations in the magnetic and biological fractions correlated with wind patterns off the African coast. Mineralogical and biological observations pointed to a continental origin of the solids, with Europe and Africa as the most likely sources. Each sample comprised a large fraction of the particulate material in several million cubic meters of air. An input rate of solid phases to the tropical Atlantic sediments of 0.6×10^{-4} cm/year was suggested (*6*). Knowledge of the pesticide levels in such materials would permit similar calculations of their inputs, for which purpose the Barbados samples have been analyzed.

The collecting screens (*6*), facing the wind, were made of 0.5-mm-diameter monofilament nylon woven to give about 50 percent voids; they were coated with a 50-percent water solution of glycerin for our work; collection efficiency was about 50 percent for particles larger than 1 μ. Rigorous standards of cleanliness minimized contamination by local dusts, which has always proved to be trivial. For blank runs for the pesticide analyses, acetone-washed dust was applied to screens, with subsequent treatment as for the real samples. Less than 100 pg of any of the DDT compounds (*8*) or other pesticides per gram of sample was found.

The dust samples were Soxhlet-extracted for 6 hours with a 2:1 mixture of hexane and acetone. Blank runs, using the same solvent volumes, extraction times, and glassware, were made before and several times during the course of the analyses; less than 250

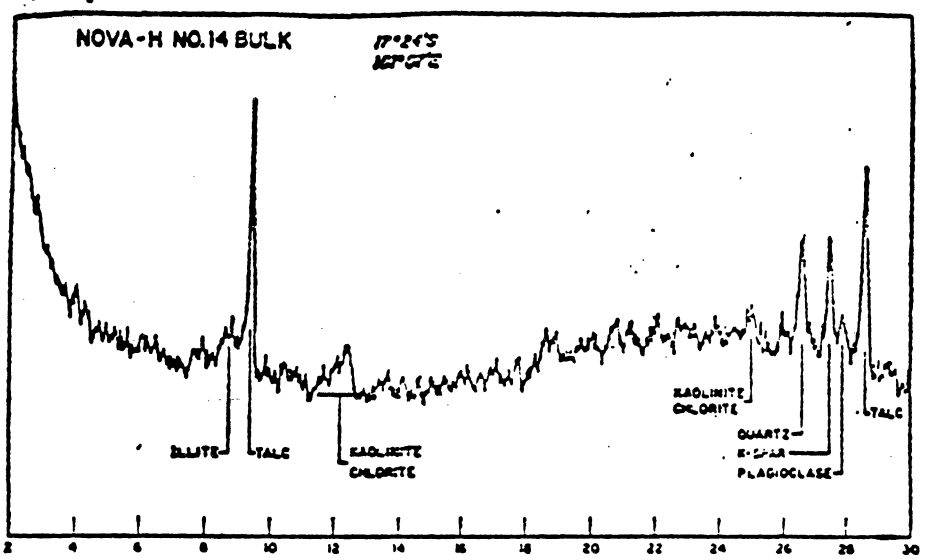

Fig. 1. X-ray diffractogram (CuKα radiation) of atmospheric dust collected over the Coral Sea, with talc predominating.

pg of any pesticide per gram of sample was present in the controls.

The extracts were concentrated and analyzed with a Micro Tek-220 gas chromatograph equipped with Ni-63 and H-3 electron-capture detectors. Two columns, a 5-percent QF-1 and a 10-percent DC-200, both on hexamethyl disilazane–treated Chromosorb W, 80- to 100-mesh, were used simultaneously. Differences in retention time between the polar and nonpolar columns, combined with occasional spiking of extracts with standards, initially confirmed the identities of several of the peaks observed. Peaks of unknown compounds fluctuating in intensity over the year were present in all Barbados extracts and occasionally interfered with determination of *p,p'*-DDE and *o,p'*-DDT.

Extracts of samples between January and September were pooled and placed on a thin-layer plate covered with silica gel G that had been washed until chromatographically clean. A small fraction of the sample extract, mixed with standards, was applied to another area of the plate. After development with 10 percent ethyl ether in hexane, the plate was divided into two sets of 13 1-cm strips which were scraped off and washed with petroleum ether. A concentrate of the petroleum ether was then injected into both columns of the gas chromatograph.

Dieldrin, *p,p'*-DDT, and *p,p'*-DDD were quantitatively recovered from the corresponding areas of the plate occupied by the standards. In several extracts the interfering peaks made measurements of *p,p'*-DDE and of *o,p'*-DDT impossible; the thin-layer recoveries of these compounds were 150 percent. A trace amount of a compound having the retention times of *o,p'*-DDE was also recovered, but a small peak provisionally attributed to heptachlor epoxide in one extract was not confirmed by thin-layer techniques. None of the unidentified peaks had retention times equivalent to those of the polychlorinated biphenyls (PCB), industrial pollutants widely dispersed in marine ecosystems (*9*). No attempt was made to isolate chemically pure pesticides from the thin-layer extracts in order to obtain infrared spectra; instead, several of the thin-layer extracts were treated with alcoholic KOH under conditions such that *p,p'*-DDT, *o,p'*-DDT, and *p,p'*-DDD are converted to their dehydrochlorinated derivatives, which have characteristic retention times on QF-1 and DC-200 columns.

The thin-layer extracts containing most of the *p,p'*-DDT, *p,p'*-DDD, *o,p'*-DDT, and dieldrin peaks were evaporated almost to dryness in a graduated test tube to which 1 ml of 10 percent KOH in ethyl alcohol was added. After heating for 5 minutes in a steam bath, water and hexane were added and the solution was swirled. Analysis of the hexane layer showed that the *p,p'*-DDT, *p,p'*-DDD, and *o,p'*-DDT peaks had

Table 1. Pesticides in airborne particles over Barbados. Concentrations in air are based on 50-percent efficiency of the collecting net; ND, not detected.

Date (1965–66)	Air volume ($\times 10^6$ m³)	Material dry wt (g)		Pesticide concentrations						
		Total	Analyzed	In samples (ppb)						Total in air (g $\times$ 10^{-12}/m³)
				p,p'-DDT	*p,p'*-DDE	*o,p'*-DDT	DDD	Dieldrin	Total	
4–6 Oct.	2.3		0.82	52	12	13	7	3.4	87	150-380*
26–28 Oct.	3.3	17.8	7.70	<1.2	ND	ND	ND	ND	<1.2	<13†
7–21 Nov.	16.3	8.9	2.67	71	19	ND	ND	ND	90	99
1–15 Dec.	16.1	5.2	2.62	10	ND	ND	ND	ND	10	6.5
23–25 Dec.	2.3	1.7	1.33	88	49	13	8	6	164	242
26–28 Jan.	2.3	1.0	0.97	30	ND	ND	10.7	8.1	49	42
15–17 Feb.	3.2	3.3	3.32	18	13	6	ND	ND	37	77
17–19 Feb.	2.9	1.4	1.42	67	ND	17	ND	4.8	96	93‡
25–27 Mar.	2.4	1.3	1.04	14	2.1	ND	6.3	2.1	25	27
12–14 Apr.	2.8	4.7	3.10	11	ND	ND	ND	ND	11	37
14–16 May	1.5	9.0	5.43	2.7	ND	ND	ND	1.3	4.0	48
11–13 June	2.1	2.6	2.69	7.6	ND	ND	ND	3.1	10.7	28
21–23 July	1.5	6.8	2.29	5.4	3.4	0.9	1.1	1.3	12.1	110
10–12 Aug.	1.9	8.6	4.59	4.3	3.1	.4	1.4	1.2	10.4	90
13–15 Sept.	1.7	7.8	4.15	8.3	1.5	1.1	1.0	1.5	13.4	120

* Total dry weight not measured. † Zero dust collected on 12 previous days. ‡ Peak, with retention time of heptachlor epoxide also present, 7.2 ppb.

disappeared, but peaks having the retention times of *p,p'*-DDE, *p,p'*-DDMU, and *o,p'*-DDE had appeared in the respective extracts. The recoveries of these dehydrochlorinated derivatives were equivalent to those obtained in the saponification of chromatographically pure standards. No other breakdown products producing peaks in the electron-capture detector were identified. The dieldrin peak was not affected by the alkaline-alcohol treatment but could not be found after concentrated sulfuric acid was added to the evaporated extract.

All extracts were analyzed with both DC-200 and QF-1 columns, and each value presented (Table 1) is the average from two or more injections of a sample. The total concentrations of the chlorinated hydrocarbons in the dust were higher during the winter months, but the total pesticide content of the air displayed no evident seasonal changes during 1 year. A relatively high content of magnetic dust had been reported (*6*) for September, October, and April when the wind circulations suggest that the dust originates in Morocco; on the other hand, the content was less between October and March, when the dust probably comes from tropical Africa south of the Sahara. Most of the biological material was present in the winter samples; fungal hyphae abounded, and bacteria, fragments of vascular plants, and marine and freshwater diatoms were observed. Among the last were *Melosira granulata*, which is worldwide in distribution, and *Denticula elegans*, which is found in the running waters of cold mountainous regions. There was no correlation between the pesticide content of the air and either the magnetic content or the number of fungal hyphae reported (*6*).

The pesticide concentration in air averages 7.8×10^{-14} g/m^3, or 41 ppb (parts per billion) by weight in the dust. Utilizing the sedimentation calculations on this dust (*6*), we can calculate the introduction of pesticides to the equatorial Atlantic by atmospheric transport in the following way. We assume that the area involved in dissemination by the trade winds lies between the equator and 30°N latitude, covering 1.94×10^{12} m^2. The reported (*6*) rate of sedimentation for this area is 0.06 cm/1000 years, equivalent to an annual input of dust solids of 9.70×10^{12} g (density of dust, 2.5 g/cm^3; water content of the sediments, 50 percent). The value of 41 ppb of insecticides in the dust yields 600 kg/year.

The input of pesticides into San Francisco Bay, measured by the average total concentration in the San Joaquin River at Antioch (*10*) (0.1 μg/liter) and the mean outflow of 18.9×10^{12} liter/year, amounts to 1900 kg/year. A similar calculation for the Mississippi yields an input into the Gulf of Mexico of 10^4 kg/year (*11*).

These rates of input indicate the relative significance of wind and river transport to the marine environment. The atmospheric rate is clearly an underestimate inasmuch as the method of collection of the dusts fractionates against materials carried on particles of less than several microns or as vapors. We must conclude that the atmosphere can transport significant quantities of pesticides to the open-ocean ecosystem; where ocean currents and river drainages cannot explain the presence of residues, wind systems may provide conveyance from continents.

Similarly we have examined samples of airborne particulate matter from the central Pacific collected on glycerin-coated nylon nets mounted on the mast of R.V. *Argo* (*12*) at 12 stations between 17°N and 18°S near 180° longitude during the summer of 1967. No sample carried a detectable pesticide residue, but the weight of each sample did not exceed 1 or 2 mg, and less than 1 part per million or 1 ng of a pesticide would have been undetectable. However, the presence of talc, the most important diffracting mineral, suggested the presence of pesticides (Fig. 1).

Dust collected from an ocean pier at La Jolla, California, between June and October 1967 yielded total pesticide contents in air ranging from 6 to 270×10^{-12} g/m^3 and averaging 7.0×10^{-11} g/m^3; the prevailing winds are landward, with an unknown admixture of air from neighboring agricultural areas. This average value is 1000 times greater than its Barbadian counterpart. Such is the difference in pesticide load between marine air adjacent to agricultural areas in which pesticides are used intensively and marine air remote from sites of application.

Extracts of the La Jolla dust samples were pooled, concentrated to a volume of about 1 ml, and refluxed for 10 minutes in 100 ml of 5 percent KOH in ethyl alcohol before 100 ml of hexane and 300 ml of concentrated aqueous solution of NaCl were added. The hexane layer, after concentration to a small volume, was then analyzed for PCB. Such treatment of extracts of marine fish from coastal waters in California reveals the characteristic profile, on gas chromatograms, of the PCB peaks (*9*); PCB are present in higher concentrations in marine birds, and the profile of the various peaks is usually evident in unsaponified extracts. No PCB, however, was detectable in the La Jolla dust samples; if PCB was present, its maximum concentration in the airborne particulates was 5 ppb—10,000 times lower than that of total pesticides. The PCB are toxic compounds widely used in industry in the manufacture of plastics, paints, and many other products, and are components of industrial air. Unlike the chlorinated-hydrocarbon pesticides, which they resemble somewhat in chemical structure, they apparently persist to a greater extent in the vapor phase. The concentration ratios of total PCB to total DDT in many seabirds, including two species of Pacific shearwaters that nest in Alaska, and in petrels and resident peregrine falcons from remote areas of Baja California are of the same order of magnitude (*9*); this fact suggests that PCB and pesticides are similarly dispersed. With other pollutants, including products of atomic explosions (*13*), they are probably universally present in air; thus their distribution in marine and terrestrial ecosystems remote from sites of application can be expected to depend on the prevailing patterns of wind circulation and the rates of fallout.

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Microstructure of Sediments: Investigation with Ultrathin Sections

Abstract. *Examination of ultrathin sections of "undisturbed" marine sediments from the Gulf of Mexico indicates that they are characterized by a loose, open, random arrangement of particles. The microstructures do not appear to conform entirely to either cardhouse or honeycomb structures.*

The microstructure ("fabric") of marine sediments has received little attention from geological oceanographers. Two popular theories prevail as to the nature of the particle arrangement in the sediments. Terzaghi (*1*) suggested a "honeycomb" structure, with adhesive forces causing the particles of clay mineral to stick together on contact; each cell of the structure consists of many adhering particles (Fig. 1A). Later was suggested (*2*, *3*) a somewhat different structure in which the clay-mineral aggregates, having a platy morphology, were arranged generally in an edge-to-face fashion forming a "cardhouse" structure (Fig. 1B). Tan (*4*) presented a three-dimensional idealization of cardhouse structure (Fig. 1C).

Fig. 1. (A) Honeycomb structure [after Terzaghi (*1*)]. (B) Cardhouse structure [after Lambe (*3*)]. (C) Cardhouse structure [after Tan (*4*)].

While some orientation studies, using polarized light and x-ray diffraction techniques (*5*), can reveal gross trends toward preferred or random orientation of particles, they do not reveal details of the microstructure. Most information has come from the electron microscope. Rosenquist (*6*) used the electron microscope and the replication technique to obtain stereomicrographs showing the microstructure of undisturbed marine clays; he concluded that the microstructure of such clays "corresponds to the cardhouse structure suggested by Goldschmidt and later by Lambe, and in fact exactly corresponds to the imaginative drawing of Tan." Use of the same technique for studying illitic Pleistocene clays led to a similar conclusion (*7*).

Whereas the electron microscope offers the best means available for study of sediment microstructure in detail, the replication technique does not provide easily interpretable results. My purpose is to illustrate the microstructure in samples of sediment from the Gulf of Mexico as revealed by ultrathin sections of the sediment, and to point out that this technique provides more easily interpretable results.

The samples (Table 1) came from cores taken by R.V. *Alaminos* (*8*). Only cores were selected that had been properly sealed and stored to preserve as well as possible the natural state of the sediment. From each core a cubic sample of 2 to 5 cm was carefully cut with a thin-bladed knife or spatula. A larger portion was cut initially in order to retain an undisturbed portion in the center of the sample; likewise, the sample itself was taken from the center of each core. From each sample, smaller samples (1 to 2 cm by 2 to 3 mm²) were cut with a taut, very thin wire; the outer, disturbed portion of each large sample was first trimmed with the wire to expose the inner, undisturbed portion. The small samples were freeze-dried; this technique is recommended (*6*, *9*) because it entails less particle disturbance due to effects of surface tension than do standard oven- or air-drying techniques.

Fig. 2. Ultrathin sections showing the microstructures of undisturbed sediments from an abyssal plane (A), a continental slope (B), and a continental shelf (C).

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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Bay Scientist's Pe

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are a major boon to industry: they are used in making coatings form the chemical is paints and plastics, electrical insulators 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 atmosphere 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 Scientists.

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 byphenyl compounds and to their invasion of man's environment. 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 eminent 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 biphonyl, 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, appar-

P... lutant Warning

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...preying on Pa...ci... ...ea birds have now vir...tu... vanished Dr. Rise...b... ...s. But small in...la... ...of California fa... ...s, which prey mostly o... ...songbirds, still a... ...be reproducing ...ll.

...hu... ...of analyses of bi... ...eggs Dr. Rise...b... ...his colleagues h... found only about a te... as much PCB as DDT ... ...from relatively ... areas. But ...on the Farallon Is... ...PCB quantities are ...between a fifth and ... DDT.

...birds and their eggs ...polluted San Francisco Ba... — falcons, gulls, terns ...night herons -- there is ...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 compounds 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 because 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 Rel... in the marine resources lab at Berkeley.