

Fig. 1 Effect of internal ^{32}P on the growth of *Marchantia polymorpha*. ■, Control; △, 5 μCi ml.$^{-1}$; ●, 10 μCi ml.$^{-1}$.

and ^{35}S, at doses generally used for labelling. Twenty to twenty-five gemmae from gemmae cups of female *Marchantia polymorpha* were cultivated in Petri dishes on 15 ml. of nutrient solution solidified with agar as indicated by Schneider *et al.*[3]. The growth conditions were continuous illumination at 1,500 lx and a temperature of 22° C. Carrier-free ^{32}P-H_3PO_4 (CEA, Saclay, France) in 0.01 M HCl solution was added to the nutrient medium, and the same amount of HCl was added to the controls.

At a dose of 5 μCi ml.$^{-1}$ of ^{32}P (specific activity: 0.4 μCi μg.$^{-1}$ of P) the growth of thalli was seriously inhibited and at 10 μCi ml.$^{-1}$ it was stopped. The inhibiting effect was measurable after 48 h of growth and the difference between control and treated plants was significant after about 3 days of culture. All thalli treated with the radioisotopes were affected and growth inhibition was visible on both length and surface of the thalli. This experiment was repeated several times and the same response was always observed. At doses that did not completely inhibit growth (3 to 8 μCi ml.$^{-1}$) all portions of thalli were uniformly affected.

When carrier-free ^{35}S was used instead of ^{32}P, inhibition of growth was complete for 80 μCi ml.$^{-1}$ (0.76 μCi μg.$^{-1}$ of S). As the energy of β particles emitted by ^{35}S is about the tenth of the energy of β particles emitted by ^{32}P we concluded that comparable inhibiting effects were obtained for equal flux of energy. Therefore the nature of the element is not by itself involved in the observed inhibition.

The effect of acute γ-irradiation on *Marchantia* has been investigated by Miller and Sparrow[4]. Contrary to our results with internal radioisotopes they found that the radiosensitivity of vegetative non apical cells was comparable to that of higher plants having chromosomes of similar size. Apical cells possess bigger chromosomes and are more radiosensitive to γ-irradiation. Since entire thalli are uniformly affected by internal radioisotopes, their action could not be the result of damaging chromosomes in the more sensitive apical cells.

It is certainly worth remembering before further studies that thalli of *Marchantia* are haploid and could therefore be more radiosensitive than diploid plants.

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Geographic Differences in Phytoplankton Sensitivity to PCBs

DIFFERENTIAL sensitivity of marine phytoplankton species to chlorinated hydrocarbons has been demonstrated in pure[1,2] and mixed[2] cultures. In particular, the toxicities of DDT (1,1,1-trichloro-2,2-bis(*p*-chlorophenyl)ethane) and PCBs (polychlorinated biphenyls), both widespread pollutants in the marine environment[4], have been investigated. Evidence does not exist, however, for correlating organochlorine sensitivity with the ecological adaptations of the organisms tested.

Previous reports suggest the existence of physiological races of marine phytoplankton. Guillard and Ryther[3] showed *Thalassiosira pseudonana* from the Sargasso Sea (clone 13-1) to be stenothermal and stenohaline, unlike the continental shelf and estuarine isolates (clones 7-15 and 3H). Intraspecific differences in half-saturation constants (K_s) for nutrient uptake have also been demonstrated; isolates from the low-nutrient waters of the Sargasso Sea had lower K_s values for nitrate[6] and silicon[7] than did coastal clones. Such findings indicate that races of phytoplankton are best adapted to their respective environments. Sloboudkin and Sanders[8] have postulated that organisms adapted to stable, "predictable" environments would, in general, be more sensitive to environmental stress than would organisms adapted to "unpredictable" surroundings. Experimental evidence for this hypothesis is lacking. We therefore investigated the toxicity of PCBs to three species of diatoms, comparing clones isolated from the relatively stable Sargasso Sea waters[9] with those from fluctuating estuarine environments.

The diatoms tested were *Thalassiosira pseudonana*, *Fragilaria pinnata*, and *Bellerochia* sp.; Fig. 1 presents the clones studied and their isolation sites. (For exact information on dates and sites of isolation, see Carpenter and Guillard[9].) Cells were grown xenically in f/2 medium[3] prepared from Vineyard Sound seawater (salinity = 33‰) filtered through a precleaned Amberlite XAD-2 resin to remove any chlorinated

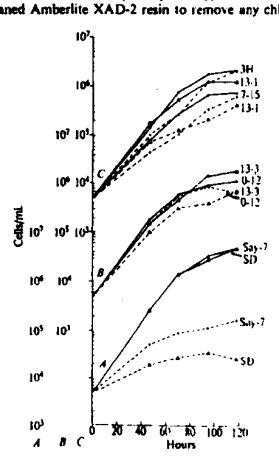


Fig. 1 Growth of (*A*) *Bellerochia* sp., (*B*) *Fragilaria pinnata*, and (*C*) *Thalassiosira pseudonana*. Clones 13-1, 13-3, and SD were isolated from the Sargasso Sea; 7-15 from the edge of the continental shelf; 3H from Moriches Bay, Long Island; 0-12 from Oyster Pond, Massachusetts; and Say-7 from Great South Bay, Long Island. Data points are the means of three replicates. ——, 0 p.p.b.; - - - -, 10 p.p.b.

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Table 1 Ratios of Mean Cell Densities from Treated: Control Cultures at Five Sample Times

	Hours after inoculation				
	0	47.5	70	95	118
T. pseudonana clones					
3H (estuarine)	1.00	0.694	0.365	0.676	0.976
7-15 (estuarine)	1.00	0.544	0.368	0.520	0.844
13-1 (oceanic)	1.00	0.422	0.241	0.172	0.341
F. pinnata clones					
0-12 (estuarine)	1.00	0.824	0.909	0.932	0.590
13-3 (oceanic)	1.00	0.688	0.707	0.269	0.387
Bellerochia clones					
Sky-7 (estuarine)	1.00	0.207	0.064	0.036	0.035
S13 (oceanic)	1.00	0.074	0.020	0.013	0.005

hydrocarbon[6,9] contamination. Exponentially growing cells were inoculated into sterile, tightly sealed screw cap bottles containing 150 ml. of medium to give an initial cell density of 5,000/ml. The procedure for adding PCBs ('Aroclor 1254') has been described[2]. For each clone, there were three cultures containing 10 parts per 10^9 (p.p.b.) of PCBs and three controls without PCBs. The cultures were maintained at 20° C and illuminated 14 h/day with 5,800 lumens/m^2 from cool-white fluorescent bulbs. Samples of 1 ml. were fixed with 0.05 ml. of Lugol's solution and counted with a Speirs-Levy Eosinophil counter.

Although growth of all seven clones diminished with PCB treatment (Fig. 1 *A*-*C*), isolates from the Sargasso Sea invariably were more sensitive than were clones from estuaries and the continental shelf (Table 1). Clone 7-15, from the continental shelf, was, in turn, more sensitive than clone 3H, its counterpart from the Moriches Bay estuary. Both *Bellerochia* clones were more sensitive than all others tested, but here, too, oceanic clone S13 proved more sensitive than did estuarine clone Sky-7. Two-way analyses of variance[10] on the logarithmically transformed data showed that, at 95 h, the interaction term between PCB treatment and geographic origin was significant for *T. pseudonana* ($F(2, 12) = 34.56$, $P < 0.001$), for *F. pinnata* ($F(1, 8) = 31.57$, $P < 0.001$), and for *Bellerochia* sp. ($F(1,8) = 12.81$, $P < 0.01$), indicating algal sensitivity was highly dependent on the sites of isolation.

Natural waters generally contain somewhat lower concentrations of PCBs (one to three orders of magnitude lower) than we employed in our experiments (ref. 11 and unpublished results of G. R. Harvey, W. G. Steinhauer and J. M. Teal), although concentrations exceeding ours have been detected[12]. Concentrations in water may be misleading, however. Organisms are probably exposed to greater amounts of chlorinated hydrocarbons than concentrations in natural waters would indicate because these substances are rapidly removed from water by organisms, including phytoplankton[13]. Holden[14], for example, found no PCBs in Scottish waters but substantial amounts in the resident organisms.

Our results suggest that estuarine-coastal phytoplankton may be better equipped to survive abiotic environmental stress than are those found in the open ocean. These data are therefore consistent with the hypothesis of Slobodkin and Sanders[8].

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Genetic Analysis of Tail Rattling in the Mouse

TAIL rattling is a prominent feature of aggressive encounters between mice and is thought to be a threat behaviour, although conclusive evidence of this is lacking[1]. A factor analysis of aggressive behaviours elicited in a single subject using footshock in conjunction with a bottle brush target indicated that tail rattling had a high loading on the "aggressive factor" and negligible loading on the other factors[2]. On the other hand, a rather comprehensive study of fourteen inbred strains by Southwick and Clark[3] revealed no consistent interstrain relationship between fighting and tail rattling. These displays are usually regarded by ethologists as having complex, rather than unitary, motivational determinants[4]. If this is correct, a linear relationship with a single variable, such as attack behaviour, would be unlikely to prove robust. An additional complication arises when genetic differences between subjects are important. The degree of manifestation or expressivity of the display, in relation to the motivational states which underlie it, may be expected to exhibit genetic variation.

In view of the potential complexity of the processes involved, it is clearly imperative that a simplified experimental paradigm is developed, which allows controlled presentation of relevant stimuli and elimination of uncontrolled behavioural feedbacks. Electric shock has proved quite useful for the study of aggression because it is capable of inducing high rates of aggressive responding between paired subjects[2]. Further simplification is possible in the mouse because many of the behaviours observed in aggressive encounters can be elicited by means of footshock applied to a single subject. I undertook the present study to examine the nature of strain differences in tail rattling elicited by shock, and to assess by means of genetic evidence the relevance of the responses obtained to natural fitness.

Roberts[5] has suggested that the genetic architecture of behavioural traits may be used to assess the relationship of measures obtained in the laboratory to natural fitness, as traits contributing to fitness should display a large amount of non-additive and little additive genetic variance. A measure of the importance of these components of genetic variance can be obtained by examining a series of crosses between inbred lines. If tail rattling elicited by shock is irrelevant with respect to fitness, the mode of inheritance should be largely additive. If, however, the response to shock is closely related to the disposition to exhibit the trait under natural conditions, and if it is indeed an important social behaviour, then a consistent,

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