separation rate obtained over such a wide range of space dimensions. My experience with individual sets of neighbor pairs, however, leads me to believe that the separation rate may be a valuable parameter of turbulent energy near the surface of aquatic habitats and that it warrants more attention than it has received. The methods are simple and inexpensive. Attempts to correlate separation rates with other environmental factors will certainly yield valuable information.

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References and Notes

1. G. E. Hutchinson, *A Treatise on Limnology* (Wiley, New York, 1957), vol. 1, p. 258.
2. F. C. W. Olson and T. Ichiye, *Science* **130**, 1255 (1959).
3. H. Stommel, *J. Marine Research (Sears Foundation)* **8**, 199 (1949).
4. Where l_0 is the distance apart initially and l_1 is the distance after T seconds. The bar indicates that the values are averages of several neighbor pairs.
5. The Oceanographic Institute generously supplied living space for my family and research facilities for me. The work was supported in part by the Atomic Energy Commission, contract AT (11-1)-536.
6. The least-squares line of Olson and Ichiye lies below most of Stommel's data. The values of 3 and 15 in Table 1 were obtained by drawing a line, by inspection, through Stommel's data.

1 June 1961

Effect of Implanted Adult Corpora Allata on That of Host in Two Species of Drosophila

Abstract. Experiments to show the effect of implanted adult corpora allata on that of the host have given negative results in *Drosophila melanogaster*, while the presumed compensatory effect has been verified in *Drosophila virilis*. Reasons are presented which suggest that the nature of the latter effect should be further analyzed.

Bodenstein (*1*) reported that implantation of corpora allata (or corpus allatum complexes) from mature *Drosophila virilis* females into freshly emerged female hosts results in a compensatory reduction in size of the host corpus allatum within 2 to 10 days. On the other hand, larval ring glands implanted into 1-day-old adult hosts have no such effect. In the stick insect, *Dixippus*, implantation of larval, but not adult, corpora allata into fifth instar nymphs is known to induce a compensatory effect (*2*). In view of the homologies made between the small round anteromedial cells of the *Drosophila* larval ring gland, which give rise to the imaginal corpus allatum, and the larval corpus allatum in other insects (*3*), this reversal of relationships is of some interest even though caution must be taken in comparing such unrelated forms.

The compensatory effect described by Bodenstein was sought in reciprocal corpus allatum complex transplantations between homozygous *female sterile* (*2*) *adipose* and wild-type adult females of *D. melanogaster* (*4*). It was hoped that the effect of the mutant complex on the corpus allatum of the wild-type host might be used as an assay of the activity of the donor's corpus allatum, which normally hypertrophies in mated females of the mutant genotype. No effect of the implants on either the mutant or on the reciprocal wild-type hosts could be detected. In addition, some question was raised as to whether the compensatory effect could be induced even in wild-type flies with implanted wild-type corpus allatum complexes.

To further test the presumed compensatory effect, another series of transplantations has been carried out on *D. melanogaster* adult females. The flies used were hybrids between two highly inbred (originally "isogenic") wild type lines of Oregon R and Sevelen, whose egg production is known to be of a high order and less variable than is generally the case (*5*). Donor females were mated, aged 4 days, and their corpus allatum-complexes were removed in Waddington's drosophila Ringer solution. Host females were 1 to 4 hours old at the time of injection and received two complexes each; operated controls of the same ages were injected with Ringer solution. Each pair of females, host and operated control, was placed in a creamer of food with three males and aged for 6 days. Fresh food was supplied 72 and 24 hours before sacrifice. Whole mounts of host and control corpora allata were made and measured, and the results were treated statistically (*6*). Hosts were then fixed, sectioned, and stained in order to determine the number of successful implants. Both implants were found and were in good shape in the hosts of 12 of the 13 successful transplantations, while only one implant was found in the remaining case. A comparison of the size of the host corpus allatum to that of the operated control in each creamer pair showed no detectable difference between them (over-all mean for hosts, from planimeter readings of camera lucida outlines, = 0.44 in.^{2}; controls = 0.43 in.^{2}). Thus, it appears that the compensatory effect of implanted corpora allata on that of the host, originally described for *D. virilis*, does not occur in *D. melanogaster*, at least when hosts are of the ages used.

Because of these results, it seemed appropriate to repeat Bodenstein's experiments on *D. virilis*. Another series of transplantations similar to those described above for *D. melanogaster* was set up. The experiment differed from Bodenstein's in that I used an operated control for each host. Both flies of each pair were placed in a creamer with three males, and all flies were sacrificed on the seventh day. The size of the adult corpus allatum in *D. melanogaster* is somewhat larger in mated females than in virgins (*6*) and it was not clear from the previous experiments on *D. virilis* whether or not virgin females had been used as hosts. Therefore, a group of unoperated controls, including both mated and virgin females (20 each), was prepared and their corpora allata were measured on the seventh day along with those of the hosts and operated controls.

Although experiments on *D. virilis* are still in progress, certain results are very clear. First, the corpus allatum of 1-week-old virgin females is smaller than that of mated females (mean of planimeter measurements for mated females = 1.35 in.^{2}; mean for virgins = 1.06 in.^{2}). The size difference appears to be on the order of that found in *D. melanogaster*, but in no way approaches the difference found by Bodenstein between hosts that received extra corpora allata and his unoperated controls. Second, the apparent compensatory effect previously described for *D. virilis* was again quite clearly demonstrated in the present study. The mean values for corpus allatum size in 14 successful pairs of hosts and operated controls are 0.93 in.^{2} for the former and 1.47 in.^{2} for the latter. (A *t*-test showed the difference to be statistically significant, $P < .01$.) The average size for eight hosts, whose paired operated controls died, is 0.74 in.^{2}; the mean for an additional six operated controls, whose hosts died, is 1.66 in.^{2} (Unlike low rates in *D. melanogaster*, the mortality of both hosts and operated controls is extremely high for the line of *D. virilis* used in both these and other experiments.) The corpus allatum in three of the *D. virilis* hosts showed no reduction in size, so that the difference in mean values between hosts and operated controls is even greater if these are omitted. Because of the failure to demonstrate the presumed compensatory effect in some of the *D. virilis* hosts, the nature of this effect is being further investigated. The species difference between *D. melanogaster* and *D. virilis* in the appearance of the effect is especially provocative (*7*).

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References and Notes

D. Bodenstein, *J. Exptl. Zool.* **104**, 101 (1947).
2. For example, see O. Pflugfelder, *Z. wiss. Zool.* **152**, 384 (1939); V. J. A. Novák and E. Rohdendorf, *The Ontogeny of Insects*, I. Hrdý, Ed. (Czechoslovak Acad. of Science, Prague, 1960), p. 157.
3. Summarized by D. Bodenstein in *Biology of Drosophila*, M. Demerec, Ed. (Wiley, New York, 1950), p. 325.
4. W. W. Doane, thesis, Yale Univ. (1960); *J. Exptl. Zool.*, in press.
——, *J. Exptl. Zool.* **145**, 23 (1960).
6. For techniques, W. W. Doane, *J. Exptl. Zool.* **145**, 1 (1960); *ibid.* (1961), in press.
7. This work was supported by a postdoctoral fellowship under the Yale University–National Institutes of Health program in genetics.

17 July 1961

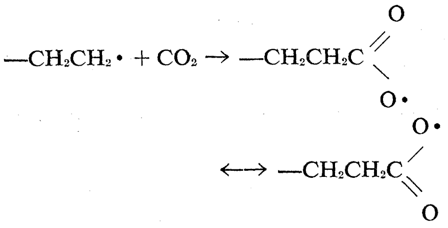
Radiation-Induced Reaction of Carbon Dioxide with Ethylene

Abstract. The gamma irradiation of mixtures of carbon dioxide with ethylene yielded long-chain carboxylic acids. The G(—ethylene) values varied with reaction temperature from essentially zero at −78°C to 175 at 100°C. Under the same conditions, the substitution of free radical agents for radiation gave polyethylene.

A new route to long-chain carboxylic acids has been found in the radiation-induced reaction of ethylene with carbon dioxide. Sargent (*1*) has reported the formation of a "carbon dioxide-modified polyethylene" by heating ethylene in the presence of carbon dioxide and a free radical-producing catalyst. The comparatively strenuous reaction conditions (benzoyl peroxide, 9000 to 15,000 lb/in.^{2} (gage), at 50° to 300°C) are reminiscent of those employed in the preparation of conventional or low density polyethylene. It is apparent from this reference that very little carbon dioxide was incorporated into the product. In the experiments discussed in this report, carbon dioxide–ethylene products were formed under gamma radiation at comparatively low pressures and temperatures (see Table 1). The importance of radiation was shown in two experiments under these conditions of temperature and pressure in which free radical initiators, di-*tert*-butyl peroxide and 2,2′-azobis(2-methylpropionitrile), were substituted for irradiation. The products were observed, by infrared spectra on each product and by carbon,hydrogen analyses on the product of the peroxide-induced reaction, to be only polyethylene.

Data listed in Table 1 clearly indicate that radiation yield, measured as G for the disappearance of ethylene (the number of molecules of ethylene consumed per 100 ev of energy absorbed), rises with rising temperature but that carbon dioxide incorporation, measured by carbon,hydrogen analyses, declines with rising temperature.

The products are white, waxy solids at temperatures between 50° and 90°C. Their infrared spectra are consistent with a linear carbon chain possessing points of unsaturation, crystalline polyethylene structure, and carboxyl groups. The failure of the products to react with 2,4-dinitrophenyl hydrazine in amounts detectable by infrared analysis (through the strong absorptions of the nitro group) indicates the absence of aldehydes and ketones. The infrared spectrum of the sodium salt includes absorption bands characteristic of RCOONa. This salt was prepared by shaking a benzene solution of the carbon dioxide–ethylene product with 10-percent aqueous sodium hydroxide. The resulting emulsion did not break in 72 hours. For the three products on which both number average molecular weight and carbon,hydrogen analyses are available, the carbon,hydrogen data closely approach agreement with those calculated for a simple carboxylic acid of the experimentally determined molecular weight. These acids may be formed by combination of a growing polyethylene chain with a carbon dioxide molecule to yield a resonance stabilized radical that is not sufficiently energetic to react by further chain growth.



This would appear to preclude polyester formation by continued reaction with ethylene. Since the infrared spectra of high molecular weight acids and esters are similar, a sample was examined by nuclear magnetic resonance (NMR) spectrometry. Had the $-\overset{\overset{\text{O}}{\|}}{\text{C}}-\text{O}-$ content indicated by carbon,hydrogen data exceeded the acidic hydrogen content determined by NMR spectrometry, one might surmise that the excess is present as polyester linkages. However, the acidic hydrogen content was too low for the NMR spectrogram to be significant. A conventional saponification equivalent determination failed to detect hydrolyzable linkages. In view of the

Table 1. Data on the formation of carbon dioxide–ethylene products with gamma irradiation and with free radical initiators. The appearance of the products is shown in the last column by the abbreviations: T.L., tan liquid; W.P., white paste; and T.W.P., thin white paste.

Reactants	Charge (g)	Temp. (°C)	Yield (g)	G ($-C_2H_4$)	Mol. wt.*	Analyses Calcd.† C	Analyses Calcd.† H	Analyses Found C	Analyses Found H	Product
CO_2 C_2H_4	29.9 140.1	−78	None							
CO_2 C_2H_4	24.2 140.1	−40	0.1	2.3						T.L.
CO_2 C_2H_4	20.0 139.8	29	1.7	39.4	568	81.0	13.5	80.1	12.0	W.P.
CO_2 C_2H_4	21.2 146.2	65	1.9	42.0	574	81.3	13.5	81.6	13.4	W.P.
CO_2 C_2H_4	19.8 142.4	100	7.7	175.0	670	81.6	13.6	83.6	13.9	T.W.P.
CO_2 C_2H_4	21.9 140.8	204	13.3	310.0	660			85.0	14.5	T.L.
CO_2 C_2H_4 (t-BuO)$_2$‡	20.3 140.3 1.0	125	4.51		1150			85.6	14.5	W.P.
CO_2 C_2H_4 ABMP¶	20.0 139.5 1.0	85	0.42§					‖		W.P.

* Determined by benzene boiling point elevation. †Calculated for a saturated monocarboxylic acid of experimentally determined molecular weight. ‡ Di-*tert*-butyl peroxide, Shell Chemical Corp. § Corrected to exclude weight of initiator residue. ‖ Product contaminated by initiator residue. ¶ 2,2′-Azobis(2-methylpropionitrile), Eastman (white label).