in Difco nutrient agar for determination of survivors. All operations were carried out in a darkened room to limit photoreactivation. Plates were counted after 3 days' incubation at 37° C. Data obtained from averaging replicate experiments are presented in Fig. 1.

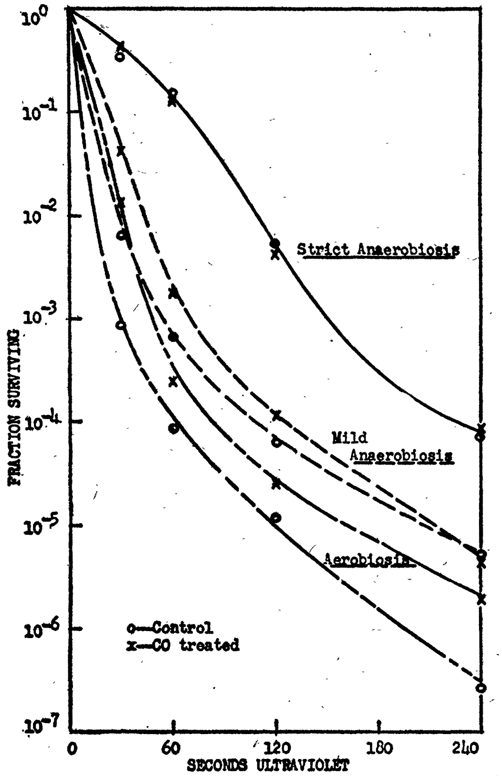

FIG. 1. Comparative sensitivities of aerobic and anaerobic cells treated with carbon monoxide prior to ultraviolet irradiation. Cultures were grown in the following: Aerobic, 95% oxygen, and 5% carbon dioxide; mildly anaerobic, methane; strictly anaerobic, methane in Brewer anaerobic jar.

Results from the monoxide-inhibited aliquots which were exposed to visible light are not reported in the figure, since the results were almost identical with those of the controls. The protection accompanying monoxide inhibition is progressively lost following its reversal by light, if the cells are allowed to respire during this time. Short intervals of exposure to light prior to irradiation only partially reversed the inhibition, but 20 min exposure resulted in a loss of almost all the protective effect. No recovery occurred upon post-irradiation treatment with the monoxide. Hollaender *et al.* (*7*) reported that anaerobically cultured *E. coli* cells exhibited a decreased sensitivity to x-rays. In our experiments we noted that anaerobic cultures were also more resistant to ultraviolet rays. Aerobic cells were markedly protected by carbon monoxide treatment. This is evident from the fact that monoxide-treated aerobic suspensions had approximately 13 times as many survivors as the nontreated controls at 30 sec irradiation. On the other hand, mildly anaerobic cells were protected to a lesser extent and strictly anaerobic cells not at all. In the latter case, since the cells are already in a highly reduced state, a further reduction is impossible. This failure of anaerobic cells to derive additional protection, coupled with the protection rendered respiring (aerobic) cells, by monoxide- and cyanide-inhibition substantiates the thesis that this protective mechanism is due to the reduced state of the enzymes which result from the treatment.

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## Selection for DDT Resistance in a Beneficial Insect Parasite[1]

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Biological control of insects is often partially nullified by the effects of chemical control; beneficial parasites, as well as pests, are destroyed by the insecticides. Experiments are in progress in this laboratory to see whether it is possible to produce, by selective breeding, appreciable DDT resistance in insect parasites of pest insects.

The work is being done with *Macrocentrus ancylivorus* Rohw. (Hymenoptera: Braconidae), an effective parasite of the larvae of the oriental fruit moth *Grapholitha molesta* (Busck). Mass propagation of this parasite is carried out by the method of Finney, Flanders, and Smith (*1*). The life cycle of the parasite is approximately 21 days, but this method involves continuous rearing with overlapping generations, so that a fresh crop of newly emerged adults is produced each day. Every day for 3 min the insects are exposed to the insecticide in the form of a thin film of celloidin in which DDT crystals have been deposited (*2*). The survivors are counted 40 hr later and are then returned to the breeding unit to oviposit on young host larvae. Selection has been continued daily in this way for 9 months; during this period the films in use contained 23 μg of pure *p-p*-DDT/cm$^2$.

Survival was initially about 30%. It increased rapidly and at the end of the first 4 months it was about 80%; this figure approximates to that for control insects exposed on plain glass surfaces. This high level of survival persisted, under selection, for the remainder of the period. Selection is now being carried out at a higher DDT concentration.

A more exact estimation of relative survival has

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been made in a separate series of experiments, in which the results are susceptible to probit analysis. Large numbers of test insects were used. Evaluation of survival was made 40 hr after each test was completed. Insects were exposed on films of the standard concentration mentioned for different periods of time. The probit regression lines fitted to the data show that the $LD_{50}$ for the original stock, before selection began, was 2.59 min for females and 2.01 min for males (*3*). After 9 months of selection, the corresponding figures are 11.26 and 7.48 min. These indicate that the resistance of the females is 4.35 times, and that of the males 3.72 times, as great as that of the original stock.

This increase is of the same order as that recorded in *Drosophila melanogaster* Meig. by Weiner and Crow (*4*), who used a different selection method and a different test surface. They recorded an increase in resistance of 3.22 times in females, and 4.47 times in males, after 1 year of selection.

The results obtained with *M. ancylivorus* are regarded as promising, but no releases are planned until the DDT resistance has been increased to the practicable limit.

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## Study of the Light Metal Carbonyls Formed by the Reaction of Carbon Monoxide with Light Metals Dissolved in Liquid Ammonia[1]

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During the past few years we have been studying the nature of the products formed by the reaction of carbon monoxide with light metals dissolved in liquid ammonia. If the reaction is carried out so that the excess ammonia is allowed to evaporate after the metal has completely reacted (as evidenced by the disappearance of the blue color), the resulting product is a solid and is referred to in the literature as a carbonyl. Measurements by Joannis (*1, 2*) and others of the ratio of weight of product to weight of initial metal sample indicate that these solid carbonyls have the composition expressed by the formula $M(CO)n$, where $n$ is the electrovalence of the metal $M$. These solid carbonyls are extremely unstable and react instantaneously with traces of moisture or oxygen. Their instability has prevented the study of their properties except for a few investigations of the products formed upon decomposition.

In our experiments we have found that the addition of ammonium chloride (or hydrogen sulfide) to the reaction product before evaporation of the liquid ammonia results in the formation of substances that are reasonably stable and susceptible to the usual methods of handling and testing.

When the sodium carbonyl is treated with ammonium chloride as described above, the final product is a mixture of several subsbtances. We have succeeded in identifying three of these: rhodizonic acid, in the form of either the ammonium or the sodium salt; glycollic acid amide; and glycollic acid. The amounts formed vary with conditions of the experiment. So far the evidence suggests that the best yields of rhodizonate and the amide (about 15–20% in the case of the amide, based on sodium consumed) are obtained when the sodium metal is added in small amounts at a time so that it is only slightly in excess during the reaction, and the greatest pains are taken to prevent the entrance of oxygen and moisture into the reaction flask. The product in the liquid ammonia is generally colored at the completion of the reaction and undergoes a color change upon adding ammonium chloride. In experiments under optimum conditions, the sodium carbonyl forms in the flask as a grape-colored product, and the addition of ammonium chloride converts it to dark-red.

These results with sodium show that the reduction of carbon monoxide in liquid ammonia solution leads to the formation of rather varied and complex polymeric units of carbon monoxide. There appears to have been only one previous attempt to identify the carbonyl products. Joannis (*3*) added water to the liquid ammonia solution of potassium carbonyl at the completion of the reaction and, from the stable products he obtained, he was able to separate one which he identified as glycollic acid. In our experiments, glycollic acid amide is separated from the reaction products directly by extraction with dioxane or ether. Our experiments offer the first evidence also that a ring compound can be formed from carbon monoxide in liquid ammonia. It is of interest to recall here that Nietski and Benckisser (*4*) showed that carbon monoxide gas reacts with molten potassium to form a product which they identified as potassium hexahydroxybenzene. Attempts to duplicate the fused potassium reaction using other light metals have been reported as yielding negative results.

In our experiments we have also used lithium, potassium, calcium, and barium for preparing carbonyls. Although these experiments have not been carried out with the improved technique we have developed for working with sodium, it is superficially evident that the products obtained with these metals will not necessarily be the same. Examination of the reaction product of potassium carbonyl by chromato-

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