

vae found in the half of the dish that contains the root piece. Each filled or open circle represents one sample (such samples were used only when 20 or more larvae were hatched from the egg masses). Thus, a high percentage in Fig. 1 signifies attractiveness of the tested root piece and a low percentage, repellency. All filled and open circles show the effect of the excised roots taken from MOPA-treated tomato plants. The stippled field is superimposed to show the whole range of variability of the effect of excised roots taken from untreated tomato plants on the nematodes as previously determined (1).

Although there is an obvious correlation in untreated plants between the length of the excised root end and its degree of attractiveness—the latter reaching a maximum at a root length of 8 mm and staying at that high level to a length of at least 16 mm—this correlation breaks down in the MOPA-treated plants. Although a number of the tested root portions still proved to be attractive, especially if they measured more than 8 mm, nonattractive and repellent samples also occurred at the same lengths. This seems to indicate that the MOPA treatment upsets the clear-cut effect of the attractive agent present in excised roots of untreated tomatoes but that it does not destroy the agent.

Whether a given root piece is attractive to the nematodes seems to depend on an interplay between this attractive agent and a repellent agent, represented by MOPA or produced in the presence of MOPA. If the attractive agent is of high concentration in a given excised root, it will prevail over the MOPA or any repellent influenced by MOPA. This holds particularly for root ends longer than 8 mm. At shorter lengths, the variation of the effect is also high in untreated plants. This makes it impossible to discern a possible MOPA effect in this region. It should also be noted that the repellent effect of the apical 2 mm of the roots that was so obvious in untreated plants (1) seems to have disappeared in the treated plants.

If segmentation of the distal root portion is disregarded, the effect of the treated and untreated samples is significantly different. Student's *t* test was used in testing the regression coefficient of the treated and the untreated material. With 55° of freedom, a *t*-value of 5.2, which is highly significant, was obtained.

As has already been mentioned, this result does not establish beyond doubt the storage of MOPA in, or its excretion from, roots, but it shows at least that the treatment of the plant with MOPA induces in the root the appearance of some agent that is still present in the distal portion of the root after it has been ex-

cised and left in wet sand for 24 hours, and that this agent has a repellent effect on larvae of *M. hapla*. The attractive agent that occurs in the region of growth of the untreated tomato root, however, is not destroyed by it. The data presented are not interpreted as indicating any practical use of MOPA for control of nematodes.

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4. The treatment of tomato plants with MOPA was carried out by J. W. Mitchell and W. H. Preston, Jr., of the Horticultural Crops Research Branch, U.S. Department of Agriculture. MOPA was mixed with 1 part of Tween 20 and 4 parts of lanolin and applied as a band around the node of the second set of true leaves just after they had been formed. Mitchell was also the first to suggest to me the use of MOPA for the treatment, and I am indebted to him for much valuable advice.

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Conversion of Lactate into Glycogen in Skeletal Muscle of Hepatectomized Rats

The synthesis of glycogen from lactic acid in skeletal muscle has been investigated from time to time. In most books on biochemistry, the discussion of this metabolic process is incomplete or else it is omitted, probably because of the contradictory results that have been reported by different groups of investigators.

According to Meyerhof, Lohmann, and Meier (1), the hind legs of dogs,

when perfused with D-lactic acid solutions at pH 7.4, increased their oxygen consumption and converted some of the lactic acid into glycogen. When Eggleton and Evans (2) repeated these experiments, they observed no synthesis of muscle glycogen. By injecting lactic acid intraarterially into the hind legs of dogs, Elias and Schubert (3) were unable to find any formation of muscle glycogen. Janssen and Jost (4) reported that perfusion of hind legs of dogs with DL-lactate caused no increase in glycogen content. Takane (5) showed that the isolated diaphragm of rat was unable to synthesize glycogen from lactic acid. Using heart muscle, Cavert and Johnson (6) found that perfusion with sodium lactate-1-C¹³ or lactate-2,3-C¹³ did not yield glycogen labeled with C¹³. Despite the failure of many investigators to demonstrate the conversion of lactic acid into glycogen in mammalian muscle, Long and Horsfall (7) claimed that infusion of decapitated eviscerated cats with 2 to 10 percent of D-lactic acid solution at the rate of 12 to 13 ml/hr caused either insignificant or no increase in muscle glycogen.

In all of the literature cited, except one article, the results were obtained from isolated muscle and might not be the same as those from intact muscle. However, in the experiments of Long and Horsfall with intact muscle of decapitated eviscerated cats, the synthesis of muscle glycogen from infused lactic acid alone was not consistently and definitely indicated. Since the data are inconclusive, experiments to show the formation of glycogen from lactic acid in skeletal muscle have been undertaken (8).

Six Wistar rats were hepatectomized according to the method of Cheng (9). Each hepatectomized rat was injected with 80 µc (2.96 × 10⁶ disintegration/sec) of sodium DL-lactate-2-C¹⁴ (specific activity 1 mc/mmol per kilogram of

Table 1. Conversion of injected sodium lactate-2-C¹⁴ into carbon dioxide-C¹⁴ and muscle glycogen-C¹⁴ in ½ hour. Radioactivity is indicated in disintegrations (d)/sec.

Rat No.*	Wt. (g)	Total activity of lactate-2-C ¹⁴ injected (10 ⁶ d/sec)	Specific activity of expired CO ₂ (10 ² d/sec mg)	Total activity of expired CO ₂ (10 ³ d/sec)	Lactate-2-C ¹⁴ catabolized into CO ₂ (%)	Specific activity of CO ₂ obtained from glycogen (d/sec mg)	Total activity of glycogen isolated (10 ³ d/sec)	Lactate-2-C ¹⁴ converted (%)
90	330	9.77	6.23	5.95	0.61	7.48	2.18	0.22
91	402	11.90	7.61	10.57	0.89	6.80	4.47	0.38
95	434	12.85	6.34	9.77	0.76	5.78	2.55	0.20
92	290	8.58	8.25	11.78	1.37	8.60	4.73	0.55
93	279	8.26	12.78	16.60	2.01	8.33	3.31	0.40
94	256	7.58	4.86	3.52	0.47	9.92	4.35	0.57
96	229	6.78	5.30	4.94	0.73	12.54	3.71	0.55

* The first three rats were male and the last four were female; rat 96 was normal.

body weight. Since each rat used in this investigation weighed 230 to 400 g, the amount of radioactive lactate required ranged from 2 to 3.6 mg. One hundred microcuries or 11.2 mg of sodium DL-lactate-2-C¹⁴ were dissolved in 6 ml of physiological saline. The volume of solution containing the required amount of the radioactive lactate was measured in a 2-ml hypodermic needle and injected into the femoral vein. The carbon dioxide expired by the rat was collected and converted into barium carbonate for activity measurement in the usual manner. Because an insufficient amount of DL-lactate-2-C¹⁴ was available, only one control was run—a normal rat was injected with the same dosage of radioactive lactate.

The rats were sacrificed 30 minutes after the injection. All the skeletal muscle was immediately removed and used for the isolation of glycogen by a procedure modified from the methods of Pflüger (10), Starkenstein and Henze (11), and McDowell (12). The glycogen was oxidized with chromic acid and the activity of carbon dioxide collected was measured as before.

As shown in Table 1, the formation of glycogen-C¹⁴ appears to indicate the ability of skeletal muscle of rats, and presumably of other mammals also, to convert lactic acid directly into glycogen. It is also possible that lactic acid-C¹⁴ was first oxidized into carbon dioxide-C¹⁴ and that the latter then took part in synthesizing the glycogen-C¹⁴ of skeletal muscle. However, since the specific radioactivity of carbon dioxide obtained from oxidizing the glycogen of the skeletal muscle did not run parallel with that of the expired carbon dioxide, the conversion of lactic acid into glycogen via carbon dioxide intermediate, if any, is evidently not the only process of glycogen formation in the skeletal muscle. On the other hand, it is unlikely that within the short duration of these experiments the glycogen-C¹⁴ present in the skeletal muscle was derived from glucose synthesized in some other organs from the injected lactate. When the activities of glycogen isolated from hepatectomized and normal rats are compared, it appears that rats with or without livers synthesize glycogen from lactic acid at about the same rate.

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Electrophysiological Correlates of a Conditioned Response in Cats

The search for neurophysiological correlates for psychological phenomena such as learning and emotion has a long history that cannot profitably be treated here. This report presents a brief account of some electric changes that are observable in the brain when animals are conditioned and extinguished to an auditory stimulus.

The animals under study lived in a box measuring 0.5 by 1.0 by 0.5 m that contained a loud-speaker through which clicks (at constant intensity) were delivered at a rate of 1 click/3 sec along with noise generated by a thermionic noise generator. The noise intensity was adjusted at the outset so that it was sufficient to mask most ambient sounds. Recording from brain structures was achieved through electrodes of the Delgado type that were implanted stereotactically at sterile operation some weeks or months prior to the testing; as many as 14 separate brain locations were thus made available for study in each animal. To date, ten cats with implantations in or on auditory and visual cortex, cochlear nucleus, hippocampus, caudate nucleus, septal area, and amygdala have been examined in the conditioning process. The electrodes were directly connected through a plug to the amplifiers of a Grass EEG machine and thereafter, alternately or simultaneously, to inkwriters and a cathode-ray oscilloscope. The cats also wore a harness bearing two metal brushes, each making contact with one side of the thorax; the output of a Grass stimulator could be delivered to these brushes, and thus shocks could be applied, at will, across the chest of the animal.

The plan and results of the experiments are as follows. The animals were placed in the box for periods of many days or weeks, clicks being delivered continuously day and night throughout. From time to time their electrodes were connected to the recording devices, and the activity evoked by the clicks was visualized. The report (1) that under such conditions the response at the cochlear nucleus becomes, with time, much reduced in size ("habituation," "adaptation") was readily confirmed; in addition, we found that responses evoked in various other brain loci diminished in a similar manner. Responses so attenuated in the cochlear nucleus can be seen in the left column of Fig. 1.

After an animal had been in the box for hours or days, the tracings from its brain showed small, absent, or irregular evoked potentials caused by the clicks, and consistent behavior toward the stimuli was absent. At this point single strong shocks were given across the chest contiguously with randomly selected clicks. After these shocks had been discontinued—perhaps some 10 or 20 having been given—the behavior in response to the click stimuli was noticeably different. The animals crouched, appeared alert, and most of them twitched, snarled, or otherwise responded to many individual clicks. When exhibiting this behavior, the animals were considered to have been "conditioned" to the auditory stimulus; records from the cochlear nucleus of

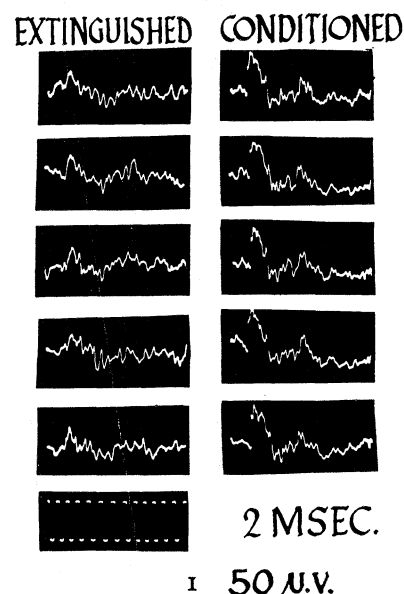


Fig. 1. Cochlear nucleus responses to successive identical click stimuli before ("extinguished") and after ("conditioned") application of three shocks to a cat. The increase in response magnitude after shocks as noted here has been observed eight times in this animal, two of them previous to the instance given here.