

I. Influence of Lactic Acid on Unicellular Organisms.

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(Introduced by Leo Loeb.)

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It is well known that malignant tumors produce a greater amount of lactic acid than the large majority of normal tissues. It appeared to us, therefore, of interest to study the effect of lactic acid on the proliferative activity of different kinds of cells and organisms. We undertook experiments on the influence of lactic acid on the growth of paramecia, yeast, rats, and malignant tumors. We neutralized the C.P. market preparation of lactic acid with sodium hydroxide until the different pH's desired were obtained. Lactic acid solutions were prepared varying between pH 3 and pH 7. In each experiment distilled water acidified with so much hydrochloric acid that the same pH was obtained as in the lactic acid solution was used as control.

In our experiments with paramecia we found that pure lactic acid is very toxic because of its strong hydrogen ion concentration. In a solution of lactic acid 1:5,000 the paramecia died within a few minutes, and even when the solution was weakened to 1:10,000 a high mortality of the paramecia was noted.

Lactic acid in the concentration of 1:1,000 neutralized with sodium hydroxide to pH 7 kills the paramecia within one or 2 days. Weaker solutions of lactic acid such as 1:5,000 at pH 7 begin to inhibit the multiplication of paramecia after some time, and kill these organisms after from 5 to 7 days. This can be seen in the following table.

TABLE I.
Number of Paramecia in 4 Watch Glasses, daily.

Hours Elapsed	24	48	72	96	120	144	168	Average
Control	10	7	7	7	5	8	8	52
With lactic acid	8	8	2	1	2	1	0	22
		pH 6.9			T 28°C.			

This table shows one of our many experiments in which we compared the rate of multiplication in paramecia in hay extract alone (control) and in the same kind of hay extract after the addition of lactic acid in a concentration of 1:5,000.

In each experiment we used 8 watch glasses, 4 of which served

as controls, and 4 of which contained lactic acid. Both of these groups of watch glasses were kept under the same conditions. Each figure in the second and third lines of the table represents the number of paramecia found in the 4 watch glasses. Every day each watch glass was examined and from those which showed an increase in the number of paramecia all save one were removed. In each watch glass, the solution was renewed every day. More than 100 series of experiments of this kind, extending over a period of several months, were carried out.

In another series of experiments we tested the influence of lactic acid on yeast.

TABLE II.
Number of Yeast Cells in 1 cc.

Time in hours	Control	Lactic acid 1:500
0	6,320	6,320
24	6,760	6,520
48	7,200	5,800

pH 3

T 27°C.

Table II shows the rate of multiplication of yeast cells in a nutritive solution of Euler-Svanberg. We compared the rate of multiplication in this nutritive solution (control), and in the same solution with lactic acid 1:500, in each case the acid being neutralized to pH 3 in the Euler-Svanberg solution. In the controls a pH of 3 was obtained through the addition of a small amount of hydrochloric acid. Although the yeast cells tolerated lactic acid better than paramecia, we found that in concentrations of 1:500 and 1:1,000 it likewise inhibits the multiplication of yeast cells. Eighteen series of experiments with yeast cells were carried out; they all gave the same result. The experiment cited in the paper represents one of these 18 experiments.

We may therefore conclude that lactic acid inhibits the multiplication of cells differing so much from each other as paramecia and yeast.