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Kinetics of Anaerobic Recovery in Muscle Contraction.

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In an earlier paper[1] the authors called attention to the fact that the lactic acid liberated per contraction in striated muscle made to contract isometrically is dependent upon the interval between contractions, and presented a curve relating lactic acid produced per contraction to the contraction frequency. The location of at least 2 of the points on the earlier curve, at frequencies of 12 per second and 4 per second, was only approximate, since the number of experiments at those frequencies was small. We have since conducted a larger number of experiments, approximately 50 each at frequencies of 12 per sec., 6 per sec., 4 per sec., 2 per sec., 1 per sec., and 1 per 2 seconds all at 22°C. We believe the number to be sufficient to indicate with reasonable accuracy the course of the time interval-lactic acid curve. The standard deviation is in each case about 0.02 mg. per 100 gm. of muscle. Stimulation was through the nerve by

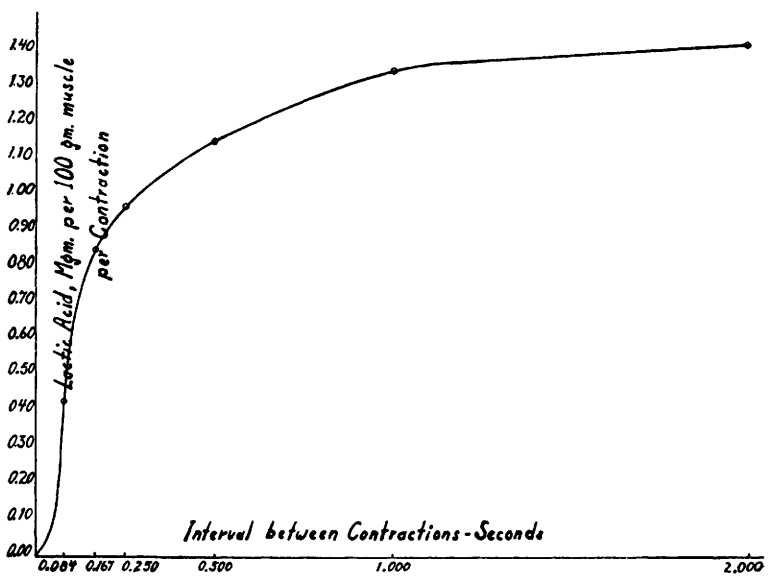

FIG. 1.

[1] Visscher, M. B., and Smith, P. W., *Am. J. Physiol.*, 1930, **95**, 121.

means of maximal break shocks from a Harvard inductorium, through a mechanical circuit breaker and make-shock eliminator.

In the earlier paper it was shown that at infinite intervals between contractions, (when the interval becomes greater than 2 seconds at 22°) the lactic acid produced per stimulation becomes constant. Evidence was presented to show that at intervals shorter in duration, removal is not complete. If we may assume the concentration of lactic acid reached when intervals are infinite to be a concentration maximum, and that in each successive contraction the concentration of lactic acid is built up to that maximum, then the amount of new lactic acid which appears in each contraction is an index to the amount removed in the preceding interval. From the data given in Fig. 1 relating lactic acid per 100 gm. of muscle per contraction to the time interval between contractions we have computed the percentage recovery in a given time interval, as presented in Table 1.

TABLE I.

Percentage Recovery in Terms of Lactic Acid Removed in Intervals Between Contractions.

Mgm. Lactic Acid per 100 gm. Muscle per Contraction	Time in Seconds	% Recovery
0.43	0.084	30.2
0.85	0.167	59.8
0.97	0.250	68.3
1.15	0.500	81.0
1.35	1.000	95.0
1.42	2.000	100.0

With a necessary correction to allow for the fact that recovery actually begins after the excitation disappears rather than at the instant of stimulation, the results above can be used to show that the reaction proceeds with a velocity characteristic of a first order reaction. Such a result might have been predicted from a consideration of the fact that during the course of a single recovery the free lactic acid concentration changes from 100% to a very small fraction of its contraction level, whereas during the same single recovery period the concentration of the substance combining with it in its removal, changes only to a small extent. Consequently the concentration of one reactant governs the velocity and the reaction appears as one of the first order over any single recovery period.