Detailed analysis of the responses to 17 of the stimuli presented to the larvae (*Vespa orientalis*)

| Larva | Day of experiment | Series within day | No. of contractions (signals) | r[a] | b[b] | a[b] | Average time[c] between 1st 10 signals | Average time[c] between last 10 signals |
|---|---|---|---|---|---|---|---|---|
| 2 | 1 | 1 | 60 | 0.77 | –.0007 | 0.075 | 13.4 | 29.3 |
| | 2 | 1 | 133 | 0.81 | –.0004 | 0.066 | 12.8 | 47.7 |
| | 3 | 1 | 69 | 0.94 | –.0009 | 0.080 | 12.2 | 36.1 |
| | 7 | 1 | 134 | 0.71 | –.0002 | 0.051 | 15.2 | 49.4 |
| | 8 | 1 | 57 | 0.26 | –.0001 | 0.048 | 20.7 | 22.7 |
| | 8 | 9 | 69 | 0.28 | –.0002 | 0.049 | 19.3 | 23.3 |
| 3 | 1 | 1 | 61 | 0.87 | –.0007 | 0.068 | 15.0 | 34.7 |
| | 2 | 1 | 71 | 0.65 | –.0003 | 0.040 | 29.2 | 61.6 |
| | 3 | 1 | 57 | 0.78 | –.0007 | 0.056 | 18.5 | 46.4 |
| | 4 | 1 | 86 | 0.69 | –.0004 | 0.049 | 15.9 | 45.3 |
| | 4 | 2 | 49 | 0.92 | –.0006 | 0.047 | 22.2 | 51.1 |
| | 4 | 3 | 32 | 0.77 | –.0007 | 0.038 | 28.4 | 51.2 |
| | 4 | 4 | 30 | 0.80 | –.0003 | 0.034 | 30.4 | 38.0 |
| | 4 | 5 | 33 | 0.72 | –.0004 | 0.037 | 27.9 | 37.6 |
| | 4 | 6 | 29 | 0.81 | –.0004 | 0.038 | 27.8 | 36.2 |
| | 5 | 1 | 52 | 0.47 | –.0002 | 0.029 | 34.6 | 47.5 |
| | 6 | 1 | 34 | 0.62 | –.0013 | 0.054 | 17.8 | 45.2 |

[a] r, correlation coefficient. [b] The regression equation is $Y = a + bx$ where $Y$ = rate between the intervals; and $x$ = index number of the signal. [c] The harmonic mean of the first and last 10 times.

mediated by some, as yet unknown, motorneurones. It occurs both spontaneously and as a result of sensory stimulation. Analogous behaviour is known in other species of Vespinae and is part of the food exchange phenomenon called trophallaxis[5].

The series of isotonic contractions resulting from a mechanical stimulus does not have a constant time difference between successive contractions. As the series continues, the length of time between contractions increases (or the rate decreases). However, the amplitude of the signal is constant for each contraction in the series. Therefore, this is not similar to fatigue and most likely represents an adaptation process similar to that occurring in the optic nerve fibre of *Limulus* in response to a flash of light[6]. A second phenomenon similar to an adaptation process is seen in the response to the repeated stimuli on the same day. The number of contractions in the response to the earlier stimuli is greater than in the latter stimuli. This trend also appears in many other series (ISHAY, unpublished).

This experiment was performed on single insulated larvae. The results contrast with the pattern of hunger signals produced in a normal comb (inhabitated by many larvae). The latter's pattern is synchronized for large groups of the larvae. This synchronized pattern is at constant rate[2] in contrast to the insulated larvae's pattern. The intervals between the signals of single insulated larvae vary over a broad range of values from 1.5–5.5 sec; this represents most probably the result of removal of synchronizing stimuli. The possible communicative value of these patterns of larval contractions among the colony mates will be examined in further research.

*Summary*. A mechanical stimulus of constant strength was applied to a single, insulated hornet larvae (*Vespa orientalis*). A chain of at most 140 bodily contractions resulted from the stimulus. The interval between consecutive contractions steadily increased throughout the period of response.

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## Role of Energy Metabolism in Enzyme Retention. A Study on Isolated Perfused Canine Hearts

Little is known of the mechanisms by which enzymes are released from normal or damaged cells. There is evidence that the prevention of enzyme leakage is directly or indirectly an energy-consuming process[1–4]. In the myocardium an unequivocal relation between enzyme release and duration of ischemia can be shown[5,6]. A close relationship exists also for enzyme loss and oxygen supply to the heart. The temperature coefficients ($Q_{10}$-values) for myocardial enzyme release and the breakdown of energy rich phosphates in the heart muscle during anaerobiosis ($\sim$ 2,2) are identical (unpublished results).

In the following the correlation between the rate of enzyme loss from the heart and the myocardial ATP content will be shown.

Ten isolated dog hearts were subjected to a non-recirculatory anoxic perfusion at 25 °C with a modified Tyrode-solution after an aerobic steady state phase. In 5 experiments the release of CPK (EC 2.7.3.2.), MDH (EC 1.1.1.37), LDH (EC 1.1.1.27), GOT (EC 2.6.1.1.), GPT (EC 2.6.1.2.), ALD (EC 4.1.2.13), and ICDH (EC 1.1.1.42), in the remaining experiments the tissue contents of creatine phosphate, ATP and lactate during anaerobiosis were determined (for experimental details see[7], for enzyme and metabolite determinations see[8]).

The results are presented in Figure 1. After even a small decrease in ATP, enzymes can be detected in the coronary effluent. At this point the cells should not yet be irreversibly damaged[7]. The rate of enzyme loss increases with increasing ATP decomposition. Plotting the enzyme release from the myocardium against tissue ATP content (Figure 2) yields straight lines with significant correlation coefficients ($p < 0.001$). (The curves for GPT, ALD, ICDH have not been evaluated.)

The following conclusions may be drawn. 1. As e.g. the liver, the heart loses enzymes when subjected to reversible damage. 2. There is a close correlation between enzyme retention and energy metabolism. The proof for a direct causal dependence cannot be adduced on the basis of the experiments discussed. An emphasis on the relations between energy metabolism and permeability of the cell membrane only obviously does not consider the entire problem. Compartimentalization, charge changes, intracellular binding etc. of enzymes are, of course, also relevant.

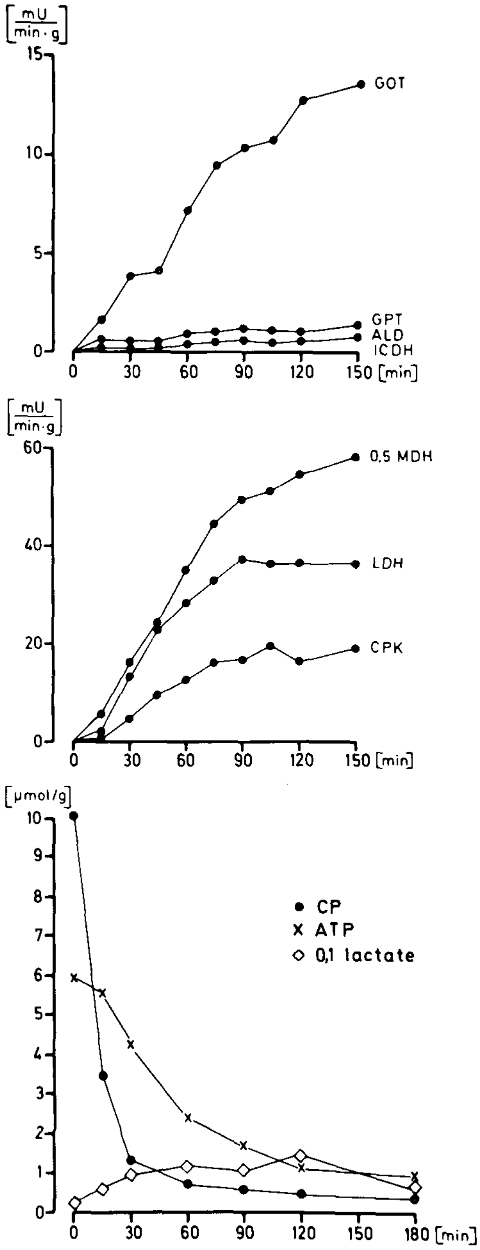


Fig. 1. Enzyme release during anaerobiosis from the isolated perfused dog heart (above and middle; 25°C; $n = 5$) in relation to the tissue content of creatine phosphate (CP), ATP and lactate (below 25°C; $n = 5$; ww, corrected for edema).

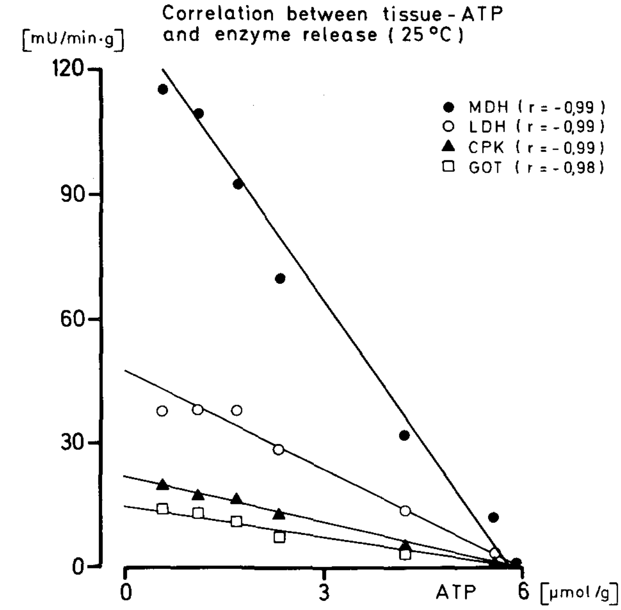


Fig. 2. Release of MDH, LDH, CPK and GOT from the anoxic perfused dog heart in correlation with the myocardial ATP content (ww, corrected for edema).

*Zusammenfassung.* Zwischen der Enzymfreisetzung aus dem anoxisch perfundierten Myokard und dem Gewebsgehalt an ATP besteht eine lineare Abhängigkeit. Die Befunde weisen auf die engen Beziehungen zwischen dem Energiehaushalt der Zelle und der Enzymretention als wahrscheinlich aktiver Stoffwechselleistung hin.

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