

## THE EFFECT OF TEMPERATURE UPON DORSAL ROOT POTENTIALS IN THE FROG

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WHEN impulses enter the spinal cord of the frog, slow potential changes result, and these spread by electrotonus to the dorsal roots where they can conveniently be recorded [Barron & Matthews, 1938]. These potential changes are constant in form if the recording electrodes are on a divided root suspended in air. But if the roots are in continuity, the form of the changes may be complex because the distal part of the root acts as a lead back to the cord and gives a "diphasic" derivation [see Bonnet & Bremer, 1938]. The present paper reports the results of an investigation of the effects of temperature upon the latency and form of the potential changes taking place in the dorsal roots cut distally, when a single volley of impulses enters the cord of *Rana esculenta*.

### METHOD

The amplifying and recording system used have been described by Matthews [1938], and the experimental procedure, also previously described by Barron & Matthews [1938], is only briefly reviewed below. In certain experiments, indicated in Fig. 2, stimulation was via a dorsal root and in these a condenser coupled amplifier was used.

The frogs were decerebrated and immobilized by subcutaneous injections of curare. (Injections of 3 c.c. 1% Gourd curare per kg. of body weight had previously been found sufficient to immobilize the animals without altering the cord potentials, and the mechanical disturbance of the cord which occurs when the anterior roots are sectioned was thus avoided.) The spinal column was opened, the dura removed; a dorsal root was lifted and divided distally, tied with silk, and freed to the point of its entrance into the cord; the sciatic nerve was divided at

the knee and freed for from 3 to 4 cm. The divided root was placed on the recording electrodes, and the sciatic nerve on the stimulating electrodes, while the remaining intact roots provided pathways to the cord for the impulses set up. When the cord was continuously irrigated with oxygenated Ringer's solution [Kato's formula, 1934], the dorsal root potential resulting from maximum induction shocks to the sciatic nerve was of large size (usually upwards of 1 mV.) and could be obtained for from 8 to 24 hr. after the cord was exposed.

The preparation was set up in a box the temperature of which could be varied by means of an electric heating unit or by packing the box with ice. (Temperatures were recorded from a thermometer placed under the skin of the frog's back.) The responses were recorded at intervals of 5° ascending or descending from 15°, occasionally descending from 25° or ascending from 5°. Since the production of a change of 5° in the temperature of the preparation required from 30 to 60 min., records of the reactions at three to six different temperatures were distributed over a period of from 3 to 8 hr. during which no measurable difference in the potential change at constant temperature occurred, although there was some indication of a progressive increase in the size of the stimulus necessary to produce a maximum response.

The potential change recorded when a single afferent volley was set up varied from about 1 to 4 mV., but the magnitude of the potentials registered at different temperatures is not comparable, since the position of the electrodes was not always at exactly the same point on the nerve. The leads were usually about 1 and 7 mm. respectively from the cord. When the root on the recording electrodes was itself stimulated by electrodes at its distal end, the potential changes recorded were similar to those recorded when the afferent impulse volley entered by different roots.

At 25° C. the amplitude of the response was reduced, possibly because the oxygen supply was inadequate to maintain the increased rate of metabolism. (When much reduced the response became irregular and the latency was increased.) However, the more rapidly the preparation was heated, the better it survived, and results have been tabulated only for responses which were regular and not less than half of the original amplitude. In such cases a maximum response could again be obtained upon cooling. At 5° C. a great increase in the strength of the shock was necessary to produce a maximum response.

The experiments were conducted in early May and June when the room temperature varied from 15 to 17°.

## RESULTS

The photographs reproduced in Fig. 1 show typical changes of potential in the cord, at the temperatures indicated, when the sciatic nerve or a dorsal root is stimulated by a supramaximal induction shock.

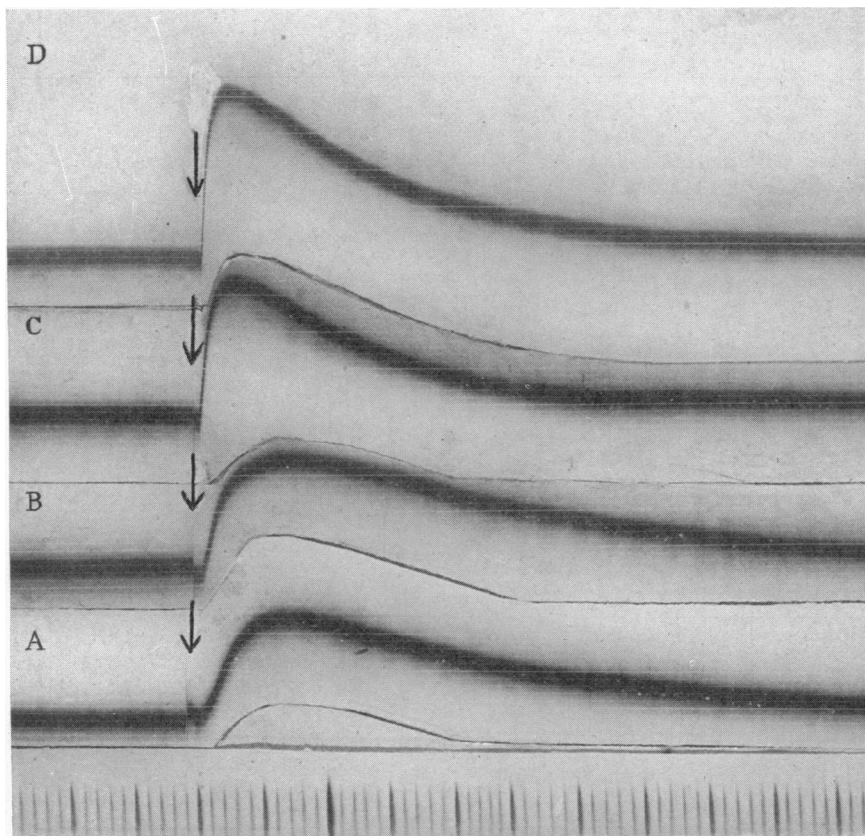


Fig. 1. Potential changes in the dorsal roots of *Rana esculenta*. A at 5°, B at 10°, C at 15°, D at 20°. Stimulus, supramaximal induction shock to sciatic nerve (8 cm. approx. from cord). Recording electrodes on dorsal root sectioned peripherally. Time marker shows 0.1 and 0.02 sec. The fine vertical line marked with an arrow is the escape of the stimulus. Order of change 3–4 mV.

The latency of response, duration of the rising phase and total duration are all clearly shortened by a rise in temperature. But when the times for these phases of the change—the latency, the time to maximum, and the time for the declining phase (measured at two arbitrarily chosen

points)—are plotted against temperature (Figs. 2 and 3), it is seen that they are not affected similarly by changing the temperature. Over the

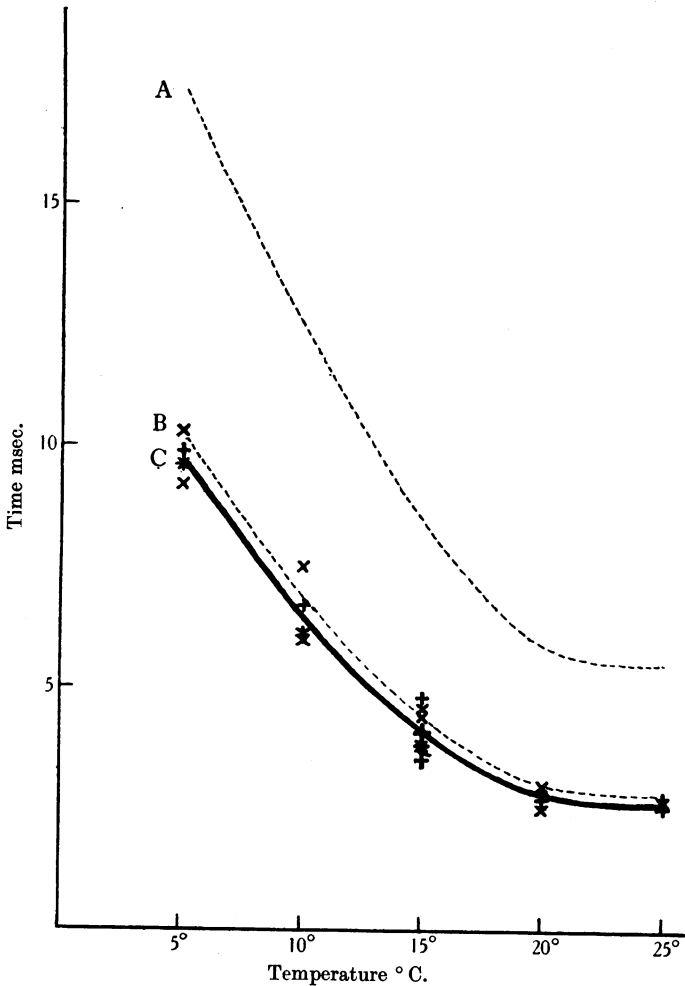


Fig. 2. Variation of latency with temperature. A. Total latency recorded between stimulus escape and rise of dorsal root potential; stimulating electrodes on sciatic nerve (approx. 8 cm. from cord). B. Total latency when stimulating electrodes are on a dorsal root. C. Latency corrected for centripetal conduction time from data of Gasser [1928] and Lucas [1908].

temperature range of 5–25°, the latency curve (Fig. 2) declines with a steady negative acceleration, showing a marked drop from 5 to 10°, and a very slight decline from 20 to 25°, while the other three curves

(Fig. 3) fail to show this initial decrease for the 5-10° interval, having, however, quite similar slopes throughout the remaining portions of the curves with slightly steeper declines at 20-25°.

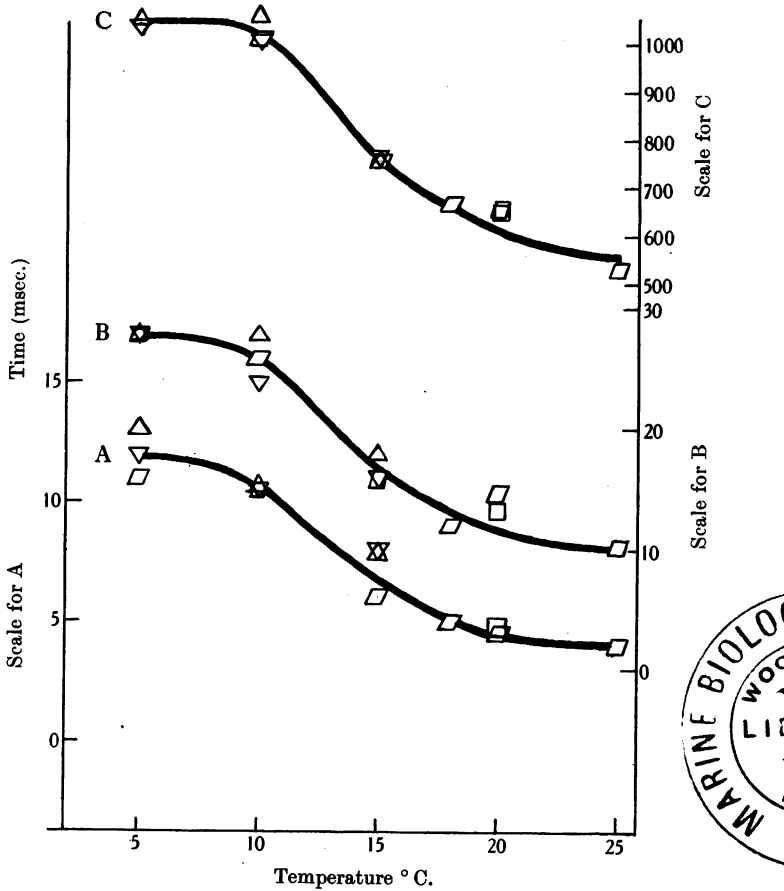


Fig. 3. Curves relating the rate of rise and fall of the dorsal root potential to the temperature. A. Time to maximum. B. Time for a fall of 25% from the maximum. C. Time for a fall of 90% from the maximum.

The latency, the time to maximum, time for 25% of this potential change to subside and time for 90% to subside bear the following ratios to the corresponding measures at temperatures ten degrees higher at the three temperature intervals 5-15°, 10-20°, 15-25°, respectively; latency

2.3, 2.3, 1.5; time to maximum 1.6, 2.0, 1.7; time for 25% decline 1.6, 2.1, 1.5; time for 90% decline 1.4, 1.6, 1.1. Thus the latency undergoes a greater change than the rise or fall of potential.

#### DISCUSSION

The high temperature coefficients of the latency of the cord potentials and the lower temperature coefficients of the rise and fall of the potential change suggest that the factors involved are complex.

The progressive change which occurs with alteration of the temperature is in general accord with Barron & Matthews' [1938] suggestion that the dorsal root potential arises from long lasting changes occurring in each of the units concerned rather than statistical summation of much briefer changes.

The different shapes of the temperature curves—for the latency and for the development and decline of the potential—suggest different underlying processes. The sigmoid nature of the curves for the rise and fall of the potential, as distinct from the latency, suggests two processes in combination speeded up at different rates by rising temperatures.

#### CONCLUSIONS

1. The cord potentials are greatly influenced by change of temperature but remain of the same general configuration over the range examined.
2. The curves relating temperature and the latency of the dorsal root potentials in the frog differ markedly from the curves relating temperature and the rising and declining phases of the potential; it is concluded that the processes responsible for the initial delay and subsequent development of the potential change may be different in nature.

#### SUMMARY

The form of the potential change taking place in the dorsal roots when a volley of impulses enters the cord of the frog (*Rana esculenta*) remains of the same general configuration at temperatures ranging from 5 to 25°. The latency of the response, duration of the rising phase and total duration are shortened by a rise in temperature. The latency is more affected by change of temperature than are the rise and fall of potential. The latency temperature curve declines with a steady negative acceleration while the curves of the remaining phases are sigmoid in nature. Temperature coefficients for four phases of the change are

presented, and it is concluded that the processes responsible for the initial delay and subsequent development of the potential change may be different in nature.

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