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Comparison of Properties of Individual Axons in the Frog.

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In large mixed nerves, such as the sciatic, the action potential started by local stimulation is much more protracted after conduction than at the locus of stimulation, and, in the former case, presents 3 principal elevations of the continuous potential.¹ Bishop and Heinbecker recognize 4 main elevations and believe that the potentials contributed to these elevations are supplied by fibers of different types.^{2, 3} Measurements of the duration of axon potentials hitherto have been based on superimposed axon responses recorded at the site stimulated. Inasmuch as axons respond to stimulation with different latencies⁴ this method cannot give the axon potential in its true form. By employing nerves containing only a few fibers at the lead, long distances of conduction and very high amplification, it is possible to record discretely the undistorted potentials of some, often of all, and to ascertain the characteristics of each, of the constituent axons.

When either the relative voltage of threshold induction shocks or the rheobasic voltage from a condenser is plotted against conduction rate the resulting curves both are hyperbolic in form, the slower fibers having the higher thresholds. Likewise a smooth curve, hyperbolic in form, can be drawn between the points relating time to maximum of the action potential to conduction rate; the slower the conduction rate the longer is the time to maximum. And in so far as it is possible to correlate the data on the relation of the

¹ Erlanger, J., and Gasser, H. S., *Am. J. Physiol.*, 1930, **92**, 43.

² Bishop, G. H., and Heinbecker, P., *Am. J. Physiol.*, 1930, **94**, 170.

³ Heinbecker, P., and Bishop, G. H., *Am. J. Physiol.*, 1931, **96**, 613.

⁴ Blair, E. A., and Erlanger, J., *Proc. Soc. Exp. Biol. and Med.*, 1932, **29**, 926.

absolutely refractory periods to conduction rates the result is a similar hyperbolic curve. The refractory periods without exception are longer than the corresponding times to maximum. The data on action voltage, due to possible occasional failure to recognize deflections produced by 2 perfectly superimposed axon potentials, are not absolutely reliable. The individual curves of correlation with conduction rate seem to deviate around a straight line inclined steeply downwards from the quicker to the slower axons. Since the slower fibers have the smaller diameters and since a larger fraction of the intrinsic potentials of the former must be shunted by inactive tissue, this result may not be inconsistent with the assumption⁵ that the intrinsic potentials all are alike in amplitude.

Comparison of these several properties is complicated by the fact that they have some, seemingly spontaneous, variability. The points in every case distribute themselves somewhat irregularly about the plotted curves but the curves seem to be free of discontinuities in the range of fibers conducting faster than 2 m.p.s.; beyond that there still is some uncertainty. The results, therefore, fail to support the view that there are fiber types distinguishable by time to maximum, conduction rate, irritability and refractory period. Nevertheless, in keeping with our observations on large nerves we find that the conducted axon potentials tend to sum to form some 3 elevations corresponding in general with A, B, and C of the action potential of large nerves, but the relative positions of these elevations in the different nerves, particularly in skin nerves, is quite variable. Since it is possible to recognize differences in the physiological responses of individual axons it is no longer incumbent upon physiologists to adhere to the doctrine of specific nerve energies.

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True Polyvalence of Pure Bacteriophages.*

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As found in their natural environment, bacteriophages often exhibit lytic activity against a variety of organisms sometimes

⁵ Gasser, H. S., and Erlanger, J., *Am. J. Physiol.*, 1927, **80**, 522.

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