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Properties of Unmyelinated Fibers of Nerve.*

PETER HEINBECKER. (Introduced by Geo. H. Bishop.)

From the Departments of Surgery and Physiology, Washington University Medical School.

Previous reports on the physiology of nerve by Erlanger, Gasser and Bishop[1] have dealt with the properties of the myelinated fibers. In this paper are presented data on the properties of fibers characteristic of the involuntary nervous system especially the unmyelinated ones. The analyses have been made by means of the cathode ray oscillograph and the use of amplification greater than was usually considered necessary for the study of the myelinated fibers.

The unmyelinated fibers can be identified by a conduction rate slower than that of the ordinary myelinated fibers of peripheral nerves (1.5 to 0.2 M. per sec. in the turtle). These rates are comparable to the rates reported by Chauchard, A. et B.,[2] as determined from the effect of stimulation at different levels along the course of nerves containing unmyelinated fibers. A second characteristic of these fibers is their high threshold. An induction shock at least 10 to 100 times that of the most irritable fibers in the same nerve is re-

* This preliminary report on unmyelinated nerve fibers is published as one phase of the more general problem of a comparative study of the differences between myelinated and unmyelinated axons, being carried out by the author and Dr. George H. Bishop.

[1] Erlanger, Joseph, Bishop, George H., Gasser, H. S., *Am. J. Physiol.*, 1926, lxxviii, 537.

[2] Chauchard, A. et B., *Compt. Rend. Soc. de Biol.*, 1925, xcv, 279 and 370.

quired for a threshold response in the turtle, in the cat 50 to 100 times.

A more suitable method of stimulating these fibers is by the galvanic current. The nerve is arranged in a bridge balanced for resistance and capacity as described by Bishop.[3] Relative thresholds can then be measured either by change in duration or by change in intensity of stimulating current. On the basis of either threshold or conduction rate the fibers, if myelinated, would have to be not more than 0.1μ in diameter in order to fit the size conduction rate ratio of Gasser and Erlanger[4] for the myelinated fibers. Myelinated fibers of this diameter are not found in the nerves under consideration.

Using the galvanic current in the manner indicated above, the chronaxie of these fibers can be measured. As read from the complete curves of time against intensity their chronaxies range from approximately 3.5 to 6 sigma as compared with 0.3 sigma for the myelinated fibers of the frog or turtle first processes.

In recording the action potential duration at or near the stimulated point, in order to obtain the form of the potential in the individual axon, considerable difficulty was met, due to the strong stimulating current required. Since the threshold of these fibers is 10 to 100 times that of the first myelinated fibers stimulated and since the sensitivity required for recording them is at least 10 times as great, the record of the stimulating current (escape) will be at least 100 to 1000 times that of the currents necessary for stimulating the most irritable fibers. Very careful balancing of the bridge circuit is necessary both to decrease the direct record of the shock and to eliminate distortion due to the capacity of the stimulating circuit itself. In this we have not been wholly successful to date and our results are presented as approximate ones. There appears to be no question, however, that the duration of the potential at the stimulated point is considerably longer than that of the ordinary myelinated axon. This is indicated by different methods, (1) direct recording in a balance bridge circuit, (2) stimulation by 2 shocks, the second applied during the refractory phase of the first process arising from the myelinated fibers, and (3) extrapolation back to the stimulated point. Of the duration of the conducted action potential all indicate a longer duration of the axon action potential of fibers possessing the properties of the unmyelinated ones than that arising from the ordinary myelinated fibers. The ratio of their rising phases appears to be between 5 and 10 to 1.

[3] Bishop, George H., *Am. J. Physiol.*, 1927, lxxii, 462.

[4] Gasser, H. S., and Erlanger, Joseph, *Am. J. Physiol.*, 1927, lxxx, 522.

The absolutely and relatively refractory phases of these fibers have been determined by plotting the curve of return of irritability after a maximal first stimulus. The potentials were recorded after conduction to allow separation out from the earlier waves (Gasser and Erlanger).[5] Condenser charges were employed usually up to 160 volts and from .01 to .1 microfarad capacity. These condensers were connected through 2 contacts of the circuit breaker and charged in series with the bridge containing the nerve, the whole being balanced for capacity and resistance. To prevent the first condenser shunting the second, the circuit breaker was made to open the first circuit before the second was closed, the condenser charging through the nerve circuit during this interval. Both repeated and single pairs of stimuli were employed and it was found that stimuli applied more frequently than at the rate of 1 per second resulted in a prolongation of the absolutely refractory phase. The nerve was supplied with oxygen at room temperature. Preliminary experiments on the effect of anoxemia on these fibers and the knowledge that in the ordinary myelinated fibers, failure of response occurs when the normal absolutely refractory period of less than one sigma has increased only 100 to 300%, both indicate that the long absolutely refractory period found for these fibers is not the result of depression by anoxemia. They have an absolutely refractory period of 4 to 6 sigma when the action potential is still maximal, as indicated by the results of single stimuli.

These measurements of the properties of the unmyelinated fibers are being used to differentiate between types of fibers found in the same nerve.

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The Direct Estimation of True Blood Sugar.

EDWARD S. WEST, VERNON L. PETERSON AND FREDERICK H. SCHARLES.

From the Laboratory of Biological Chemistry, School of Medicine, Washington University.

Blood sugar values obtained by Somogyi's[1] fermentation technique very probably represent the *true sugar* of blood. This procedure, while the standard for comparison, is somewhat laborious,

[5] Gasser, H. S., and Erlanger, Joseph, *Am. J. Physiol.*, 1925, lxxiii, 613.

[1] Somogyi, M., *J. Biol. Chem.*, 1927, lxxv, 33.