

TABLE I.

Diffusion cell	Cell constant (K) as determined with 0.1 N HCl	Time in days	Phage diffused as cc. of original filtrate	D. for phage in cm. ² /days
No. 1	.1975	.0208	.00188	.0178
" 1	.1975	.0208	.00188	.0178
" 2	.1975	.0208	.000406	.0192
" 2	.1975	.0208	.000406	.0192
" 3	.1975	.0208	.00133	.0182
" 3	.1975	.0208	.0015	.0205
Average.....				.0188

Using this average value of $D = (.0188)$ in the Einstein equation,¹⁰ the radius of an average size particle of phage is calculated as having approximately the value of 6.1×10^{-7} cm. (or $6 \mu\mu$). Of course, one has still to determine whether such particles represent the units of bacteriophage or serve merely as carriers for a more highly dispersed agent.¹¹

4440

Differentiation Between Types of Fibers in Certain Components of Involuntary Nervous System.

PETER HEINBECKER AND GEORGE H. BISHOP.

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

Criteria discussed in a previous report¹ have been employed to distinguish between 3 different types of fibers which occur together in nerves of the involuntary nervous system. Comparative measurements of threshold² have also been extended to these fibers. The cervical sympathetic trunk of one variety of turtle serves as a typical nerve containing such axons, recognizable by 3 groups of waves in their conducted action potential record on the oscillograph. These groups will be designated as the A, B, and C groups.

A second type of turtle has only 2 groups of waves in the cervical sympathetic nerve trunk, the second and third. Sections of the first type of nerve* show scattered, larger, and for the most part thinly

¹¹ Bronfenbrenner, J., see pages 527-529 in the "Newer Knowledge of Bacteriology and Immunology," Jordan and Falk, University of Chicago Press, 1928.

¹ Heinbecker, P., PROC. SOC. EXP. BIOL. AND MED., 1929, xxvi, 349.

² Bishop, George H., and Heinbecker, P., PROC. SOC. EXP. BIOL. AND MED., 1928, xxvi, 241.

* We are indebted to Mr. William Masek of the Department of Cytology for making sections of these nerves.

myelinated fibers, with islands well marked off by trabeculae containing unmyelinated and small myelinated axons. Sections of the second type show only such islands containing practically no large fibers. The second and third groups of waves in these nerves are therefore inferred to correspond to the thinly myelinated and unmyelinated axons respectively of these islands. The relative areas of potential of the third wave in various other nerves studied corresponds in general to the relative number of unmyelinated axons. In the second type turtle the third wave group is larger than the second in area.

The white and gray rami of the frog's 7th nerve consist almost exclusively of these typical islands of myelinated and unmyelinated fibers, and Gasser and Erlanger (personal communication) have observed *B* and *C* waves in a gray ramus. Certain dorsal roots of bullfrog and turtle also have similar thinly myelinated axons which are being studied as a possible source of sympathetic outflow. The sympathetic trunk of the frog has besides these, some larger myelinated axons, as has that of the dog. The latter has been found to give a very low potential corresponding in properties to the late *A* group, a higher one corresponding to the *B*. A human genitofemoral nerve gave a large second process following 4 waves of the first process; the cross section shows many typical islands of myelinated and unmyelinated axons, and the refractory phase was short for the first group and long for the second. Failure of the third group to appear from this nerve may have been due to its long time out of the body. The refractory phases of the frog and turtle sciatic *B* and *C* waves, like those of the sympathetic, are 4 times as long as that of the *A* group, as if these waves were, in part, at least, due to sympathetic components.

The turtle vagus is similar in cross section and in potential form and in other properties of the axon processes to the sympathetic, except that more large fibers are present, and a larger first group of potentials. In the cat vagus and cervical sympathetic trunk the same situation holds, except that the islands are not so sharply marked off from areas of large fibers; there are relatively more of the latter and relatively fewer unmyelinated. The potential distribution, conduction rates, thresholds, etc., correspond closely to those of the turtle allowing for differences in temperature. As shown by Gasser and Erlanger³ for peripheral nerves, so also in the sympathetic

³ Gasser, H. S., and Erlanger, J., *PROC. SOC. EXP. BIOL. AND MED.*, 1929, xxvi, 647.

nerves the relationship between fiber size and conduction rate (Gasser & Erlanger⁴) fails to hold as between one main group of axons and the next. There is a sharp break in character between the first and second groups in the properties discussed above, and much less difference in certain respects between the small myelinated and unmyelinated fibers. The first group of axons conducts through the superior sympathetic ganglion of the turtle in either direction, the second irreversibly, indicating a motor fiber synapsing in this system. Part of the third group axons, at least, also synapse here and are motor and part go through probably having synapsed in other ganglia more centrally. Some at least of the post-ganglionic fibers synapsing with the second group pre-ganglionic are also second group fibers. If the second group axons are the thinly myelinated ones, post-ganglionic myelinated fibers are therefore present. There are many more of these fibers post-ganglionically than pre-ganglionically.

It is anticipated that such thinly myelinated axons associated with unmyelinated will contribute to B and C elevations in other nerves where present, and the investigation of their properties is being extended to test this possibility.

The potential analysis of the sympathetic nerves has been undertaken by Heinbecker, the study of the differentiation between types of axons in various nerves is a joint research of Bishop and Heinbecker.

4441

The Action Potential in Fibers of Slow Conduction in Spinal Roots and Somatic Nerves.

H. S. GASSER AND JOSEPH ERLANGER.

From the Departments of Pharmacology and Physiology, Washington University School of Medicine, St. Louis.

The group of waves, *alpha*, *beta*, *gamma* and *delta*, hitherto described as constituting the conducted action potential of mixed somatic nerve^{1, 2} are confluent and are produced by groups of fibers conducting at rates ranging in round numbers, in the bullfrog, green

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

¹ Gasser, H. S., and Erlanger, J., *Am. J. Physiol.*, 1922, lxii, 496.

² Erlanger, J., Gasser, H. S., and Bishop, G. H., *Am. J. Physiol.*, 1924, lxx, 624.