

transmission rate became more pronounced the electrical complexes appeared more and more degraded.

With conditions of altered hydrogen ion concentration, then, the rate of propagation of the excitatory process in the auricular muscle undergoes definite changes, rising with increasing alkalinity and falling as the hydrogen ion concentration is increased. If, upon a state of increased hydrogen ion concentration there be superimposed one of absence of oxygen there results a condition in which the excitation wave moves slower the farther it travels and the electrical responses become progressively degraded until finally there may appear block within the auricular muscle itself. This condition bears a striking similarity to that found in nerve and described there as "decrement".

In a series of observations soon to be reported Drury has demonstrated progressive slowing of the propagation of the excitatory process beneath a pressure clamp.

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#### The sympathetic innervation of voluntary muscles.

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The experimental anatomical studies of Boeke (1913),<sup>1</sup> Boeke and Dusser de Barenne (1919),<sup>2</sup> and Agduhr (1919)<sup>3</sup> indicate clearly that, in addition to somatic afferent and efferent components of the cerebrospinal nerves, nerve-fibers of sympathetic origin also terminate on voluntary muscle-fibers. Not a few physiological studies tend to corroborate this anatomical finding, others yield only negative results. Consequently, the sympathetic innervation of voluntary muscles is not yet universally accepted even as an anatomical fact.

The material on which the present study is based was obtained from three dogs in which the somatic nerve-fibers supplying cer-

<sup>1</sup> *Anat. Anz. Bd.*, xlv.

<sup>2</sup> *Proc. Amsterdam Akad. von Wettenshappen*, xxi, 1227.

<sup>3</sup> *Proc. Amsterdam Akad. von Wettenshappen*, xxi, 1231.

tain muscles had undergone degeneration following section of the corresponding nerve roots.<sup>4</sup> In two of the dogs the roots of the seventh, eighth and ninth thoracic nerves were exposed by laminectomy and cut distal to the spinal ganglia and proximal to the communicating rami. These animals were killed four weeks later. To avoid confusion which might arise by reason of overlapping of the areas of distribution of the intercostal nerves or the plurisegmental innervation of muscle-fibers, muscle was taken for study only from the eighth intercostal space. Control material was taken from intercostal spaces in which the nerves were left intact. In the third dog the mandibular nerve was cut intracranially. When this dog was killed twenty-three days later, portions of the masseter and pterygoid muscles on the side of the operation and control material from the corresponding muscles on the opposite side were taken for study. In all cases muscle tissue in which the somatic nerve fibers had undergone degeneration and control material was prepared both by the gold chloride and the pyridine-silver method.

In the control material prepared by both methods the terminal branches of the nerves comprising both myelinated and unmyelinated fibers as well as the terminations of fibers of both types on muscle-fibers may be observed. Our observations on the end-plates of the ordinary myelinated somatic efferent fibers corroborate those of Boeke (1921),<sup>5</sup> who described these end-plates as hypolemmal in position and resting on nucleated 'sole-plates' composed of granular sarcoplasm which lies superficial to the myofibrillae and in which is imbedded a delicate reticular structure. As the myelinated somatic efferent fibers approach the end-plate some of them are accompanied by a slender unmyelinated fiber which terminates in a small end-net or end-loop within the area occupied by the 'sole-plate' on which the motor end-plate rests. Doubtless, these are the accessory fibers described by Boeke. Similar slender unmyelinated nerve-fibers also terminate on muscle fibers entirely apart from the end-plates in which the large myelinated fibers terminate.

In the preparations of the intercostal muscles in which the somatic nerve-fibers had undergone degeneration, neither myelinated nerve-fibers nor their terminal structures are present. In some instances the area occupied by the 'sole-plate' is still appar-

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<sup>4</sup> We are indebted to Dr. F. J. Tainter for these operations.

<sup>5</sup> Brain, xlv, 1.

ent. In the preparations of the muscles of mastication in which the fibers of the mandibular nerve have undergone degeneration, remnants of some of the end-plates of the myelinated fibers are still visible. In all these preparations slender unmyelinated nerve fibers, some of which are intimately associated with the blood vessels while others occur either singly or in small bundles entirely apart from the blood vessels, are present. None of these fibers, many of which terminate on muscle-fibers, show any evidence of degeneration. The terminal structures of these fibers, like the ordinary motor end-plates, are always hypolemmal in position and rest on a layer of granular sarcoplasm which lies superficial to the myofibrillae. Some of these fibers terminate in a single end-net or end-loop, others give rise to two or more terminal branches which terminate in smaller end-nets or end-loops of similar character. These observations conform in all essential details to those recorded by the authors named above regarding the unmyelinated nerve-fibers and their terminal structures in preparations of voluntary muscles in which the somatic nerve-fibers have undergone degeneration. Inasmuch as, in our experimental animals, all the somatic nerve-fibers supplying the muscles in question had been cut and ample time was allowed for the degeneration of these fibers we must conclude that the unmyelinated nerve-fibers which remain are sympathetic in origin.

#### 14 (2537)

#### **Experimental observations on the functional significance of the sympathetic innervation of voluntary muscles.**

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In this study we adopted the plan of extirpating the sympathetic trunk in the lumbar region on one side only, using dogs as the experimental animals, and comparing the tonus, the power of contraction and the resistance to fatigue of the muscles of both hind limbs both immediately after the operation (6 dogs) and after ample time (10 to 36 days) had been allowed for the degeneration of the sympathetic nerve-fibers supplying the mus-