

*Citation:*

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**Anatomy.** — “*The sympathetic innervation of the cross-striated muscle fibres of vertebrates.*” By Prof. J. BOEKE and Dr. J. G. DUSSER DE BARENNE.

(Communicated in the meeting of January 22, 1919.)

Some years ago one of us, partly in these proceedings and in the transactions of this Academy <sup>1)</sup>, published a number of observations, which tended to show that on the cross-striated muscle fibres of reptiles, birds and mammals there existed, beside the usual motor endplates, still a second set of hypolemmal nervous endorgans, very fine and delicate, which are seen in BIELSCHOWSKY-preparations as very small neurofibrillar end-rings and small end-nets, lying on the surface of the muscle-fibres at the end of fine non-medullated nerve-filaments. These so-called “accessory” nerve-endings lie hypolemmally on the muscle-fibres embedded in the granular sarcoplasm of the fibre, and in some cases are found in the same layer of granular protoplasm which surrounds also the terminal ramifications of the common motor end-organ; in other cases they are found as separate endings, lying embedded in a distinct layer of nucleated sarcoplasm independent of the motor sole, but, as far as could be made out, they always appear as hypolemmal structures. The non-medullated nerves that have these end-organs attached to their terminal nerve-ramifications, are seen running in bundles between the muscle-fibres, remain amyelinic throughout their whole course, and seem to form a distinct system of nerve-fibres, independent of the motor and sensible nerves. These observations, and especially the amyelinic structure of these nerve-fibres gave room for the supposition, that this so-called “accessory innervation” (BOEKE, 1909) is of a sympathetic nature, and in this way the conclusion was drawn (BOEKE, 1909, 1911) that the cross-striated muscle-fibres (the end-organs, mentioned above, were found in the muscles of the tongue, the eye, the iris, the back, the m. pectoralis, in the intercostal muscles, and afterwards AOYAGI found the same structures in the muscle of the diaphragm) are not only innervated by the spinal nerves, but also by the sympathetic system. The function of this sympathetic inner-

<sup>1)</sup> J. BOEKE, Studien zur Nervenregeneration I and II. Verhandelingen K. A. W. Second series. Vol. 18 and 19.

vation might be of a tonic or of a trophic nature. This question however is to be answered by means of physiological experiments, and the investigation of it therefore must be left to practised physiologists, and need not to be discussed in this paper.

The sympathetic nature of these "accessory" fibres could be shown afterwards by cutting the eye-muscle-nerves (trochlearis, oculomotorius) directly after they have left the mid-brain, which caused the sensible and motor nerve-fibres to degenerate. The accessory non-medullated nerve-fibres however and their end-organs on the muscle-fibres remained unaltered (BOEKE, 1911, 1916), which could only be explained by admitting, that they are transferred to the eye-muscle nerves by way of the sympathetic branch, which reaches the orbita along the arteria ophthalmica from the plexus caroticus, so that they were not dissected when the eye-muscle nerves were cut directly behind their place of origin from the brain-stem.

Experiments, in which a series of spinal nerve-roots of the cat were cut, made in collaboration with Prof. MAGNUS, however did not give clear and unquestionable results, which perhaps may find its explanation in the fact, that the elements of the sympathetic nervous system generally take the stain far less readily than the other nervous elements. A negative result of a staining reaction is therefore in no case evincing for the non-existence of these sympathetic elements. Afterwards similar experiments have been executed with better results, and Dr. AGDUNK, who has a communication on this subject appearing in this number of the Proceedings, obtained the same definite and positive results with the muscles of the extremities as those, which we are going to describe for the intercostal musculature.

The experiment, the result of which we are going to describe here, was executed by one of us (D. DE B.) in the following manner:

In a cat were extirpated at the right side of the medulla spinalis inside the dura mater a series of 4 consecutive ganglia spinalia with simultaneous section of the corresponding posterior and anterior roots. This was done on the 15<sup>th</sup> of February. The wound healed per primam, the animal remained healthy. A month afterwards (15<sup>th</sup> of March) the animal was killed by chloroform, and the blood-vessels were cleaned thoroughly by rinsing them with RINGER'S fluid. After that the thoracic wall was rinsed with a neutralised solution of formalin (12 %), and preserved in formalin 12%, alcohol 60%. The autopsy showed that the posterior and anterior roots of thoracalis VI, VII, VIII and IX with the corresponding ganglia spinalia were cut through. The most reliable results therefore were to be expected

from the microscopical examination of the intercostal muscles of the seventh intercostal space. Pieces of these muscles were cut out, stained after the method of BIELSCHOWSKY and afterwards cut into serial sections of  $10\mu$ — $30\mu$  and studied.

The staining reaction gave excellent results, even the finest neurofibrillar threads being distinctly visible in the sections, and, from the examination of the serial sections the following conclusions may be drawn: the axis-cylinders and the myelinic sheaths of the motor and sensory nerve-fibres were entirely degenerated and had disappeared. Only the neurilemma and the nuclei of SCHWANN remained visible in the form of the curious protoplasmic bands of BÜNGNER, so characteristic for degenerated nerve-fibres; of the original motor end-plates no trace was to be found, only the thickened layers of multinucleated granular sarcoplasm (soles) were to be seen, indicating the place of the original motor end-plates, the neurofibrillar structure itself having entirely disappeared. So the motor and sensory nervous elements of the intercostal muscle-fibres of the 7<sup>th</sup> intercostal space were absolutely degenerated. Not a single medullated nerve-fibre was left intact. But then there appeared in the sections between the muscle-fibres thin bundles of fine non-medullated nerve-fibres, often composed only of two or three threads (fig. 1 and 2), and when we follow these fibres under the microscope until the point where they seem to end, they appear to be connected with the muscle-fibres by means of very small and delicate end-organs, end-rings or loops or small endnets (fig. 1, 2). Not only at the end of the nerve-fibres, but also here and there in their course, often small side-branches are given off, which come into connection with the muscular fibre across which the nerve-fibre is running, by means of the same small endrings. A look at fig. 2 gives a better idea of the structure and form of these different endrings than a long and detailed description. Fig. 1 teaches us, that besides the small endrings and endnets more complexly built structures occur also, but even these are always finer and more delicately built than are the common motor end-organs. This case besides shows us the terminal ramifications of the neurofibrillar structure lying embedded in a layer of granular sarcoplasm which contains a number of nuclei (3). This seems to indicate, that the endorgan in question has a hypolemmal position.

In fine, the form of these end-organs and their neurofibrillar structure are exactly identical with that of the terminal ramifications and end-organs of the non-medullated nerve-fibres, which remained intact in the eye-muscles after the stem of the eye-muscle nerves had been cut through (BOEKE, 1911, 1916), and we may

reckon them to belong to the same class of the so-called "accessory" innervation apparatus of the cross-striated muscle-fibres.

These nerve-fibres and their endorgans on the voluntary muscle-fibres, described above, cannot well be otherwise than of a *sympathetic nature*. Non-medullated nerve-fibres in general take a longer time to degenerate after section of the nerve than do the medullated fibres and their end-organs. Whilst as a rule 3 or 4 days after dissection of the nerves all the motor nerve-endorgans on the muscle fibres have disappeared, it is possible to find here and there in the sections seemingly intact non-medullated nerve fibres as long as 14 days after dissection of the nerves. But when we give the nerve-fibres, as was done in the experiment described above, a month to degenerate in, before the animal is killed, we are sure to find *all* the *dissected* nerve-fibres, medullated and non-medullated degenerated. So when, after the lapse of a month, we kill the animal, and when we then find in the sections intact nerve-fibres, clearly and sharply outlined, which take the neurofibrillar stain readily, and are found ending in beautifully-stained regular endrings and endnets, we are justified to draw the conclusion, that these nerve-fibres were not cut through when the nerves were dissected. It follows from the description of the experiment, that these intact nerve-fibres must be fibres which enter the nerves after the ganglion spinale has been passed, and whose trophic centre, the ganglioncell, lies outside the medulla spinalis and outside the ganglion spinale, viz. sympathetic nerve-fibres, derived from ganglion-cells lying in the ganglia of the sympathetic chain.

So our experiment has given convincing evidence for the exactness of the conclusion, drawn by one of us (BOEKE, 1911, 1916) from his former observations.

*It is proved by the results of our experiment, at least for the muscles of the trunk, not only that the accessory fibres and their end-organs belong to the sympathetic system, but also, that they are sympathetic elements with a centrifugal, efferent transmission of nerve impulses.*

In the communication by Dr. AGDUHR, appearing in this same number of the Proceedings, it will be shown, that the identical conclusion may be drawn for the muscles of the extremities.

Leiden,  
Utrecht, January 1919.

**J. BOEKE and J. G. DUSSER DE BARENNE: "The sympathetic innervation of the cross-striated muscle fibres of vertebrates".**

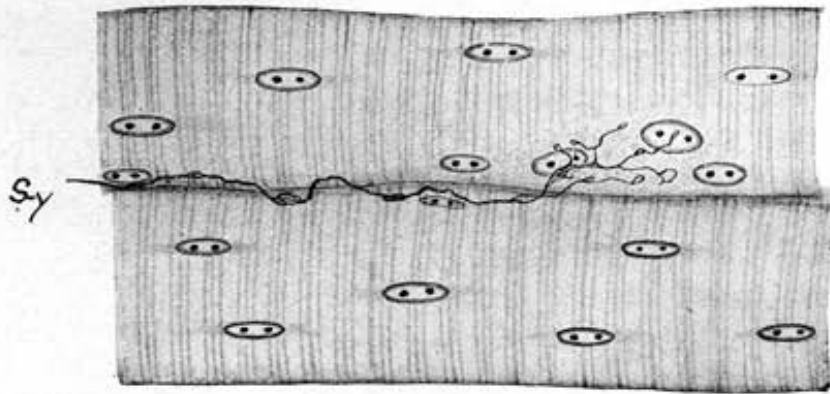


Fig. 1.

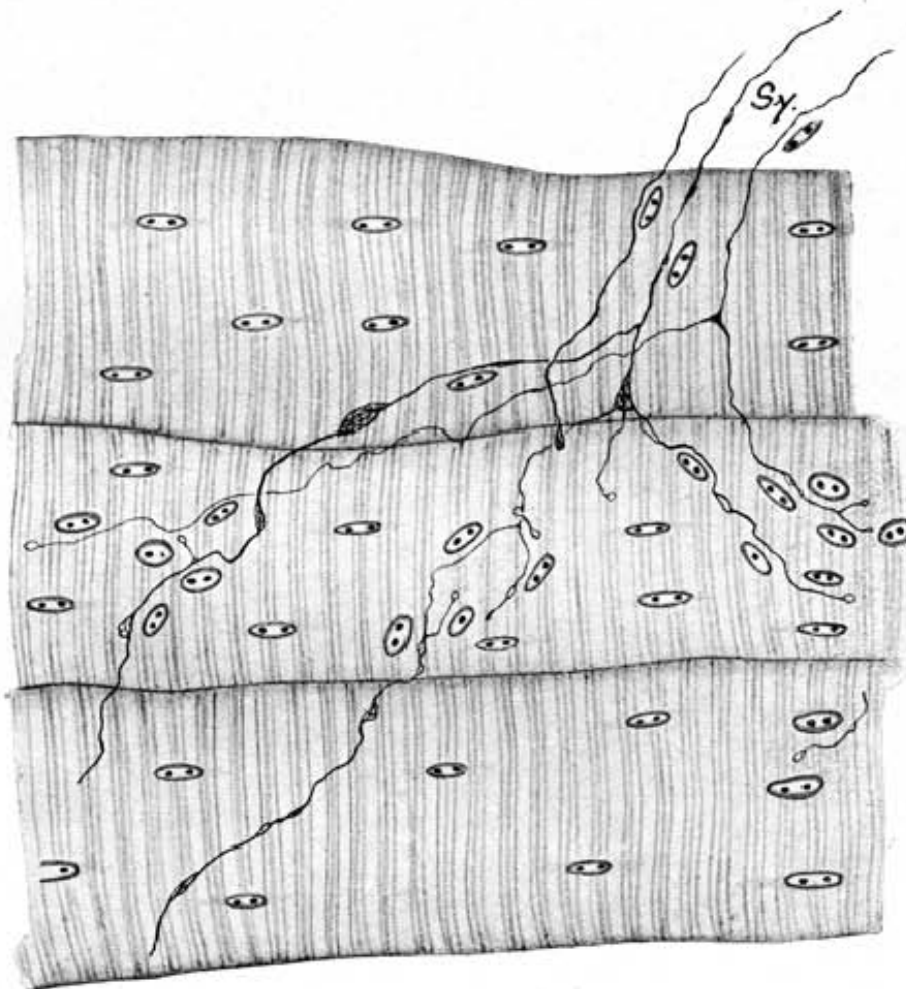


Fig. 2.

**DESCRIPTION OF FIGURES.**

Fig. 1 en 2. Muscle-fibres from the musc. intercost. of the 7<sup>th</sup> intercostal space, with non-medullated nerve-fibres and end-organs, which remained intact after the dissection of the roots and extirpation of the ganglia spinalia of the VI, VII, VIII and IX intercostal nerve in the cat. Magn. 1800 diameters. sy = sympathetic nerve-fibres.

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