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Axon Branching After Nerve Regeneration.*

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Langley and Anderson[1] proved by physiological methods that regenerating axons often branch; Kilvington[2] employed both physiological and histological methods to demonstrate the multiplication of axons in the regenerating segment of a peripheral nerve. Bender and Fulton[3] showed functional disorders after regeneration of the oculomotor nerve in the chimpanzee and attributed them to fiber splitting and aberrancy. There is complete unanimity regarding the presence of branching axons during regeneration, and in fact this response has been used as a method to make up for the deficit of axons in cases of anterior poliomyelitis (Feiss,[4] Dogliotti,[5], Aird and Naffziger,[6] and others). To our knowledge, however, there have been no experiments reported which directly record those muscular contractions which fiber branching makes possible through the axon-reflex.

After section of the peroneal and popliteal branches of the sciatic nerve at the knee in the cat and dog and regeneration has well commenced, an opportunity is afforded to show the axon-reflex contraction in both the anterior and the posterior tibial muscles. Stimulation of the posterior tibial nerve (a mixed nerve) at the heel will cause a contraction of the gastrocnemius and stimulation of the superficial peroneal nerve (sensory only) at the ankle will provoke a contraction in the tibialis anticus even after cutting the sciatic in the thigh (Fig. 1). With the use of a strong tetanizing current, the curves are similar in form to those produced by stimulating the appropriate motor branch of the sciatic nerve with a like current. Progressive downward section of the sciatic nerve to a point just above the neuroma does not affect the contraction in the least, but

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1 Langley, J. N., and Anderson, H. K., *J. Physiol.*, 1902, **29**, iii.

2 Kilvington, B., *Brit. Med. J.*, 1905, **1**, 935.

3 Bender, M. B., and Fulton, J. F., *J. Neurophysiol.*, 1938, **1**, 144.

4 Feiss, H. O., *Bost. Med. and Sci. J.*, 1911, **164**, 667.

5 Dogliotti, A. M., *J. de Chir.*, 1935, **45**, 30.

6 Aird, R., and Naffziger, H. C., *Arch. Surg.*, 1939, **38**, 906.

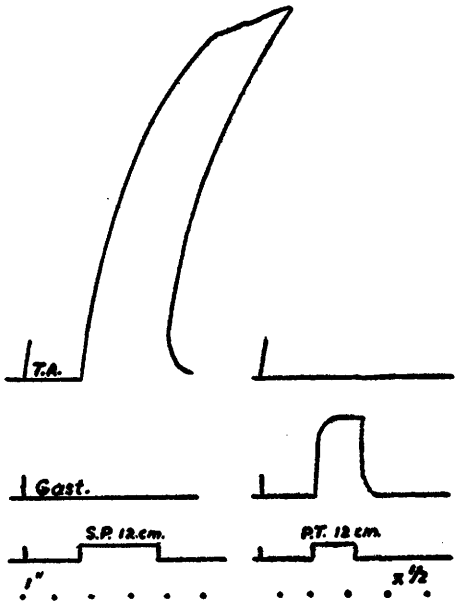

FIG. 1.
Tracing of an axon-reflex contraction of the tibialis anticus on stimulation of the superficial peroneal nerve, and of the gastrocnemius on stimulation of the posterior tibial nerve, after cutting the sciatic in the thigh.

section of the sciatic nerve just below the neuroma immediately and permanently abolishes the axon-reflex contraction. No histological counts were made, but an idea of the degree of fiber-splitting may be gained from the fact that such an axon-reflex contraction may be as much as three-fourths the height of the contraction caused by maximal motor nerve stimulation.

The fiber branching undoubtedly contributes to the incoordination which follows nerve section and nerve regeneration in the limb, as previously shown by Bender and Fulton[8] for the eye, but since the peroneal nerve innervates exclusively flexors and the popliteal nerve innervates mainly extensors, this factor is minimized. The axon-reflexes furthermore persist and are not eliminated by a process of atrophy as suggested by Langley[7] for aberrant fibers, since they are found in full force even after eighteen months.

Summary. Confirmation of axon branching as a result of nerve regeneration has been obtained by physiological methods. The axon-reflex contraction made possible through such branching possesses all the characteristics of a muscular contraction evoked by direct electrical stimulation of the motor nerves concerned.

[7] Langley, J. N., *J. Physiol.*, 1897, **22**, 215.