"Further Note on the Sensory Nerves of Muscles." By C. S. SHERRINGTON, M.A., M.D., F.R.S., Holt Professor of Physiology in University College, Liverpool. Received February 26,—Read April 8, 1897.

In a former number* of these 'Proceedings' I drew attention to the occurrence of reflex reactions evoked by mechanical and electrical excitation of individual eye-muscles and of their nerve-trunks. I was later somewhat surprised when, after the sensory nature of the structures originally termed muscle-spindles (Kühne) had been proved,† I was unable to find in the eye-muscles any examples of these structures.‡ I had expected to find in those muscles, on account of the great delicacy of their control and co-ordination, and in view of the well-known richness of their innervation, a field peculiarly favourable for the examination and study of "spindles." It appeared to me possible, however, that spindles if of a *very* simple type, *e.g.*, containing a single muscle fibre not enveloped in a distinct capsule, but with simply an unthickened perimysial sheath and without any circumfusal lymph space, in short if reduced to a far simpler type than I have ever met actually existent, might, although present, yet escape recognition. I turned, therefore, to the production of degeneration for further information.

I had noted that the intrafusal muscle-fibres, of the "red" variety as they are, undergo when the nerve-trunk of a muscle has been severed, a much slower course of alteration than do extra-fusal muscle fibres,§ *i.e.*, I found no pronounced degeneration for even two years following section. I therefore cut through *n. oculomotorius* at its origin, and examined the resultant degenerations in the eye-muscles which it innervates and in their individual nerve-trunks. The degenerative process was allowed scope for various periods. This method of test failed, however, to give me distinct results because (1) the muscle-fibres of the eye-muscles (in monkey) exhibit normally a certain variable amount of fatty granulation, simulating degenerative change; and because (2) the resultant changes in the muscle-fibres, although the fatty granulation distinctly increased, did not even after a period of sixty days show the clearly distinctive characters I had hoped.

On the other hand, in the nerve-trunks, extra-muscular and intra-

* 'Roy. Soc. Proc.,' vol. 52. April, 1893. Further note on the "Correlation of the Action of Antagonistic Muscles."

† 'Proc. Physiol. Society,' No. 3, 1894.

‡ *Ibid.*, and 'Journal of Physiology,' vol. 17, 1894. "The Constitution of the Nerves of Muscles."

§ 'Journ. of Physiology,' vol. 17, 1894, *ibid.*

muscular, the Wallerian degeneration did clearly demonstrate a result of importance. With the exception of a few minute fibres, of variable number, derived perhaps from the ciliary ganglion, *all* myelinate nerve-fibres in all these eye-muscles were degenerated. Therefore these eye-muscles derive the vast majority of their myelinate nerve-fibres from *n. oculomotorius*. The sensory innervation of these muscles does not therefore seem derivable from the Vth cranial pair. In accord with this I found (α) that severance of both trigemini caused no obvious impairment of the movement of the eye-balls, (β) that the combined severance of both *nn. trigemini*, and of both optic nerves even after section of the encephalic bulb did not severely depress the tonus of the eye-muscles. Now we know that section of the sensory spinal roots belonging to muscles does very severely depress the tonus of them.

At the same time I was struck with the long distance to which many of the nerve-fibres in these muscles travel forward toward the ocular tendons of the muscles. I was the more impressed with this fact because direct examination proved that the region of the distribution of motor end-plates in these muscles is almost confined to the middle portion of the fleshy mass of the muscle. Further investigation of the course and destination of the nerve-fibres at the tendon end of the muscle revealed them (both in cat and monkey) undergoing terminal subdivision, and in very numerous instances passing beyond into the bundles of the tendon itself. The terminations of many of these nerve-fibres lie within the tendons; many recurve again toward the muscular fibres, and end just at junction of muscle-fibre with tendon bundle. The nerve-fibres in so terminating frequently become thick—as I have described in the case of muscle-spindles—with shortened internodes.

The terminal arborisation which the nerve-fibres finally make is as a rule small as compared with the end-arborisation of ordinary Kühne-Ruffini "spindles" or the Golgi "tendon-organs," but closely resembles in numerous instances the form of arborisation of the latter.

In my former communication I wrote*—"The question therefore arises whether the above cranial nerves (IIIrd and IVth) are not in reality sensori-motor." In view of the additional observations now recorded I think it must be conceded that *nervus oculomotorius* is perhaps not a merely motor nerve, but although purely "muscular" may be sensori-motor.

My observations have included also the IVth cranial pair, and with like result. Investigation of the VIth cranial pair is also in progress.

It also appears clear from the above that the absence of the dis-

* 'Proc. Physiol. Society,' No. 3, 1894.

tinct Kühne-Ruffini "spindles" from a muscle does not exclude the possession by it of sensorial end-organs, and of afferent nerve-fibres. This point is not without importance, because examination of various muscles has led me to the conclusion that the "spindle-organs" are absent from the following muscles:—From all the orbital eye-muscles, from the intrinsic muscles of the larynx (though Pacinian corpuscles occur in these as in various other muscles), from the intrinsic muscles of the tongue, and from the diaphragm. It is notable that all these muscles belong to that set which are innervated by nerve-fibres of rather smaller calibre (Gaskell) than those supplying the skeletal muscles generally, that is to say, are innervated by the non-ganglionated splanchnic efferent nerves of Gaskell.

"On the Breaking-up of Fat in the Alimentary Canal under Normal Circumstances and in the Absence of the Pancreas." By VAUGHAN HARLEY, M.D., M.R.C.P., Professor of Pathological Chemistry, University College, London. Communicated by Professor HORSLEY, F.R.S. Received March 18,—Read April 8, 1897.

(From the Department of Pathological Chemistry, University College, London.)

In a previous paper* I discussed the simple absorption of milk fat from the alimentary canal of dogs, and compared the results with a series of dogs in which the pancreas had been previously removed. Fasting dogs fed on milk absorbed no less than 21 to 46 per cent. of the total fat given in seven hours, while in those where the pancreas had been entirely removed some two days previously, there was, during that space of time, no evidence of any absorption whatever from the alimentary canal.

The fact that no marked absorption of fat occurred in dogs after the extirpation of the pancreas seems to confirm the old view that the pancreatic secretion was necessary for absorption.

This alleged action of pancreatic juice in preparing fat for its absorption from the alimentary canal, is usually supposed to be due to the secretion containing, firstly, a fat-splitting ferment, which, by breaking up part of the neutral fat into free fat acids and glycerine, leads to the first stage of emulsification; and, secondly, alkaline sodium carbonate, which combines with some of the freed fat acids to form a soap, thus rendering the emulsification of the fat a simple matter—as can easily be demonstrated in a test-tube—and at once facilitates its absorption through the intestinal walls.

* 'Journal of Physiology,' 1895, vol. 18, p. 1.