

Innervation of the Intrinsic Muscles of the Eye: An Experimental Study.

W. A. STOTLER. (Introduced by Albert Kuntz.)

From the Department of Microanatomy, St. Louis University School of Medicine.

The innervation of the iris and the ciliary body of mammals has been well worked out physiologically, but the recent interest in the nerve fiber terminations in smooth muscle affords ample justification for further investigation of the nerves to the intrinsic muscles of the eye.

In an investigation of the endings on the smooth muscle of the gut, Stöhr¹ described the terminal structure as a reticulum or syncytium. Boeke² has described a rich supply to the ciliary muscle which resembles that described in smooth muscle by Stöhr. Using the Bielschowsky technic, Lawrentjew³ has described degenerating fibers in the nictitating membrane after extirpation of the superior cervical sympathetic ganglion.

Our experiments have been carried out on cats. The Bielschowsky block technic and the protargol section technic have been used. The superior cervical and the ciliary ganglion were removed on the left side, both together in some cases and one or the other alone in others. The time allowed for degeneration varied from 2 to 52 days. The eye of the contralateral side was stained as a control.

In a series of cats sacrificed after degeneration periods of 7 and 14 days respectively in which both the superior cervical and the ciliary ganglion had been removed, no intact fibers could be found in the iris or ciliary body on the operated side. The contralateral side showed the normal picture.

In a group in which the ciliary ganglion alone was removed and the cats allowed to survive for 6 days, degenerating fibers could be demonstrated in the sphincter and ciliary muscles by the Bielschowsky method, but no intact fibers were observed.

The superior cervical ganglion of the left side was removed in another group and degeneration periods ranging from 7 to 52 days allowed. In none of these were any of the fibers of the fine plexus in the dilator pupillae muscle intact when stained by the protargol method. A few fibers could be seen running to the iris border where

¹ Stöhr, P., Jr., *Z. Zellforsch.*, 1932, **16**, 121; 1934, **21**, 243.

² Boeke, J., *Z. mikrosk.-anat. Forsch.*, 1933, **33**, 275; 1936, **39**, 477.

³ Lawrentjew, B. I., *Z. Zellforsch.*, 1936, **23**, 560.

the dilator muscle is located, but none could be seen entering the muscle. The innervation of the ciliary muscle and of the sphincter appeared entirely normal.

In 4 cats, the ciliary ganglia were removed on the left side and the animals sacrificed at the end of 21, 16, 7, and 2-day periods. Stained by the protargol method, no trace of nerve fibers could be found in the ciliary body and sphincter of the iris on the operated side in animals which survived for 21- and 16-day periods. In the animal sacrificed on the seventh day, the sphincter and ciliary muscle contained but a few degenerated nerve fibers which were greatly swollen and varicose. In the eye for which the degeneration period was only 2 days, the finer fibers of the terminal plexus were present in part, but presented a granular and extremely varicose appearance. In all these cases the fine plexus in the dilator muscle remained intact.

My preparations of normal eyes stained with protargol agree in the main with those described by Boeke. The plexus is in much closer contact with the nerve fibers than is indicated in the illustrations of Stöhr. The fibers supplying the sphincter and ciliary muscles are of large calibre and a large percentage are myelinated. The fibers to the radial muscle are extremely fine. The axons leaving the more superficial plexus above the muscle ramify among the muscle fibers and give off many branches, usually at right angles, which run among the muscle fibers and show varicosities at various levels. In no case did the finer ramifications of the "terminal net" anastomose.

In sections cut transversely through the ciliary muscle at 4 and 6 microns, the nerve fibers can be seen to course in great numbers in close proximity to the muscle cells. They appear to become intraprotoplasmic in the more distal part of their course and show structures which appear as knoblike terminations near the nucleus. No ganglion cells were seen in either the chorioid, sclera, or uvea. No sensory endings were found in the smooth muscle and none were recognized in the stroma cells.

Summary. All nerve fibers in the ciliary and sphincter muscles degenerate following extirpation of the ciliary ganglion. All nerve fibers to the dilator pupillae degenerate after extirpation of the superior cervical ganglion. The terminal nervous structure in these muscles is not independent of the axons but undergoes degeneration with the latter following extirpation of their cells of origin. Terminal branches of the axons seem to enter the cytoplasm of the muscle cells.