## Adrenergic Nerve Endings in the Peripheral Autonomic Ganglion

Recently, the fluorescence histochemical technique has revealed the existence of numerous adrenergic nerve endings within the sympathetic ganglia in several mammalian species[1-3]. For example, adrenergic endings are abundant in the stellate, celiac, and superior cervical ganglion of the rabbit and the rat[4,5]. These findings suggest the important role of adrenergic endings in impulse transmission in the autonomic ganglia[6]. ECCLES[7] and BECK[8] postulated that noradrenaline acts as an inhibitory modulator of intraganglionic transmission.

There is, however, little information concerning the subcellular localization and the ultrastructure of the adrenergic endings within the autonomic ganglia. The present paper deals with the electron microscopic observation of nerve endings in the hypogastric ganglion of male adult guinea-pigs. It has been known that sympathetic fibers to the pelvic viscera relay partially in this ganglion.

After stunning the animals, the hypogastric ganglia were isolated and immersed into fixatives. The fixation was carried out for 1.5 h at room temperature in 2% glutaraldehyde solution and then for 2 h in 1% ice-cold osmium tetroxide. These fixatives were adjusted at pH 7.4 with Millonig's phosphate buffer. After the fixation, the ganglia were embedded in Epon 812.

The nerve endings found within the hypogastric ganglion were classified into at least 3 structurally distinct types. The first type contains numerous small non-cored vesicles, about 500 Å in diameter, together with occasional large vesicles measuring roughly 1000 Å in diameter which possess an internal core or granule of moderate density (Figure 1). The second type has many small vesicles measuring about 500 Å in diameter which are either empty or contain a dense core (Figure 2). The dense cores are somewhat irregular in shape and often eccentrically placed in the vesicles. A few large cored vesicles, about 1000 Å in diameter, are also seen in the second type. In addition, mitochondria and scattered glycogen granules are contained in the endings of both types.

The first type endings are regarded as cholinergic in the light of recent electron microscopic studies[9]. They are much more abundant than the second type and form the typical axo-somatic and axo-dendritic synapses with the ganglion cells.

The second type endings show the characteristic structures of the adrenergic endings[10]. It has been verified that the dense cores of the small vesicles represent noradrenaline. The empty and the dense cored vesicles of small size are said to be a homogeneous population differing in the degree of amine filling only[10]. These

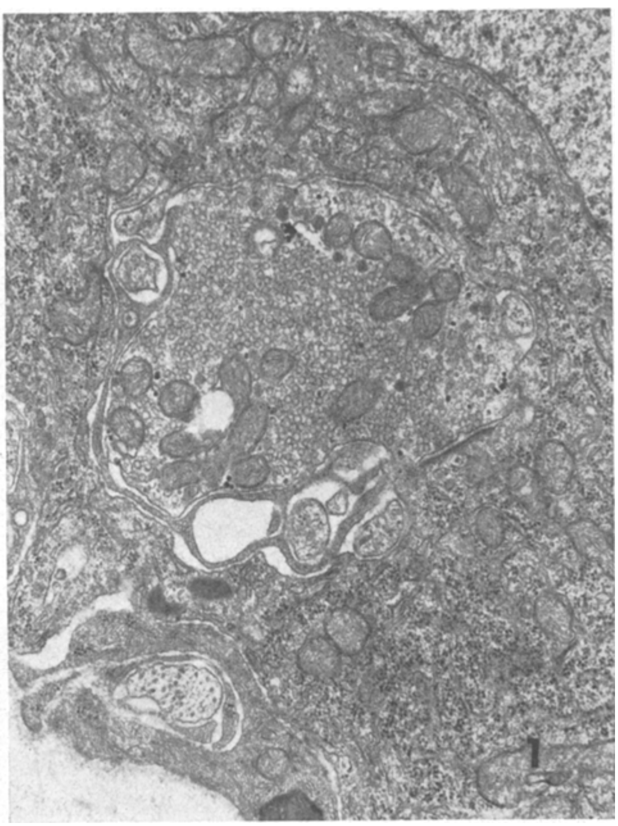

Fig. 1. The cholinergic nerve ending forms the axo-somatic synapse with the ganglion cell. The ending contains numerous small non-cored vesicles, about 500 Å in diameter, together with large cored vesicles measuring about 1000 Å in diameter. × 20,000.


[1] B. FALCK, CH. OWMAN and N. O. SJÖSTRAND, Experientia *21*, 98 (1965).
[2] CH. OWMAN and N. O. SJÖSTRAND, Z. Zellforsch. mikrosk. Anat. *66*, 300 (1965).
[3] A. E. BADAWI and E. A. SCHENK, Z. Zellforsch. mikrosk. Anat. *87*, 218 (1968).
[4] B. HAMBERGER and K.-A. NORBERG, Acta physiol. scand. *65*, 235 (1965).
[5] K.-A. NORBERG and F. SJÖQUIST, Pharmac. Rev. *18*, 743 (1966).
[6] E. COSTA and A. M. REVZIN, Science *133*, 1822 (1961).
[7] R. M. ECCLES and B. LIBET, J. Physiol. Lond. *157*, 484 (1961).
[8] L. BECK, Tex. Rep. Biol. Med. *22*, 375 (1964).
[9] K. C. RICHARDSON, Am. J. Anat. *114*, 173 (1964).
[10] J. P. TRANZER and H. THOENEN, Experientia *23*, 123 (1967).


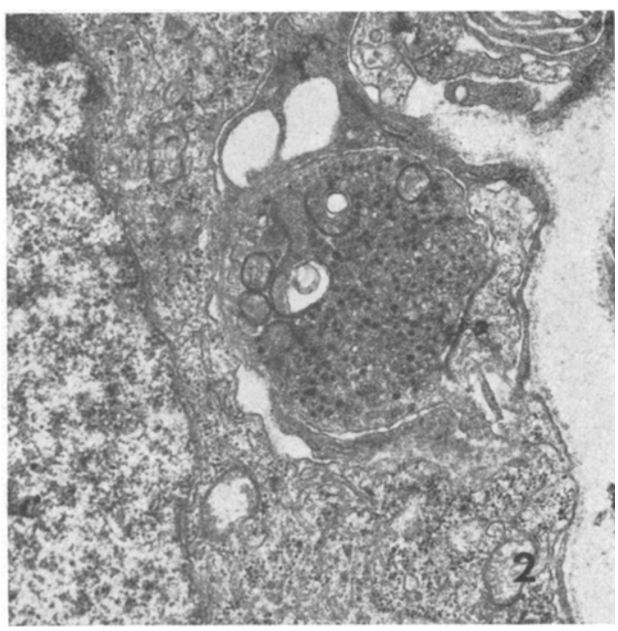

Fig. 2. The adrenergic nerve ending contains numerous small cored vesicles and a few non-cored vesicles. The ending forms the synapse with the small protrusion of the ganglion cell. × 20,000.

endings are partially enclosed with the Schwann cell cytoplasm. The remaining axonal surfaces are separated from the surrounding connective tissue by only an external lamina, which passes from the Schwann cell cytoplasm on to the axon. In most cases, the endings lie more than 500 nm apart from the surface of the ganglion cells, but may approach more closely to the dendritic protrusions of the cells. This study, however, has failed to reveal the formation of typical synapses with the synaptic cleft approximately 200 Å in width and the density increases of synaptic membranes between the second type endings and the ganglion cells.

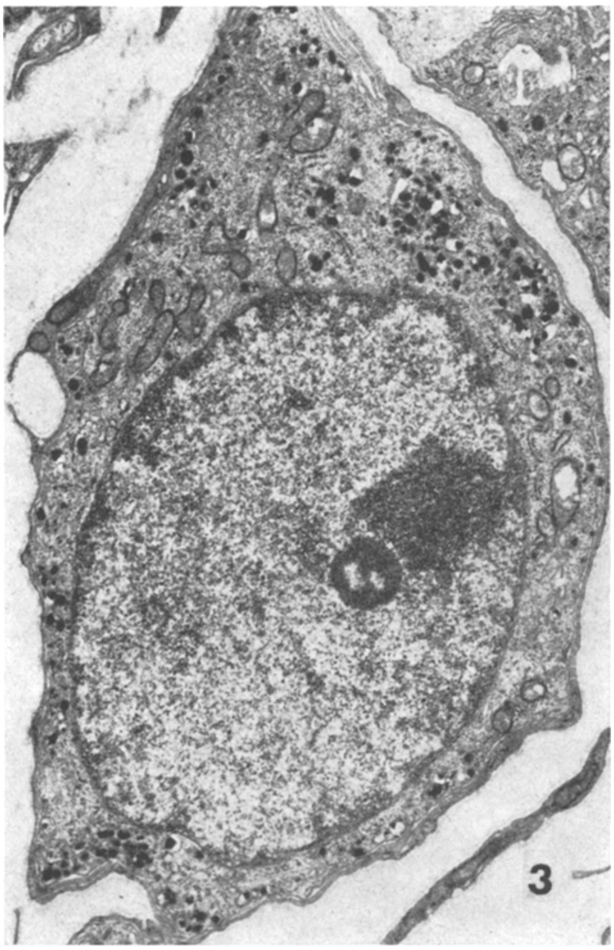

Fig. 3. Electron micrograph showing a cell containing large granular vesicles. The cell is surrounded by a sheath of satellite cells. × 6000.

Small nerve cells which contain large granular vesicles measuring about 1250–2500 Å in diameter were found in the present study (Figure 3). The large granular vesicles show a similar appearance to the noradrenaline containing granules in the adrenal medulla. Recently, similar ganglion cells containing large granular vesicles were described in the sympathetic ganglion by some authors[12,15].

These small nerve cells may correspond to so-called chromaffin cells[13,14] or small, intensely green-yellow fluorescent cells[1,2] described by some authors. The somas are covered by the satellite cells. No axo-somatic synapses have been found around them. The nerve cells have a few processes which contain many large granular vesicles. Their distal ends denuded of the Schwann sheath often lie about 500 nm away from either the surface of ganglion cells or the capillary wall. These third type endings with the large granular vesicles are apparently different in structure and origin from the second type endings described before.

The observations reported above have furnished an adequate ultrastructural basis for the presence of adrenergic endings within the hypogastric ganglion. NORBERG et al.[5] and KÀLMÀN et al.[11] suggested that the fluorescent endings are of an intraganglionic origin, and that they are formed by either interneurons or collaterals from the postganglionic adrenergic neurons. At least some of these fluorescent endings may be on the third type of this paper.

*Zusammenfassung.* Mittels elektronenmikroskopischer Untersuchungen wird die Anwesenheit adrenergischer Nervenendigungen im Ganglion hypogastricum des Meerschweinchens bewiesen.

H. WATANABE

*Department of Chemical Pharmacology and Department of Anatomy, Tohoku University School of Medicine, Sendai (Japan), 28 July 1969.*

[11] B. CSILLIK, G. KÀLMÀN and E. KNYIHÀR, Experientia *23*, 477 (1967).
[12] G. SIEGRIST, M. DOLIBO, Y. DUNANT, C. FOROGLOU-KERAMEUS, FR. DE RIBAUPIERRE and CH. ROVILLER, J. Ultrastruct. Res. *25*, 381 (1968).
[13] CH. OWMAN and N. O. SJÖSTRAND, Experientia *22*, 759 (1966).
[14] CH. OWMAN and N. O. SJÖBERG, Z. Zellforsch. mikrosk. Anat. *74*, 182 (1966).
[15] L.-G. ELFVIN, J. Ultrastruct. Res. *22*, 37 (1968).

## The Larval Ring Gland of *Drosophila melanogaster*: A Comparison of Ebony and Oregon Strains by Use of a Qualitative Protein Stain

In *Drosophila melanogaster*, molting and metamorphosis are controlled by hormones from 3 endocrine structures: neurohormones produced by neurosecretory cells in the brain, ecdyson secreted by the prothoracic gland, and juvenile hormone from the corpus allatum[1]. If juvenile hormone is present in abundance, the molt will be a larval molt; if it is present in small amounts or absent, the result will be a pupal or imaginal molt[2]. Previous evidence[3] suggests an increase in the activity of the prothoracic gland at metamorphosis, but it must be pointed out here that this apparent increase in activity may merely be compensating for the increased volume of the final instar larva[4].

To study the protein content and, therefore, the activity of the ring gland we used the procedure of MAZIA, BREWER and ALFERT[5]. The larval molts of the Ebony