THE FINE STRUCTURE OF MEISSNER'S TOUCH CORPUSCLES OF HUMAN FINGERS

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ABSTRACT

Thin slices of the finger pads of six individuals were fixed in buffered 1 per cent osmic acid, embedded in deaerated, nitrogenated methacrylate, and cut into thin sections for electron microscopic study. Before embedding, the slices were trimmed so as to include several digital tactile corpuscles. Some thin sections were stained in 10 per cent aqueous phosphotungstic acid solution. The principal part of Meissner's corpuscle is made up of flattened laminar cells stretching across the corpuscle in irregular layers. The perinuclear cytoplasm of these cells contains numerous small mitochondria, a sparse granular endoplasmic reticulum, and a large number of small vesicles. Nerve fibers enter the side or base of the corpuscle, lose their myelin sheaths, and follow a meandering course between the laminar cell plates. The nerve endings enter into a close appositional relationship with the flattened portions of the laminar cells. In some areas the apposed axolemma and cell membranes are slightly thickened with small vesicles located along the cell membrane or on both surfaces. These regions are interpreted as synapses. The most prominent feature of the nerve endings is an extraordinary accumulation of small mitochondria which vary in size and internal density. The nerve endings also contain vacuoles, groups of dense concentric membranes, and small dense vesicles of irregular distribution. The laminar cells are separated from one another by a dense intercellular substance of uniform thickness which also envelops the entire corpuscle. This material contains randomly oriented collagen fibers and fine fibrils bound together by a dense material at nodal points recurring at regular intervals of approximately 120 mμ. These findings are discussed in relation to the problems of the function of Meissner's corpuscle, neural material loss and replacement, and the presence of synapses.

INTRODUCTION

The structure and innervation of Meissner's tactile corpuscle has been reinvestigated in recent years by one of the authors (N. C.) using neurohistological and cytological methods (1–5). It was demonstrated that the corpuscle is made up of a cylindrical column of flattened laminar cells interleaved with terminal nerve fibers and surrounded by an adventitial capsule that consists of fibrocytes and fine elastic and collagenous fibers. From two to nine myelinated nerve fibers enter the base and sides of the corpuscle from the underlying corial plexus, lose their myelin sheaths, and branch repeatedly within the corpuscle without forming intercommunications. They run a meandering

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course and, in young individuals, terminate in expansions between the cells in close contact with the cell membranes. The form of the nerve endings undergoes characteristic changes with advancing age, particularly in individuals engaged in manual labor (3–5).

The present electron microscopic study was undertaken to extend these earlier light microscopic observations. A recent publication from another laboratory (26) describes the fine structure of Meissner's corpuscle in the Rhesus monkey but the accompanying micrographs illustrate structures lacking the laminar organization which is the most characteristic feature of the receptor. The observations recorded here therefore appear to be the first detailed description of the fine structure of Meissner's corpuscles in man. These observations provide new information on the relation of the neural and cellular elements of the corpuscle and on the nature of the axoplasmic organelles in the nerve endings. An intercellular fibrous component is described which has not hitherto been found in any other sensory receptor.

MATERIAL AND METHODS

The material studied was obtained from the palmar aspect of the finger-tips of four women 20 to 25 years of age and of two men 19 and 44 years of age. The biopsies were taken without anaesthesia. Using a razor blade, the superficial layer of the epidermis was first sliced off exposing the tips of the dermal papillae in an area approximately 3 mm. in diameter. A second cut was then made 0.3 to 0.5 mm. deeper, removing a thin slice including the papillary layer of the corium in the center surrounded by a rim of epidermis. The slices removed in this manner were immediately immersed in the fixative which consisted of 1 per cent osmium tetroxide adjusted to pH 7.5 to 7.8 with veronal acetate buffer (19). After 30 minutes to 2½ hours fixation at 1°C. the tissue was rinsed briefly in saline, dehydrated in a graded series of alcohols, and infiltrated for 3 hours in three changes of a mixture of *n*-butyl and methyl methacrylate (8:1). The methacrylate mixture used for embedding contained 2 per cent luperco CDB as a catalyst and was degassed by evacuating with a pump and kept under nitrogen for 2 hours prior to use. This is a modification of a technique originally proposed by Moore and Grimley (18). Polymerization was allowed to proceed in an oven at 60°C.

While in 70 per cent alcohol the tissue slices were cut under direct vision with a dissecting microscope into smaller blocks each including one or more Meissner's corpuscles. Most of the blocks were trimmed so as to favor the cutting of cross-sections of the corpuscles but a few were cut longitudinally or obliquely. Sectioning was done with a Porter-Blum microtome

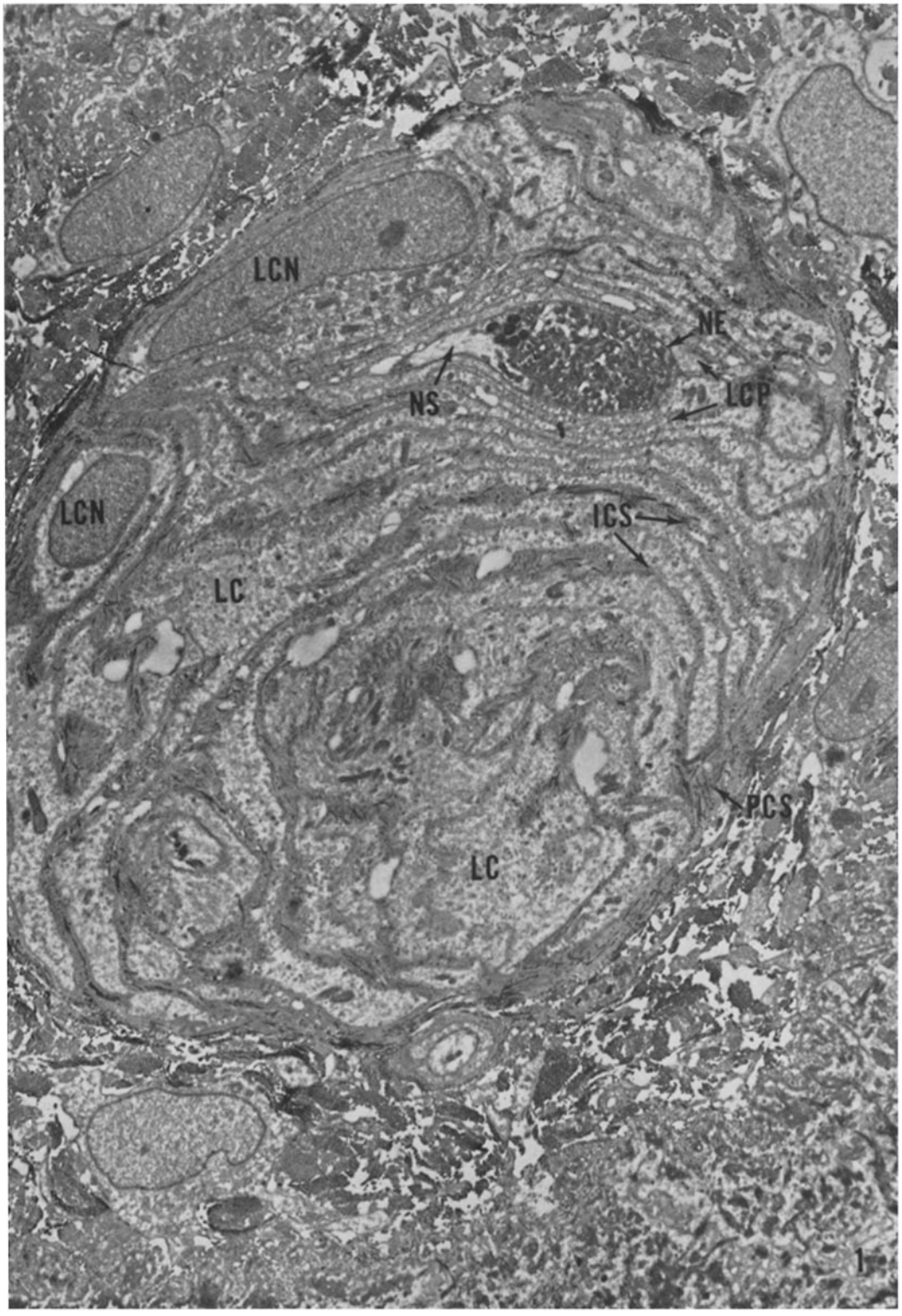
Explanation of Figures

ABBREVIATIONS USED IN FIGURES

C	collagen fiber	*M*	mitochondrion
DM	dense mitochondria	*MF*	myelin figure
EP	epidermis	*NE*	nerve enlargement
ER	endoplasmic reticulum	*NS*	narrow segment of beaded nerve ending
F	fibrocyte	*PCS*	pericellular substance
G	ribonucleoprotein granule	*SC*	Schwann cell
GC	Golgi complex	*V*	vesicles
ICS	intercellular substance	*Va*	vacuole
LC	laminar cell	*NF*	neurofilament
LCN	laminar cell nucleus		
LCP	laminar cell process		

FIGURE 1

A transverse section through the apical portion of Meissner's corpuscle showing laminar cells (lighter zones) and intercellular substance (darker bands). The intercellular substance (*ICS*) extends around the surface of the corpuscle as pericorpuscular substance (*PCS*). The corpuscle is surrounded by an adventitial capsule of connective tissue cells and collagen fibers. Nuclei of the laminar cells (*LCN*) are located at the periphery of the cell body. Darkly stained collagen fibers, singly or in groups are scattered in the dense intercellular substance. A nerve enlargement (*NE*) and a narrow segment (*NS*) of a beaded nerve ending are surrounded by cytoplasmic processes of the laminar cells (*LCP*). Female, 21 years. PTA stain. × 5400.


LCN
NE
NS
LCP
LCN
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PCS
LC
1

(28) using either glass or diamond (16) knives. The micrographs were made on an RCA electron microscope, model EMU-3D, at magnifications of 2000 to 10,000. Greater magnifications were obtained by photographic enlargement.

To increase the contrast of the electron microscopic image some sections mounted on grids were stained in a 10 per cent aqueous phosphotungstic acid solution according to the method of Watson (34).

OBSERVATIONS

Laminar Cells: The cells of the principal part of Meissner's corpuscle appear as thin cytoplasmic laminae stretching across the corpuscle in irregular layers (Figs. 1, 2, 4). Their flattened nuclei are usually found at the periphery of the cell body, which, at that point, reaches 4 to 6 μ in thickness. Away from the nucleus, the cell becomes flattened into broad thin (300 mμ or less) extensions of irregular outline. In the apical portion of the corpuscle (Figs. 1, 4), the laminar cells have a rather regular distribution. In the deeper portions, they become thinner and increasingly irregular (Fig. 2). In the vicinity of a nerve ending, the laminar cells modify their prevailing transverse orientation and extend along the nerve, forming concentric layers around it (Figs. 1 to 3).

The laminar cell nucleus is generally flattened, finely granular, and contains one or more nucleoli (Figs. 1, 2, 4). In the perinuclear cytoplasm are numerous small (100 to 200 mμ) mitochondria with a dense matrix and sparse, randomly oriented cristae (Figs. 1, 3, 12). In the cytoplasmic extensions the mitochondria become less numerous and are rarely observed in those parts of the laminar cells which surround the nerve endings (Figs. 8 to 10).

The perinuclear cytoplasm also contains a sparse endoplasmic reticulum in the form of widely scattered cisternae. Associated with the membranes are small (10 to 20 mμ) dense granules identical in appearance to those described as ribonucleoprotein in other cell types (20–22, 25). Small groups of these granules not associated with membranes are found scattered in the perinuclear cytoplasm.

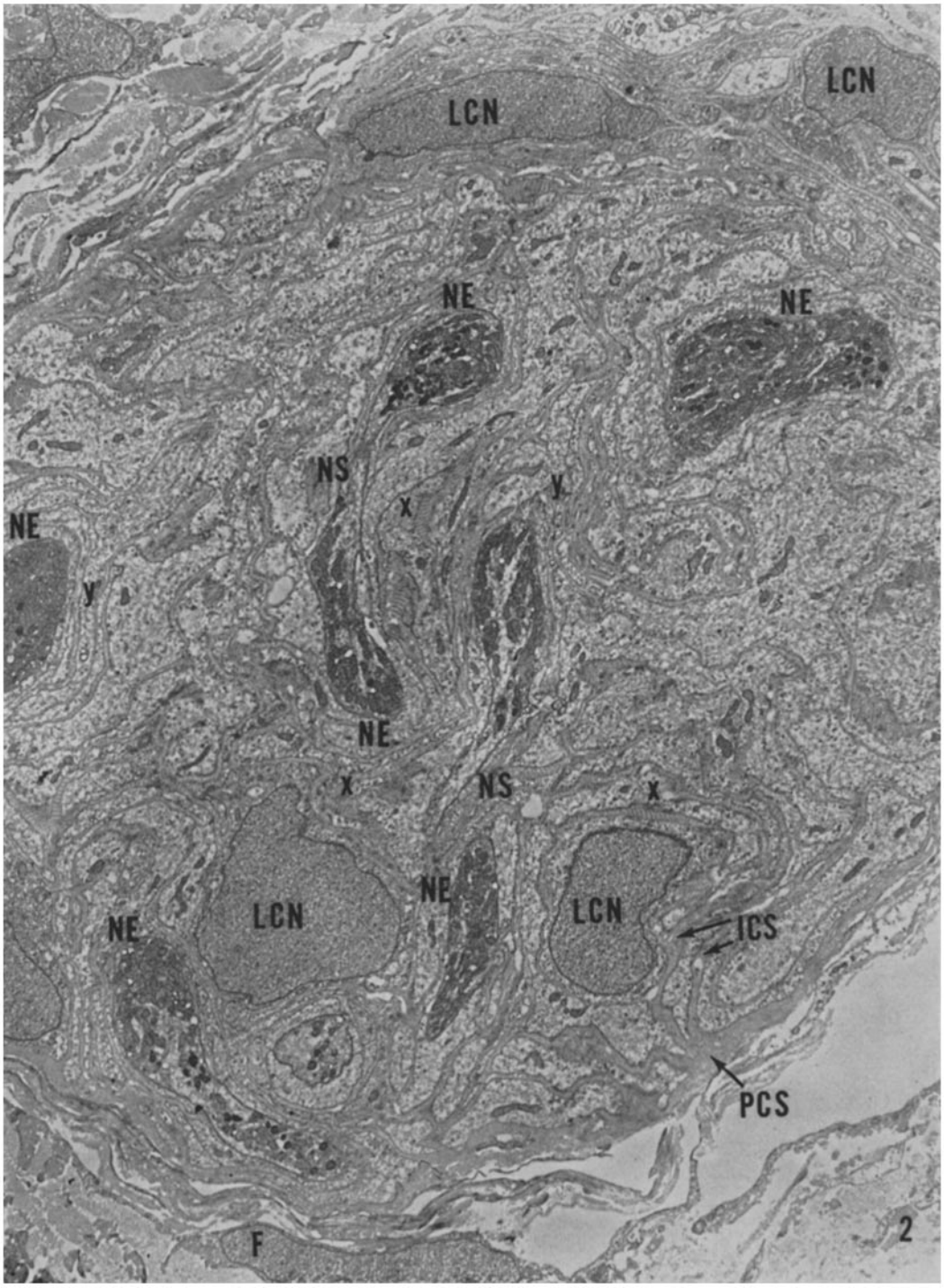
Another characteristic feature of the laminar cell is the presence of numerous small (40 to 50 mμ) vesicles which are found in all regions of its cytoplasm (Figs. 6, 7, 12). These vesicles are membrane-limited structures whose contents have a density greater than that of the surrounding cytoplasmic matrix. In that part of the cell which immediately surrounds a nerve ending the vesicles are lined up along that portion of the cell membrane adjacent to the axolemma (Figs. 7, 9). In other areas, some of the vesicles appear to be confluent with the plasma membrane (Fig. 12).

Nerve Endings: Nerve fibers derived from the myelinated axons of the deep corial plexus enter the sides of the corpuscle or through its stalk from beneath. Non-myelinated fibers were not observed entering the corpuscle nor ending as a pericorpuscular network in its capsule.

Nerve fibers entering the stalk of the corpuscle may retain their myelin sheaths for a short distance. When the myelin sheath is lost the Schwann sheath becomes irregular and terminates as the stalk gradually blends with the principal part of the receptor. Nerve fibers which enter the side of Meissner's corpuscle usually lose their myelin sheaths penetrating the capsule and are surrounded only by a thin sleeve of Schwann cell cytoplasm. Once inside the receptor, the neurilemmal sheath terminates and is replaced by a covering of laminar cells. In those instances

FIGURE 2

A transverse section through the middle portion of a Meissner's corpuscle. It is surrounded by a dense pericorpuscular substance (*PCS*) which is continuous with the intercellular substance (*ICS*) inside the corpuscle. In certain areas the intercellular substance reveals periodic banding (indicated by *x*). A flattened fibrocyte (*F*) lies inside the adventitial capsule. The laminar cell nuclei (*LCN*) are disposed around the perimeter of the corpuscle and the flattened cytoplasmic processes (here cut horizontally) extend across the corpuscle and surround the nerve endings (indicated by *y*). The nerve endings show mitochondria-filled enlargements (*NE*) and narrow segments (*NS*). Female, 21 years. × 4600.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PCS
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2

when a nerve fiber enters the side of the corpuscle and retains its myelin and Schwann cell sheaths, the myelin sheath is lost by a sequential peeling-off of the myelin lamellae from around the axon (Fig. 5). As this happens, the Schwann cell sheath becomes reduced and, when the last layer of myelin is lost, the neurilemmal sheath terminated and the investment of the ending is assumed by the laminar cells.

The nerve endings remain extracellular throughout their course, but the axolemma is always very closely apposed to the plasma membrane of the immediately surrounding laminar cell, being separated from it by an intercellular space of about 90 A. In some areas, the two apposing membranes appear slightly thickened (Fig. 9). Nerve fibers are not observed in direct relation to the perinuclear portion of laminar cells, nor in relation to the adjacent surfaces of two cellular laminae.

Nerve fibers approaching Meissner's corpuscle do not differ in structure from those found elsewhere in the corium. The axoplasm contains neurofilaments, small (40 to 50 mμ) vesicles, and scattered mitochondria. On entering the corpuscle, either proximal or distal to the termination of the myelin sheath, certain structural alterations can be seen in the axoplasm (Figs. 5, 11). The most prominent of these is an accumulation of small (100 to 300 mμ) mitochondria which becomes so numerous and closely packed that they often crowd out and obscure the other axoplasmic constituents. It can be seen, however, that the axoplasm is denser and more granular than in more proximal regions of nerve fibers and it contains clumps of small vesicles (Fig. 11).

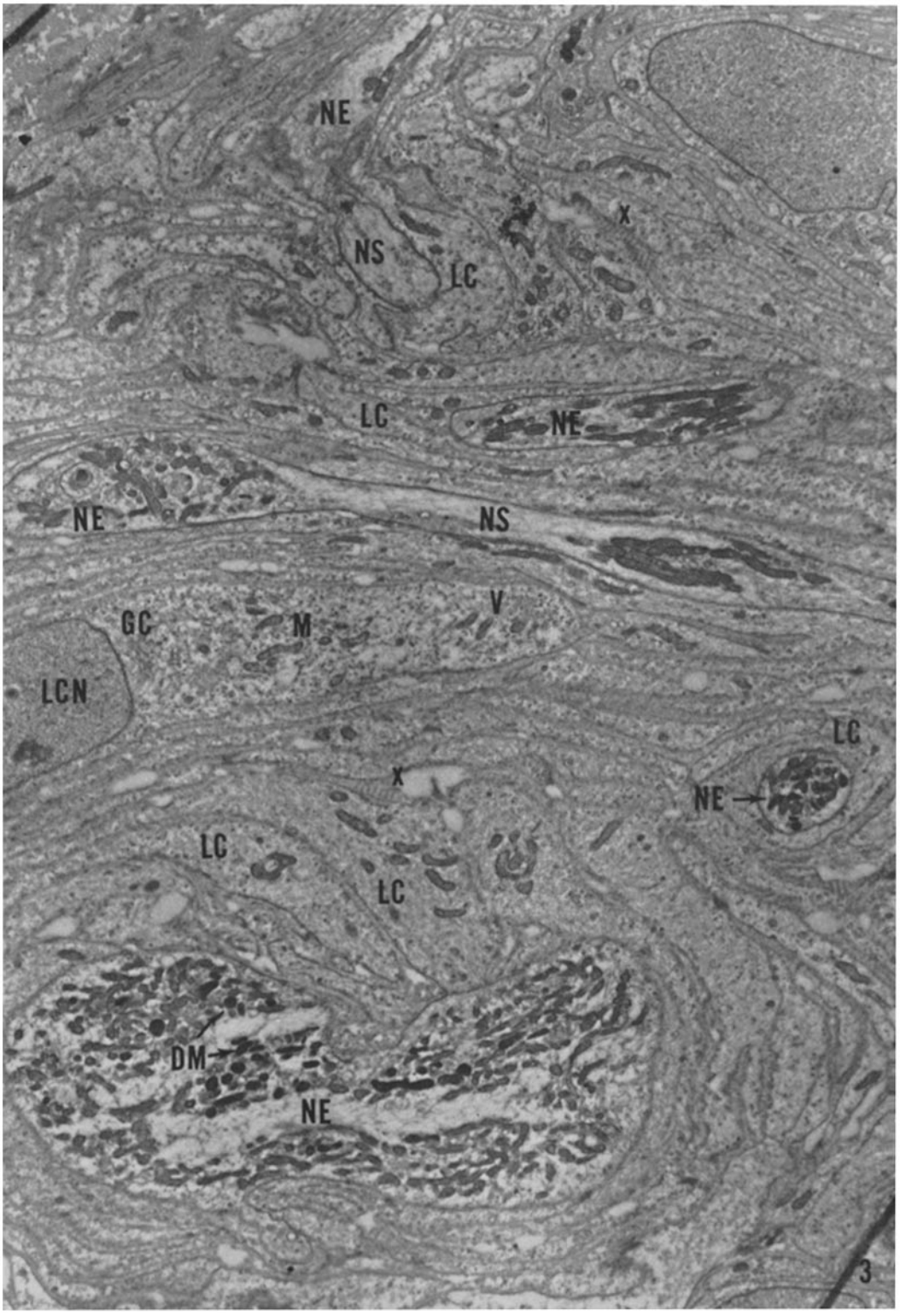
It has been shown in earlier histological studies (3) that two distinct types of nerve endings can be distinguished on the basis of their intracorpuscular course. The first type occurs in corpuscles of adult males and in females engaged in heavy manual work. These "male" endings seldom ramify, but follow a simple meandering course and end gradually. The second, "female" type endings, divide repeatedly and end in large flattened expansions or, less frequently, in a succession of varicosities (3, 5). In the present electron microscopic study, what appear to be male type endings are packed with small dense mitochondria whose cristal structure is obscured by their internal density (Fig. 9). Some segments of these endings, probably near their termination, show a reduction in the number and the size of mitochondria (Fig. 10). Mitochondria found in these regions often appear smaller or vacuolated. In addition, the axoplasm in these regions contains a dense granular substance of irregular distribution.

Of the four females included in this study, three of them possessed corpuscles with large expansive terminals (Fig. 1), while one had the rare case of beaded endings in which the nerve fibers undergo successive expansions and reductions in diameter before their terminations (Figs. 2, 3). In the narrower segments the axoplasm is characterized by a network of tubules about 10 mμ in diameter representing the endoplasmic reticulum, scattered neurofilaments less than 5 mμ in diameter, small (40 to 50 mμ) vesicles, and large (100 to 200 mμ) clear vacuoles (Figs. 3, 6). The mitochondria in these constricted segments are generally long (up to 1 μ) and slender (75 to 150 mμ). Most of them exhibit randomly oriented cristae in a fairly dense matrix, but some contain numerous concentric membranes.

Both the enlargements of the beaded endings and large expanded terminals of the other female corpuscles show a great similarity of structure. The expansions are almost completely filled with small mitochondria, most of which are long and slender with few, randomly oriented cristae (Figs. 2, 3, 7). Scattered among these long forms are small spherical mitochondria containing dense closely spaced concentric membranes. Examples

FIGURE 3

A field from a transverse section of Meissner's corpuscle showing the complex relationship between the laminar cells (*LC*) and nerve enlargements (*NE*). Nerve enlargements and narrow segments (*NS*) differ in structure (see text). A laminar cell with its nucleus (*LCN*) is shown in the center of the field. Its cytoplasm contains a Golgi complex (*GC*), many small vesicles (*V*), and small mitochondria (*M*). Note the dense mitochondria (*DM*) in the nerve endings. At *x* the intercellular substance is cut in such a plane that the periodic banding is shown. Female, 21 years. × 8800.


NE
NS
LC
X
LC
NE
NE
NS
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X
NE
LC
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DM
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3

of mitochondria with concentric disposition of internal membranes are also noted occasionally in the myelinated segments of the intracorpuscular fiber (Fig. 11). Mitochondria are seen which are transitional in form between the regular and the dense types (Figs. 6, 7).

Packed between the mitochondria are small (40 to 50 mμ) vesicles randomly distributed throughout the enlargement. In some instances, the vesicles of the laminar cell are fewer in number than those of the axoplasm. Also seen in the varicosities and terminal enlargements are large (100 to 200 mμ) clear vacuoles and, occasionally, a complex group of dense circular membranes which resemble myelin figures. Several mitochondria of the type having dense concentric membranes appear to be sequestered within this complex (Fig. 8).

While nerve endings are usually closely surrounded by laminar cell processes, a portion of the axolemma may be exposed to the intercellular substance (Fig. 12). This is a rare occurrence, however, and it is usually possible to distinguish a nerve ending from a portion of the perinuclear cytoplasm of the laminar cell by the fact that the latter is always surrounded by intercellular substance.

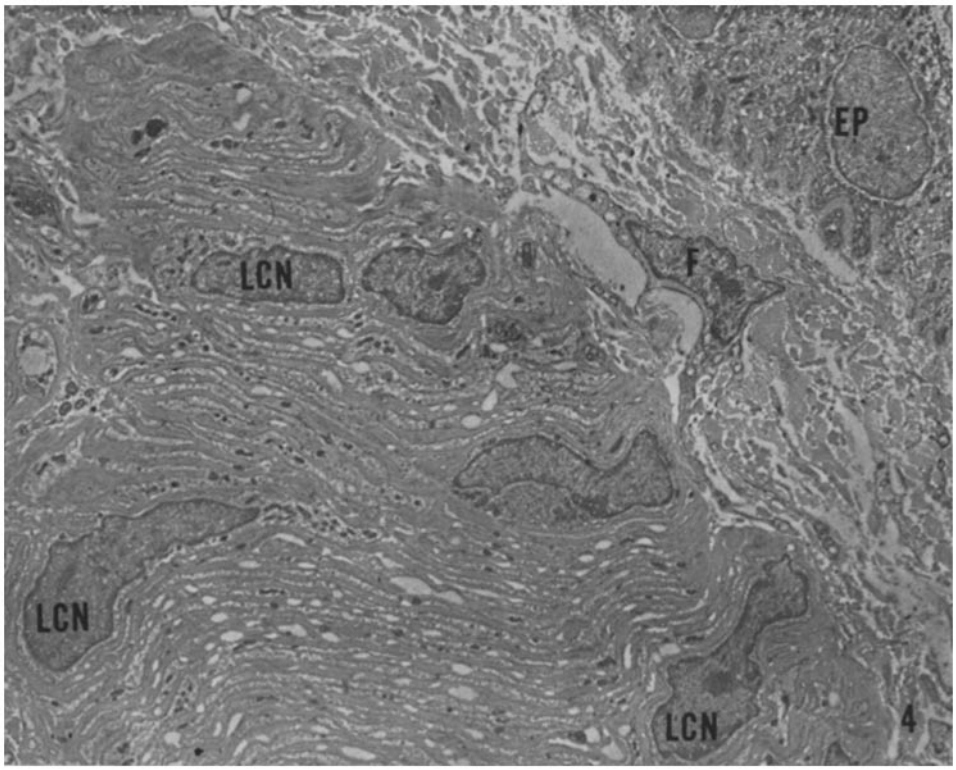
Capsule and Intercellular Substance: In phosphotungstic acid (PTA)-stained preparations (Fig. 1), Meissner's corpuscle is surrounded by a thin capsule consisting of multiple layers of collagen fibers embedded in an amorphous matrix. On the basis of previous light microscopic studies (2), this capsule would be expected to consist of elastic fibers and ground substance. In unstained preparations the intercellular substance in the interior of the corpuscle appears as a relatively dense material which envelops all the laminar cells and their processes except where they are in relation to a nerve ending (Figs. 1 to 4). The intercellular spaces are of uniform thickness (100 to 150 mμ) in the bulk of the corpuscle, but increase in width in the more peripheral regions. The intercellular material is ordinarily devoid of recognizable structure, but in certain areas a periodic cross-banding is discernible (Figs. 2, 3). Far greater detail is revealed in sections stained with PTA (Figs. 1, 13). Randomly oriented collagen fibers about 25 mμ in diameter are scattered throughout the intercellular substance. In some areas of the intercellular substance, especially when the plane of the section is oblique or perpendicular to that of the interlaminar space, a pattern of very fine (less than 10 mμ) fibrils can be made out (Fig. 13). These fibrils are bound together by a dense material at nodal points recurring at regular intervals of approximately 120 mμ. Sections which coincide with the plane of the interlaminar space

FIGURE 4

An oblique-longitudinal section through the periphery of Meissner's corpuscle showing the stacking of the flattened leaves of the laminar cells. These flattened cytoplasmic processes (lighter bands) extend across the corpuscle, separated from one another by sheets of intercellular substance (darker bands). The nuclei (*LCN*) are located at the periphery of the corpuscle. A portion of the basal cell layer of the epidermis (*EP*) can be seen in the upper right hand corner of the micrograph, separated from the corpuscle by a wide zone of dermal connective tissue. A fibrocyte (*F*) lies in this zone. Female, 20 years. × 3500.

FIGURE 5

A field from Meissner's corpuscle showing a myelinated nerve fiber entering the receptor and losing its myelin and Schwann cell (*SC*) sheaths. At *x* is indicated the sequential peeling-off of the myelin lamellae. At *y* is shown the site where the Schwann cell sheath terminates and the laminar cell processes (*LCP*) surround the nerve ending. The whole fiber with its sheaths is surrounded by numerous attenuated laminar cell processes separated from one another by intercellular substance (*ICS*). The medullated part of the nerve fiber contains a packet of mitochondria of ordinary appearance. The enlarged segment, surrounded by laminar cells, contains mitochondria of various sizes and densities, some with dense concentric membranes (*DM*). Female, 21 years. × 17,000.


EP
LCN
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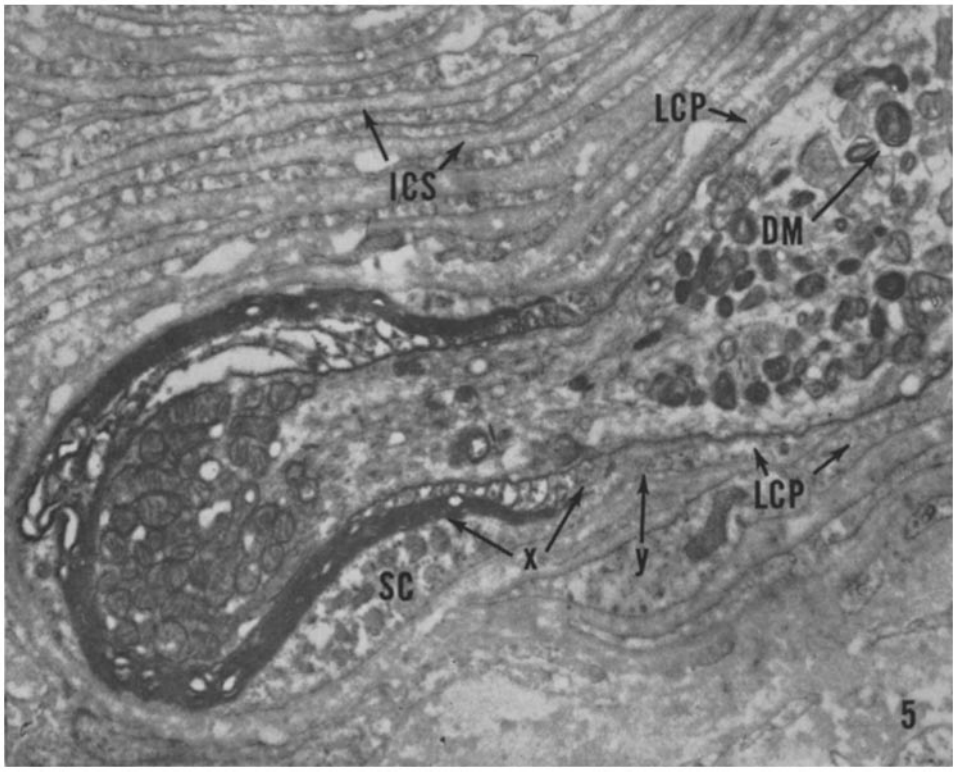
LCN
LCN
4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reveal that the fibrils radiate from the nodal points to produce a hexagonal pattern reminiscent of that described by Jakus (17) in Descemet's membrane.

These fibrils and the coarser collagen fibers are embedded in a dense amorphous material which is continuous with the layer of similar material around the periphery of the corpuscle (Figs. 1, 2, 4).

DISCUSSION

Examination of Meissner's corpuscle with the electron microscope has clarified some aspects of the structure of this receptor which have been obscure for over 100 years (reviewed in 2–4). The present findings are in support of earlier light microscopic observations (4) that the principal cells of Meissner's corpuscle are arranged in laminae and that the nerve endings are extracellular. The electron microscope, however, has revealed a greater complexity in the arrangement of these laminar cells than had previously been envisioned. This is especially true in the areas where laminar cells surround the nerve endings. There is a remarkable similarity between the laminar cells and the Schwann cells in their relation to the axons and in certain features of their fine structure. In the stalk region of the corpuscle a gradual transition can be observed from the Schwann cells to the laminar cells, much like that which has been described in the core of Pacinian corpuscles (6). On this basis, it may be suggested that the laminar cells are of lemmoblastic origin, a concept originally advanced by Krause nearly 80 years ago (reviewed in 4). This question, however, cannot be resolved completely by the present study. Observations of developing corpuscles are needed to clarify this point.

A structural component of Meissner's corpuscle not previously adequately described is the abundant intercellular material. Its functional role is problematical but one may speculate that in a receptor exposed to mechanical stimulation the intercellular material may provide a firm supporting framework, preventing expansion or shearing motion of the cellular laminae. It appears to be only loosely bound to the surfaces of adjacent cells, a fact which may explain the common observation by light microscopy that the laminar cells can easily be separated from one another except at the periphery of the corpuscle (4).

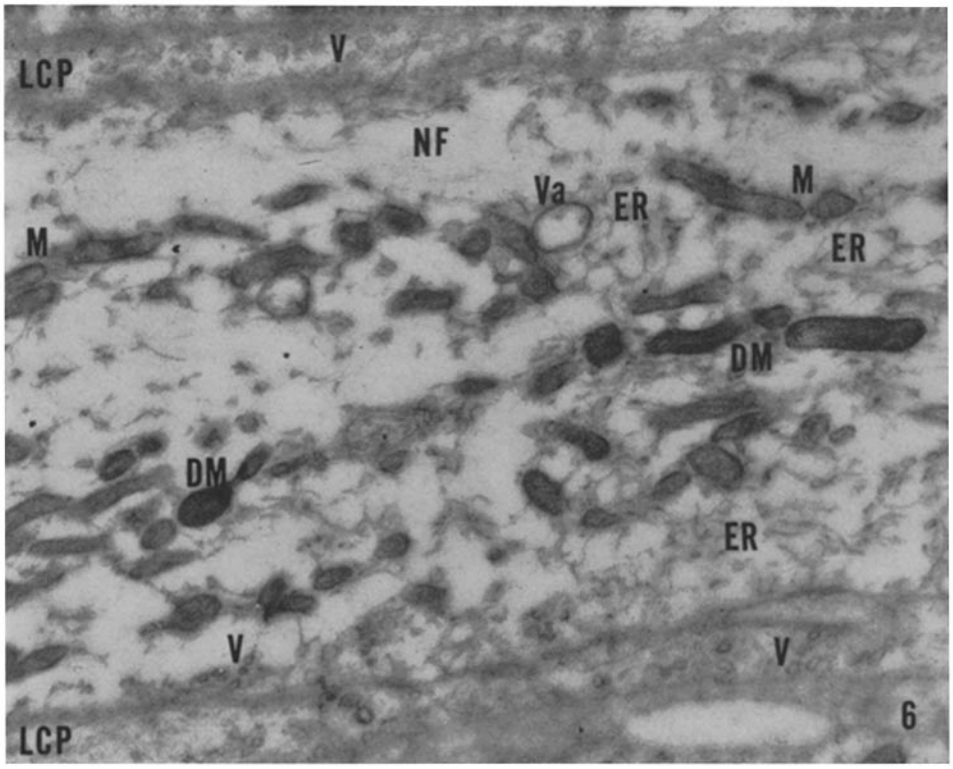
Only one other tissue is known which appears to possess a fibrillar structure similar to that in the interlaminar matrix. This is Descemet's membrane as described by Jakus (17). This tissue is characterized by narrow dark bands separated by wide light bands traversed by fine filaments. While the average distance between the dark bands was 1070 A in Descemet's membrane compared to 1200 A in the intercellular substance of Meissner's corpuscle, the basic structural pattern appears to be similar in the two organs. There has been, however, a more exact definition of the character of Descemet's membrane by diffraction and selective staining studies than is available for the intercellular substance. Jakus has suggested that this particular arrangement of fibrils serves to keep Descemet's membrane under the proper degree of tension so that it may act as a collimating device.

FIGURE 6

A field showing the narrow segment of a nerve ending surrounded by laminar cell processes (*LCP*). The axoplasm contains mitochondria (*M*) of varying size and density. Several of the mitochondria (*DM*) show dense concentric membranes. The axoplasm also contains vesicles (*V*), a reticulated system of tubular elements (*ER*), neurofilaments (*NF*), and large, clear vacuoles (*Va*). The surrounding laminar cells are packed with small, dense vesicles (*V*). Female, 22 years. × 27,000.

FIGURE 7

A field of a nerve enlargement and its surrounding laminar cell processes (*LCP*). The enlargement is filled with many small vesicles and mitochondria (*M*), some of the latter showing dense concentric membranes (*DM*) and some transitional forms between the regular and the dense (*y*). The laminar cell shows many vesicles, in some areas (*V*) lined up along the laminar cell membrane apposing the axolemma. Female, 22 years. × 27,000.


LCP
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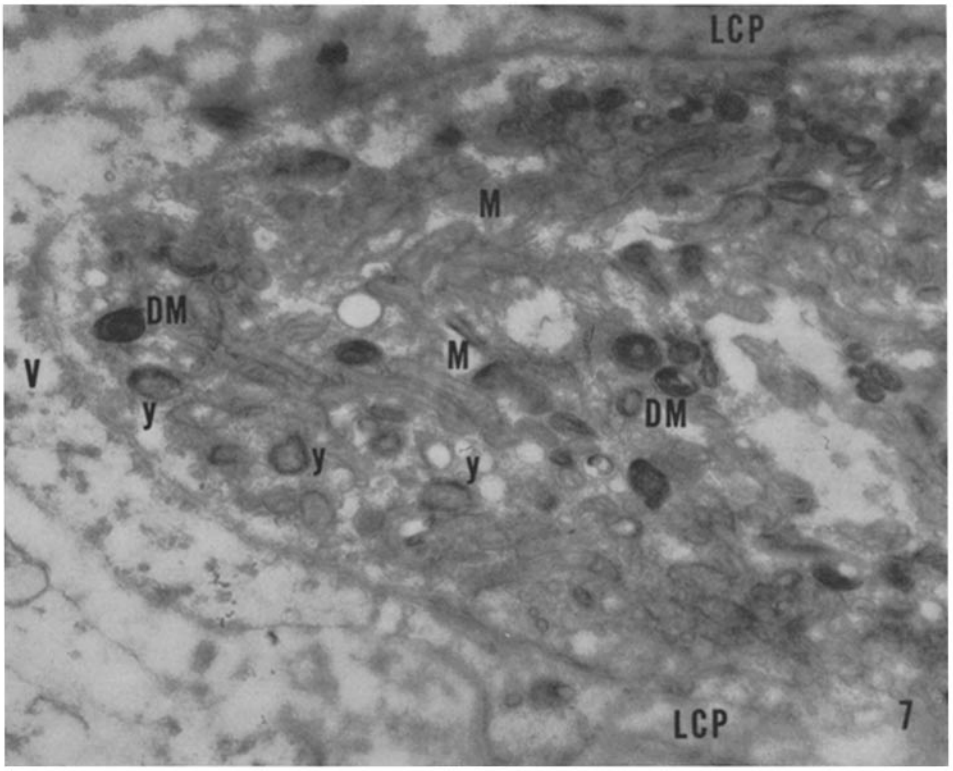
LCP
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LCP
7

The similar structural organization of the intercellular material of Meissner's corpuscle may act to maintain a tautness within the whole structure, which would enhance the responsiveness of the corpuscle to physical deformation.

The occurrence of an extraordinary number and variety of mitochondria in the nerve endings was not unexpected. Earlier light microscopic studies have demonstrated that there are wide variations in the type of nerve endings in the corpuscle, the neural pattern changing with age, occupation, and degree of use (3). In these earlier studies, evidence was found suggesting that nerve endings of certain receptors, including those of Meissner's corpuscle, undergo a continual process of loss and replacement of neural material (5). Indeed, one of the reasons for undertaking the present electron microscopic study was to extend our investigation of this process.

The morphological variation observed in the mitochondria may signify a continual turnover of these organelles at the endings. The mitochondria with dense concentric membranes may be in the early stages of involution, while the vacuolated forms and those with a particularly dense matrix may be in a more advanced stage of this process. The dense granular and vesicular substance seen in some endings may represent the final stages in the disintegration of the mitochondria. It may be of significance in this regard that the relationships between the axolemma and the plasma membrane of the laminar cells become less complex in those endings which show signs of mitochondrial degeneration. Presumably, the mitochondria lost are replaced by organelles carried centrifugally by axoplasmic flow from the perikaryon.

The concept of continual turnover at the nerve endings does have some experimental support. Weiss and Hiscoe (35) have maintained that growth and centrifugal convection of axoplasm are not confined to the period of active elongation and enlargement but continue in the mature fiber. The concept of axoplasmic flow accompanied by turnover at the endings provides an explanation for the mechanism whereby the neural pattern may change throughout the life of an individual.

On the other hand, the possibility exists that the accumulation of mitochondria in the endings may be the morphological reflection of an extremely high rate of metabolism, possibly involved in the propagation of the impulse. On the basis of this interpretation, the mitochondria with dense concentric membranes may be specialized to perform a particular metabolic function and need not necessarily be regarded as degenerating forms.

Another observation which is deserving of com-

FIGURE 8

A nerve ending (*NE*) surrounded by laminar cell processes. Note the variety of mitochondria in the ending and the myelin figure (*MF*) which appears to contain mitochondria with dense concentric membranes (*DM*). Female, 22 years. × 16,000.

FIGURE 9

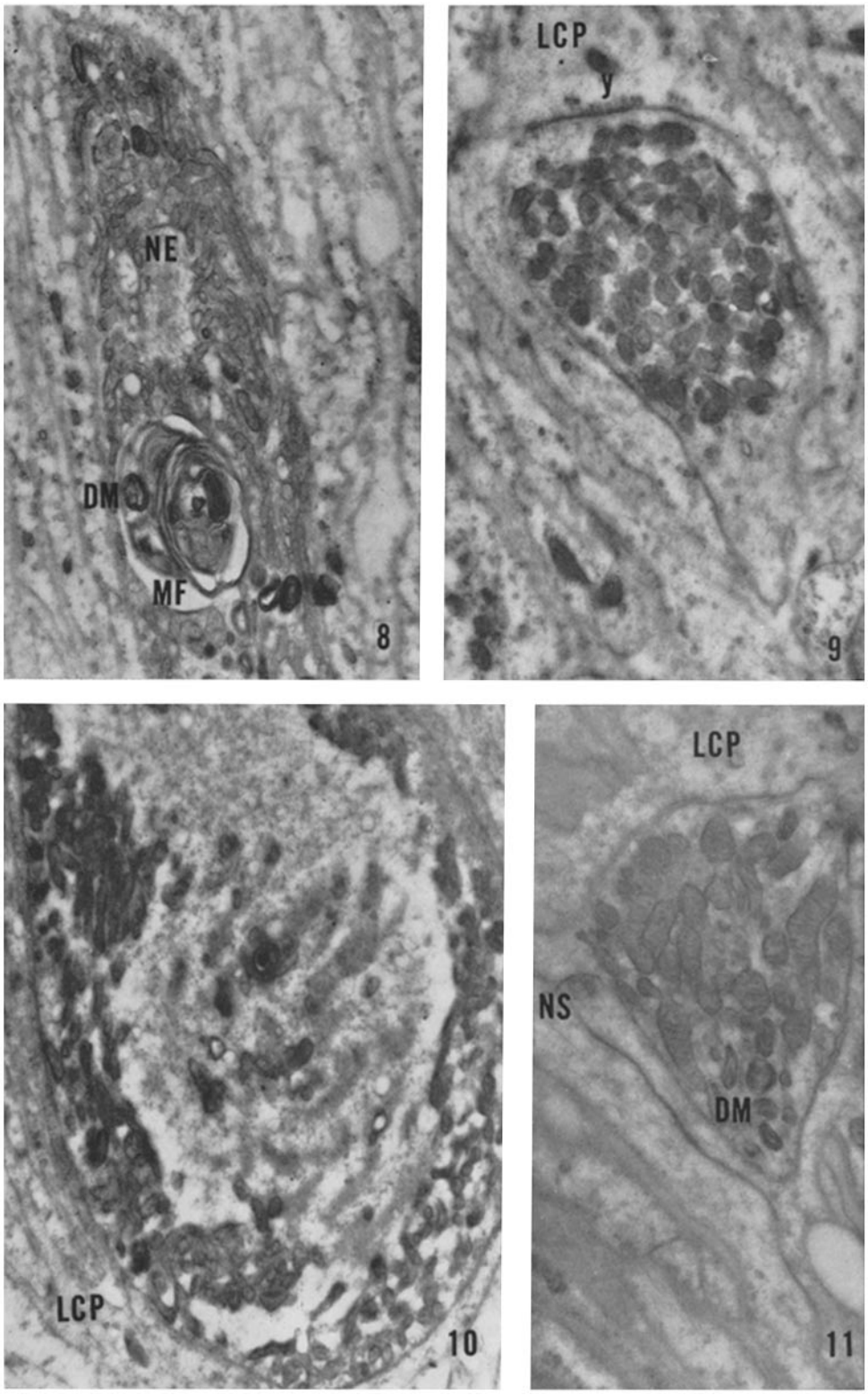
A nerve ending (male pattern) surrounded by laminar cell processes (*LCP*). The ending contains mitochondria, the internal structure of some of which is obscure. At *y* there is seen to be an increase in density of the apposing axolemma and laminar cell membrane with an alinement of the laminar cell vesicles. This is presumably a site of synaptic relationship. Male, 44 years. × 18,000.

FIGURE 10

Part of a nerve ending (male pattern) from the same corpuscle as in Fig. 9 but probably representing a nerve segment near its termination. The ending is surrounded by laminar cell processes (*LCP*) and contains mitochondria, vacuoles, and accumulations of small dense vesicles. Male, 44 years. × 18,000.

FIGURE 11

A nerve ending (female pattern) surrounded by laminar cell processes (*LCP*). The ending continues from a narrow segment (*NS*) and contains many small mitochondria, several of the dense type (*DM*), and many small vesicles. Female, 21 years. × 21,000.


NE
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11

ment is the presence of numerous small vesicles in the terminal axoplasm and in all parts of the laminar cell cytoplasm. Because of their structure and location it would be reasonable to assume that many of these vesicles are "synaptic vesicles" and to postulate that certain areas of contact between the axolemma and the laminar cell membrane constitute a synaptic junction.

De Robertis and Bennett (10) and Palay and Palade (23, 25) first advanced the theory that submicroscopic vesicular components, termed "synaptic vesicles," are present in synapses and that these may be associated with production and release of acetylcholine or other neurohumoral transmitters. The rapidly growing body of observations on these cytoplasmic vesicles has been reviewed by De Robertis (9) and by Palay (24). They have been found in all synapses so far studied (30). In certain ones their number is reported to increase after prolonged experimental stimulation (12) and decrease after denervation (8, 13, 29). The suggestion has been advanced (9) that these vesicles represent the "quantal units of acetylcholine."

In most synapses such vesicles are found only in the presynaptic member. In the sensory receptors, however, their location varies according to the type. Vesicles are found in the presynaptic member in the rod and cone cells (11) and carotid body chemoreceptors (31), in the postsynaptic member in the taste buds (7, 33), and in both members in the hair cells of the organ of Corti (32), the cristae ampullares (14, 15, 36), and in the Pacinian corpuscle (27). Meissner's corpuscle, in this respect, belongs to the last group, which evidently comprises receptors responding to mechanical stimulation.

An adequate explanation for the presence of vesicles on both sides of the presumed synaptic junction in Meissner's corpuscle is not immediately available. These observations would tend to throw doubt on the concept of the uniformity of nature of these vesicles. Vesicles in the presynaptic member may have an entirely different function from those in postsynaptic member. Indeed, many of the vesicles in both members probably have a more general metabolic significance as pinocytotic vesicles. It is apparent that the concept that vesicles found in synapses represent quantal units of acetylcholine is in need of further investigation and reevaluation, particularly in those incongruous instances where the vesicles are located in the postsynaptic member.

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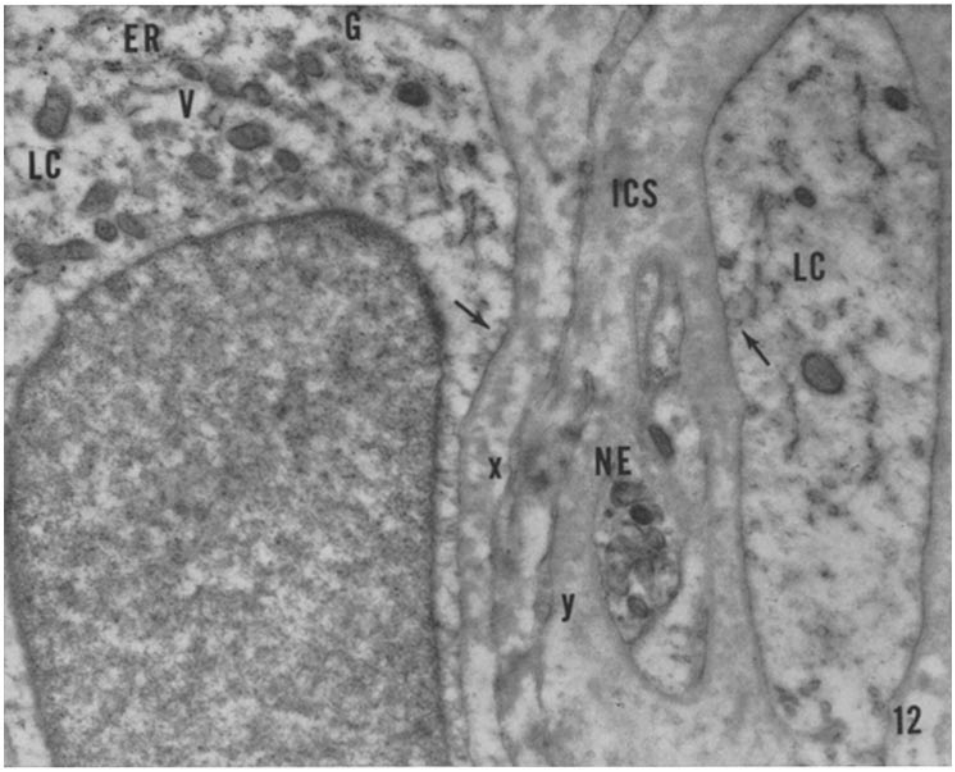
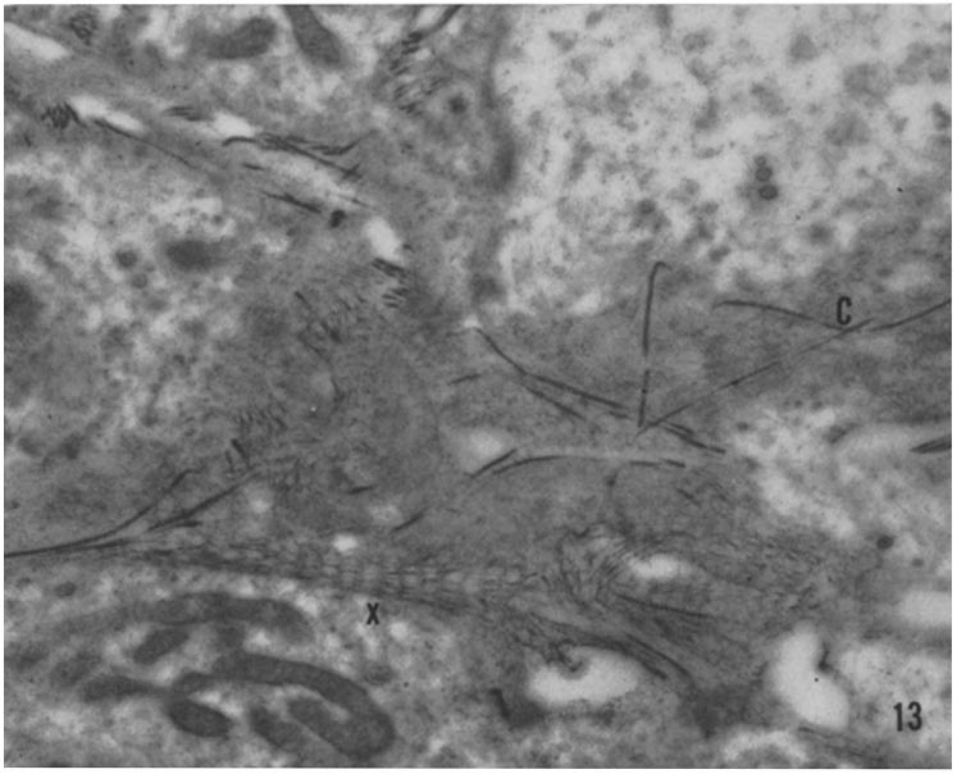
FIGURE 12

A field from a Meissner's corpuscle showing portions of several laminar cells (*LC*) separated by the intracellular substance (*ICS*). The cell on the left exhibits a finely granular nucleus, small mitochondria, scattered granular endoplasmic reticulum (*ER*), groups of unassociated ribonucleoprotein granules (*G*), and groups of small vesicles (*V*), some of which (arrow) appear to be attached to the plasma membrane of this cell. Note the two laminar cell processes (*x* and *y*) which are nothing more than two plasma membranes enclosing an occasional vesicle. A portion of a nerve ending (*NE*) is covered by a laminar cell process on one side but exposed to the intercellular substance on the other side. Female, 22 years. × 21,000.

FIGURE 13

A field from a Meissner's corpuscle showing intercellular substance surrounded by laminar cells. The matrix of the substance contains darkly staining collagen fibers (*C*) and fine parallel fibrils bound together by a dense material at repeated intervals of approximately 1200 A (visible at *x*). Female, 21 years. PTA stain. × 21,000.


ER
G
V
LC
ICS
LC
x
NE
y
12


C
x
13

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