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Cytological Studies on the Lateral Canal Cell in the Pig *Ascaris* (*Ascaris lumbricoides suum*)
II Ultrastructure of the Lateral Canal

MICHIO ISHIKAWA

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Abstract

In the pig *Ascaris*, the lateral canal of the lateral canal cell was embedded in the lateral line tissues. Mitochondria, Golgi complex, agranular and granular endoplasmic reticulum, ribosomes, lysosome-like dense bodies, secretory granules and glycogen particles were visualized in the cytoplasm of the lateral canal. In addition, a main huge canal lumen was surrounded by the cytoplasm of the canal cell. The luminal surface of the canal was provided with numerous microvillus-like processes. In the cytoplasm near the lumen, pits, invaginations of varying lengths and vesicles were situated. A number of mitochondria were associated with these apical ultrastructures. In addition, substantial amounts of secretory granules and lysosome-like dense bodies were found in the cytoplasm. Such unique ultrastructural features of the apical cytoplasm facing the lumen of the lateral canal have been discussed with special reference to the water and electrolyte transport across the canal.

Key words: *Ascaris lumbricoides suum*, lateral canal cell, ultrastructure, excretory function

Introduction

In the lateral canal cell of the pig *Ascaris*, the cytoplasm is embedded in the lateral line to form slender lateral canals with a huge canal lumen.

The canals involved in the lateral canal cell are known to exhibit varying ultrastructural characteristics with their different regions. In a previous study (Ishikawa, 1985), the ultrastructures of the perinuclear region of the cytoplasm of the cell have been recorded.

In the present study, the ultrastructures of the cytoplasm embedded in the lateral line have been studied and the ultrastructural images obtained have been correlated with the possible cytophysiological functions of the cell.

Materials and Methods

Thirteen adult females of *Ascaris lumbricoides suum* were obtained from pigs sacrificed in a slaughter house of Nagoya City, Japan. The worms obtained were kept alive in Ringer's solution maintained at 37°C. Those parts of the cytoplasm of the lateral canal cell embedded in the lateral line with their neighbouring tissues were dissected out from the living worms.

A ventral view of the lateral canal cell of the pig *Ascaris* is schematically illustrated (Fig. 1). Two kinds of tissue blocks in the lateral canal (Fig. 1, A) and the lateral line (Fig. 1, B) were removed.

These tissue specimens were cut into tiny cubes and fixed in chilled (4°C) phosphate-buffered (pH 7.2) 2% osmium tetroxide or in chilled (4°C) cacodylate buffered (pH 7.2) 2.5% glutaraldehyde for 1.5 to 4 hrs. The fixed tissue specimens were dehydrated in a graded ethanol series and embedded in Epon 812, according to the procedures prescribed by Luft (1961). For the orientation of the particular region of the cytoplasm, thick sections (1 μm) were cut with a JUM No. 5 microtome, affixed to glass slides and then stained with 1% tolui-

Department of Anatomy, Nagoya City University Medical School, Nagoya 467, Japan.
石川道雄（名古屋市立大学医学部第2解剖学教室）

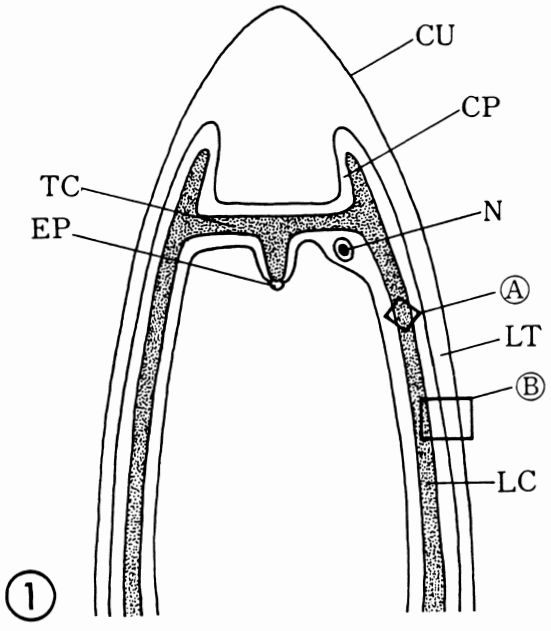

Fig. 1 A schematic illustration of the lateral canal cell in the pig *Ascaris* (a ventral view). N (nucleus), LT (lateral line tissues), TC (transverse canal), EP (excretory pore), CP (cytoplasm), CU (cuticle), LC (lateral canal), A (a tissue block in the left lateral canal), B (a tissue block in the left lateral line).

dine blue. Ultrathin sections were cut with a Porter-Blum microtome (MT-1), mounted on copper grids and stained doubly with uranyl acetate (Watson, 1958) and lead citrate (Reynolds, 1963). The stained sections were examined in a Hitachi HU-11D or HS-4 electron microscope.

Results

Figure 2 represents an electron microscopic image from ultrathin sections of the tissue block (Fig. 1, B), whereas Figs. 3, 4, 5 and 6 reveal images from the sections of the block (Fig. 1, A).

The lateral canal was embedded in the lateral line tissues (Fig. 2 LT). The cytoplasm of the lateral canal included different types of cell organelles and inclusions such as mitochondria, Golgi complex, elements of endoplasmic reticulum, lysosome-like dense bodies, secretory granules, and glycogen particles (Figs. 2, 3 and 4). A main huge canal lumen was surrounded by the cytoplasm of the cell. Mitochondria were spherical or oval and provided with small numbers of cristae, and tended to be disseminated in the regions of the cytoplasm facing the main huge canal lumen (Figs. 2, 4 and 5). In the cytoplasm of the cell, the elements of Golgi complex were scattered here and there. These elements contained substances of varying electron densities and were associated with secretory granules (Fig. 2). The cytoplasm was more or less fine granular throughout, due apparently to the presence of free ribosomes (Fig. 3).

The elements of both agranular and granular endoplasmic reticulum were detected in the cytoplasm of the cell. The granular moieties were better developed than the agranular ones and abundant ribosomes were attached on the outer surface of the former (Figs. 2 and 3). In addition, lysosome-like dense bodies were visualized in the cytoplasm, and they were spherical or irregular in shape and of heterogeneous contents (Figs. 2, 3, 4 and 5). Within the cytoplasm of the cell, secretory granules were found to be spherical or oval, to exhibit moderate or high electron densities and to be bounded by a limiting membrane (Figs. 2 and 3). Electron-dense glycogen particles were visualized throughout the cytoplasm (Fig. 3). A huge lumen was embedded in the cytoplasm (Figs. 4 and 5). The luminal surface was provided with numerous microvillous processes. They were long and slender in shape and irregularly arranged (Figs. 4 and 5). The pits and invaginations of varying sizes were detected at the bases of these slender processes, and the latter were seen to extend into the cytoplasm (Figs. 4 and 5). Many of such invaginations appeared to be pinched off, forming apical vesicles, which were electron lucent, spherical in shape, and 25–50 nm in diameter (Figs. 4, 5 and 6). These vesicles were fused to form vacuoles (Figs. 5 and 6). Mitochondria were distributed in clusters in the cytoplasm near the lumen. Both secretory granules and lysosome-like dense bodies were likewise scattered

(Figs. 4 and 5). In the cytoplasmic regions beneath the microvillous processes, mitochondria, vesicles, vacuoles and abundant glycogen particles were noted (Fig. 6).

Discussion

According to Dankwarth (1971), the luminal surface of the lateral canal in *Ascaris lumbricoides* was provided with a cytoplasmic plate (Zytoplasmische Platten) which played a particular role in osmoregulating functions of an excretory system. On the contrary, the present study disclosed numerous microvillous processes on the luminal surface of *Ascaris lumbricoides suum*. The ultrastructures of the luminal surface of the lateral canal appear to be more or less similar to those of the mammalian gastric parietal cells, clear cells of the eccrine sweat gland and renal distal tubule epithelial cells.

Terzakis (1964) made an electron microscopic study on adjacent clear cells of the monkey eccrine sweat gland and reported the presence of complex interdigitating processes in the cells, which are known to play a role in sweat excretion.

Sedar and Friedman (1961) investigated the ultrastructures of the dog gastric parietal cells under a variety of experimental conditions. They substantiated that these cells participate in the process of acid secretion. Thus, it seems that cells with cytoplasm containing an abundance of vesicles, intracellular canaliculi and microvilli are concerned with the transport of water and electrolytes. Lentz (1971) pointed out that the renal proximal tubule epithelial cells are provided not only with numerous closely packed microvilli on the luminal apical surface but with well-developed infoldings of the basal plasma membrane associated with a number of mitochondria. It is well established that these cells are capable of transporting water and electrolytes.

In the present study, the ultrastructures of the cytoplasm near the lumen of the lateral canal in *Ascaris* are regarded as providing an evidence that water and electrolytes are actively transported across the apical cytoplasm. Such a concept is in keeping with the results of a previous study by Inatomi *et al.* (1970), who described that the excretory canals of male *Schistosome japonica* are provided with cilia and micro-villus-like projections. In addition to Inatomi *et al.* (1970), a series of previous authors have made studies on the structures and functions of the excretory systems in nematodes.

Bird (1971) described that there are two basic types in the nematode excretory system: a glandular and a tubular. Both types of excretory ducts open to the exterior through an excretory pore that is commonly situated in the anterior mid-ventral line. A wide range of chemical compounds passes out of the excretory pore, including some of relatively high molecular weight such as polypeptides and proteins.

Waddel (1968) described the growth and morphology of the excretory system of *Stephanurus dentatus*. The lateral canals are extensions of the excretory sinus and lie embedded in the hypodermal tissue of the lateral chords.

Lee (1970) described the ultrastructures of the excretory system, including the subventral glands of the nematode *Nippostrongylus brasiliensis*. The walls of the lateral excretory canals contain numerous canaliculi which open into the central lumen of the canal. It was suggested that these canals play a role in osmoregulation and excretion. The excretory system of *Tylenchulinae* from hematoxylin stained serial sections and glycerine prepared totomounts was recorded by Maggenti (1962). Moreover, in *T. semipenetrans*, the role of the excretory system in the production of the gelatinous matrix was described (Maggenti, 1962). Furthermore, Savel (1955) has investigated the constitution and protein metabolism in *Ascaris lumbricoides* and elucidated the natures of the excretory mechanism in that worm.

The results obtained in the present study are believed to be not only a significant addition to those reported previously but useful for thorough recognition of the excretory mechanism in nematodes.

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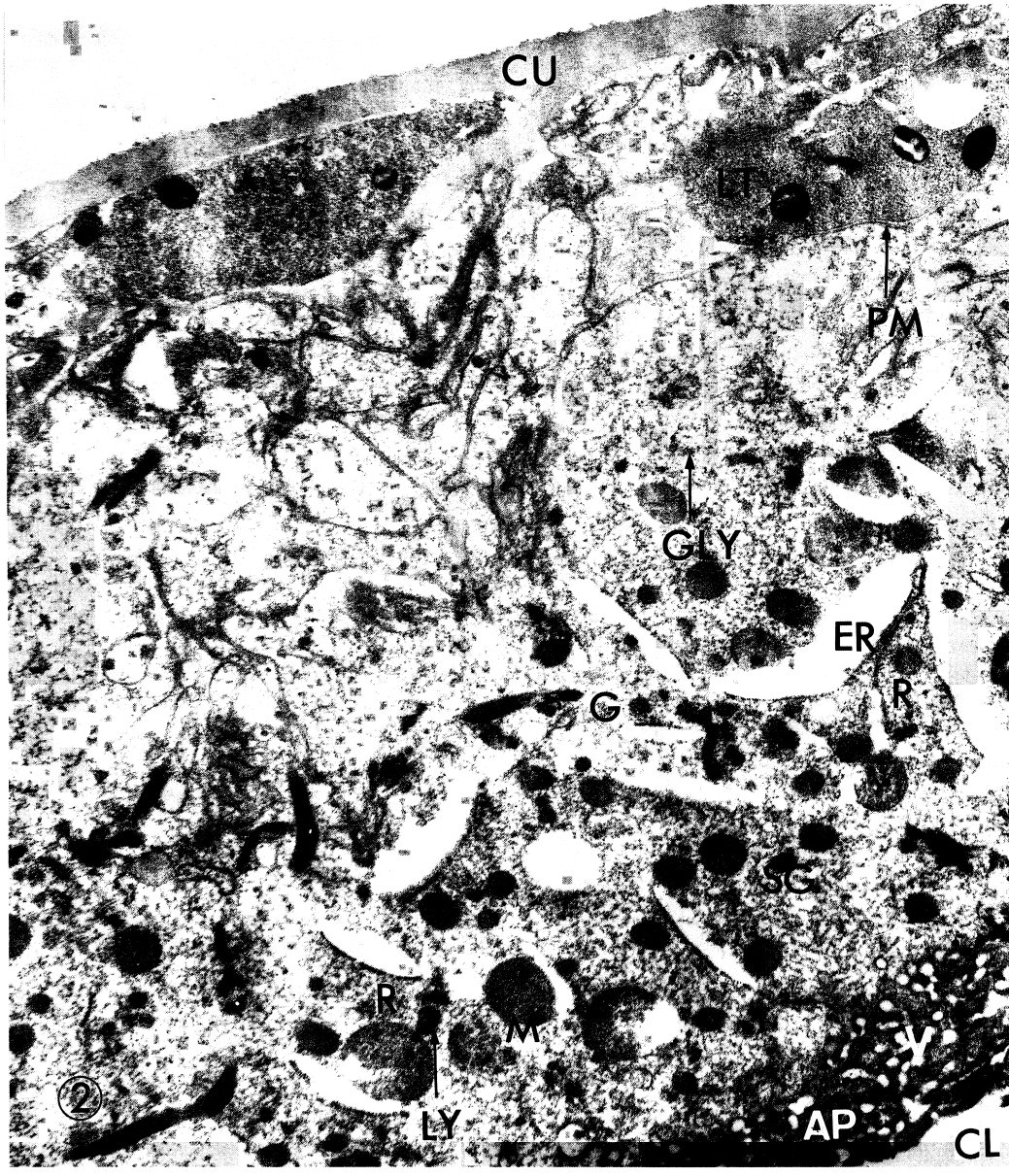

Fig. 2 Cross section of the lateral line in a pig *Ascaris*. Cuticle (CU), plasma membrane of the lateral canal cell (PM, arrow), lateral line tissue (LT), Golgi complex (G), endoplasmic reticulum (ER), ribosomes (R), lysosome-like dense bodies (LY, arrow), secretory granules (SG), vesicles (V), glycogen particles (GLY, arrow), canal lumen (CL), apical cytoplasm (AP), Mitochondria (M). (× 14,000)

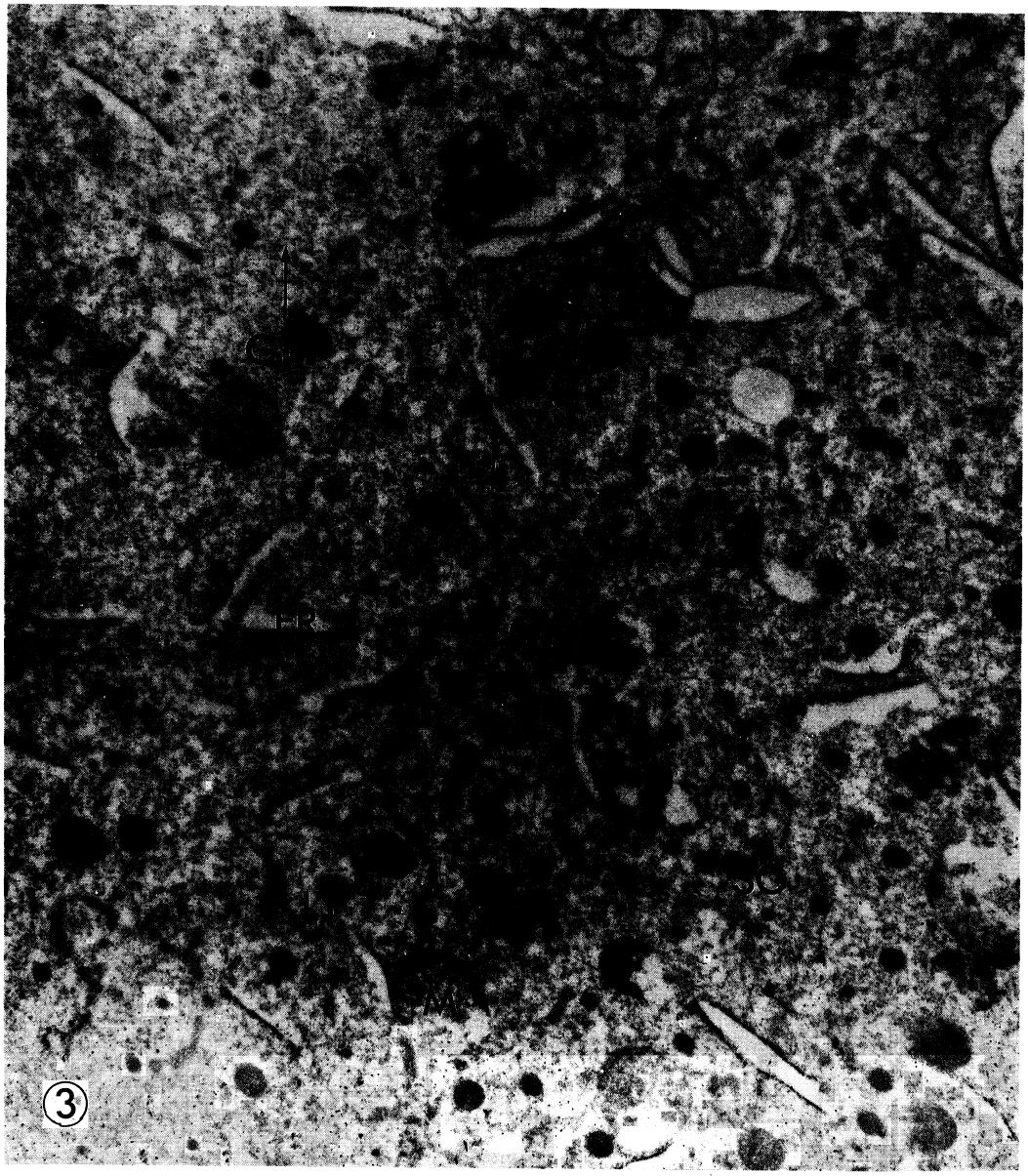

Fig. 3 Part of the lateral canal cell. Mitochondria (M), Golgi complex (G), endoplasmic reticulum (ER), ribosomes (R, arrow), glycogen particles (GLY, arrow), secretory granules (SG), lysosome-like dense bodies (LY). (× 14,000)

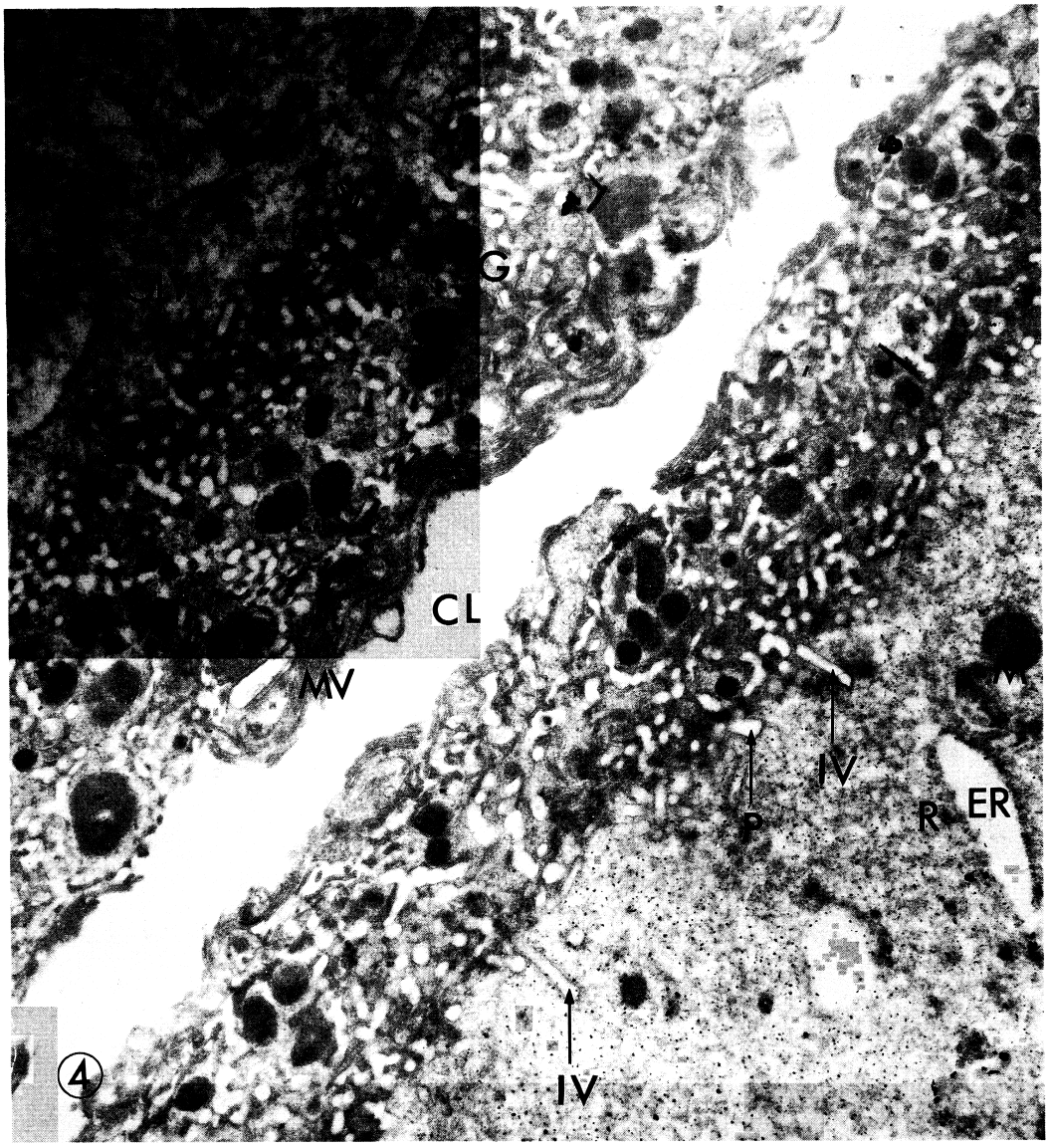

Fig. 4 Part of the lateral canal cell. Mitochondria (M), Microvilli (MV), invaginations (IV, arrow), pits (P, arrow), canal lumen (CL), secretory granules (SG), lysosome-like dense bodies (LY), vesicles (V), ribosomes (R), endoplasmic reticulum (ER), glycogen particles (GLY). (× 12,000)

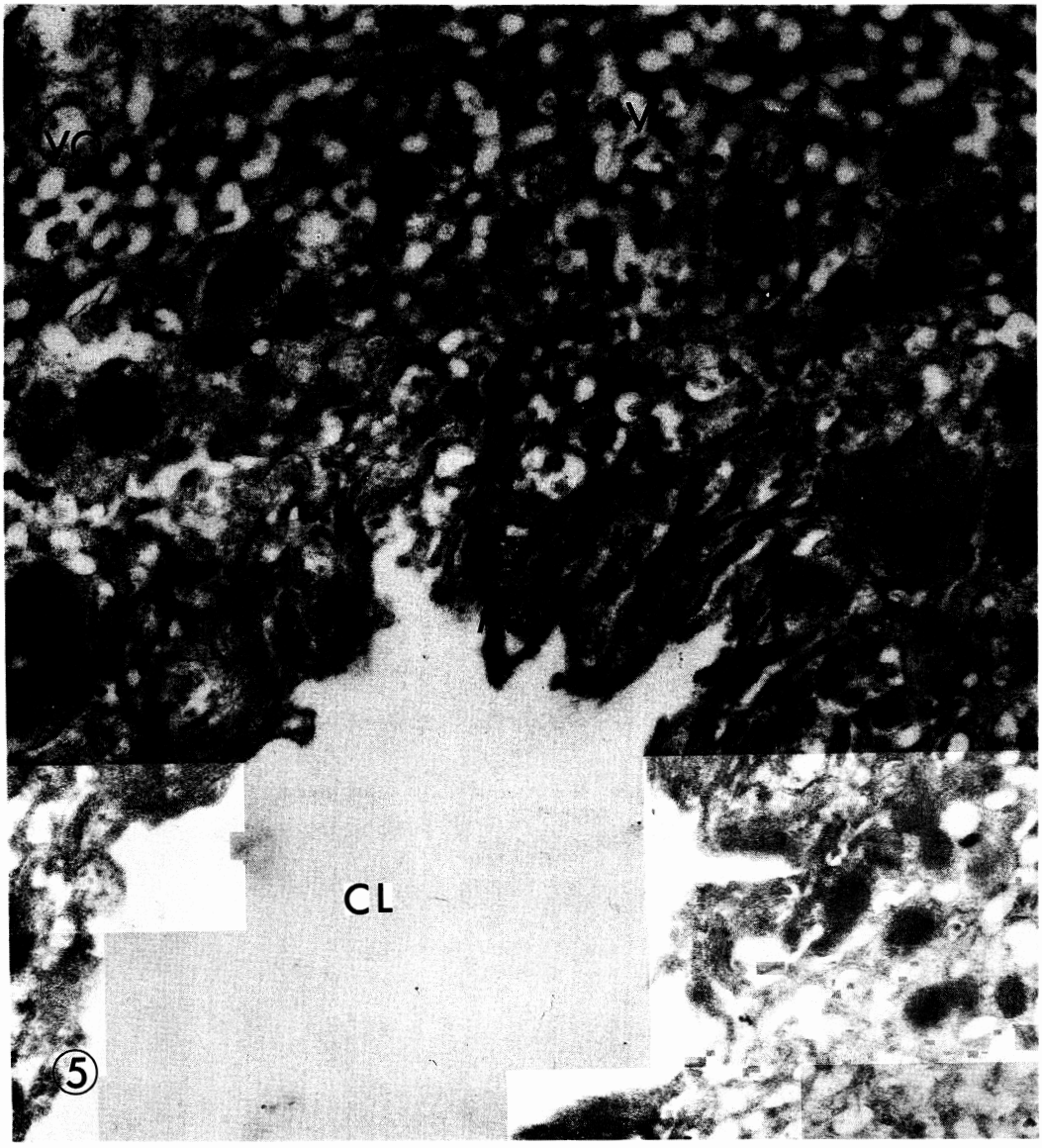

Fig. 5 A high power view of parts of the canal cell. Canal lumen (CL), microvilli (MV), mitochondria (M), lysosome-like dense bodies (LY), vesicles (V), vacuoles (VO). (× 26,000)

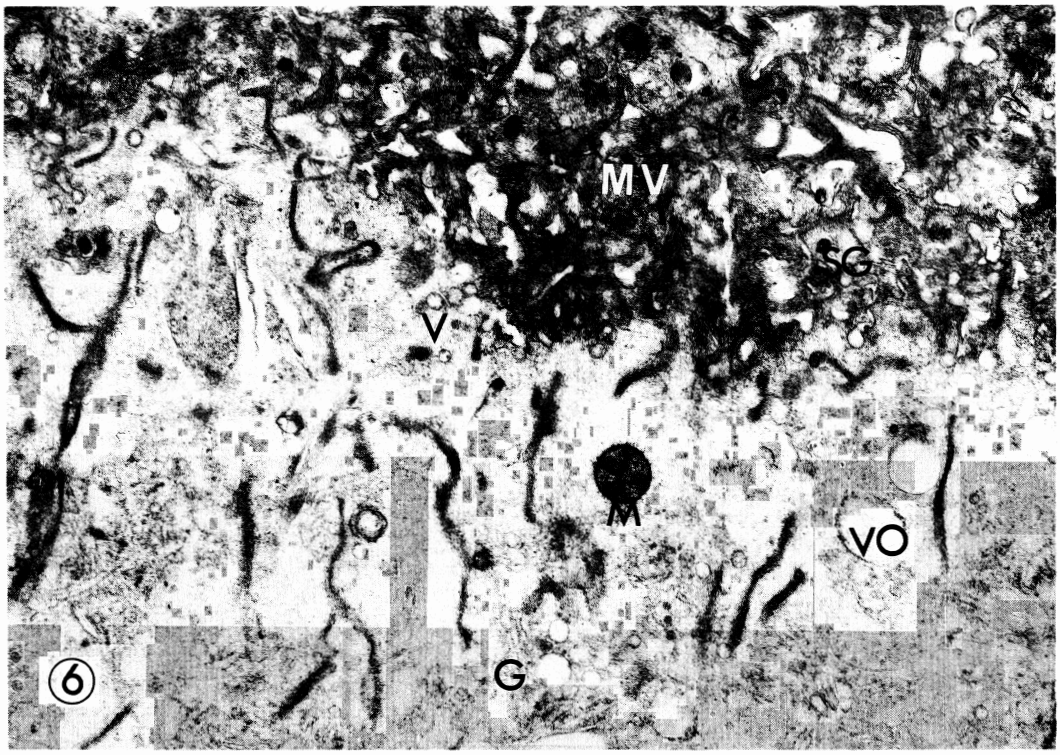

Fig. 6 Cytoplasm near the lateral canal lumen. Microvilli (MV), secretory granules (SG), vesicles (V), vacuoles (VO), mitochondria (M), Golgi complex (G). (x 12,000)