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ULTRASTRUCTURE OF THE DEEP POSTERIOR LINGUAL GLANDS (VON EBNER'S) IN THE ONE-HUMPED CAMEL (CAMELUS DROMEDARIUS)

(With 28 Figures)

By

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التركيب الدقيق للغدد اللسانية الخلفية الغائره (فن إبنرز) في الجمل وحيد السنام

أحمد سالم

أجري هذا البحث على عدد سبعة جمال بالغة من كلا الجنسين لدراسة الغدد اللسانية الخلفية الغائرة "فن إبنرز" بإستعمال المجهر الضوئي والإلكتروني. أظهرت الدراسة أن هذه الغدد توجد تحت الحليمات المخندقه وتتكون من وحدات مفرزة نبيبية سنخاء وجهاز إفراغي. وأظهرت الدراسة أن الخلايا المفرزة وكذلك بعض خلايا الأقنية العنبية تظهر تفاعلا قوياً مع معامل شيف وخفيفاً مع الألسين الأزرق. وأوضحت الدراسة أن هذه الخلايا المفرزة تعتبر خلايا مصلية مخاطية تفتقر إلى الإنثناءات القاعدية ، وتتميز بإحتوائها على العديد من الحبيبات الإفرازية التي تتكون من لب ذو عتامة إلكترونية من مادة ليفية دقيقة محاطة بمنطقة فاتحة الكترونيا تحتوي على خيوط دقيقة ، وكذلك العديد من المتقدرات التي تظهر في بعض الأحيان بأشكال غير معتادة . هذا وتحتوي الخلايا المفرزة على الشبكة الإندوبلازمية الخشنة التي تظهر في صورة صهاريج متراصة متوازية في قاعدة الخلية وكذلك جهاز جولجي ، وريبوزومات ، خيوط سيتوبلازمية ، أنيبيبات والنقط الدهنية. هذا وقد أظهرت الدراسة أن الجهاز الإفراغي يتكون من الأقنية العنبية والقنيات الإفراغية والقناة الرئيسية . وقد لوحظ أن التحول من الوحدات المفرزة إلى الأقنيه العنبية كان تدريجياً. هذا وتظهر الأقنية العنبيه تشابهاً في التركيب مع مثيلاتها في الغدد اللعابية الأخرى ، أما الأقنية المخططة فتغيب في الحيوان محل الدراسة . وأوضحت الدراسة أيضاً أن الخلايا العضلية الطلائية تظهر خصائص الخلايا القلوصية. وأن هذه الخلايا أظهرت علاقات غير معتادة مع كل من الوحدات المفرزة وكذلك الأقنية العنبية . هذا وقد قورنت شكلياء غدد فن إبنرز في الجمل مع مثيلاتها في الحيوانات الأخرى وكذلك مع الغدد اللعابية الكبرى.

SUMMARY

Camel deep posterior lingual glands (von Ebner's glands) were studied by light and transmission electron microscope. They were located beneath the circumvallate papillae. These glands were formed of tubuloalveolar secretory units and an excretory system. Intense PAS reactivity and slight alcinophilia were demonstrated only in the secretory cells as well as in few intercalated duct cells. The seromucous secretory cells lacked basal folds and characterized by numerous secretory granules, that consisted of electron dense core of fine fibrillar material surrounded by electron lucent marginal zone containing fine strands. These cells contained also numerous mitochondria, some of them of unusual shapes, well developed Golgi-apparatus and abundant RER cisternae stacked at the basal pole. In addition, numerous ribosomes, cytoplasmic filaments, microtubules and few lipid droplets were observed. The excretory system was organized in intercalated ducts, excretory ducts and main duct. The transition between the glandular portions and the intercalated ducts was gradual. The intercalated ducts show similarities with the analogous ducts of the other salivary glands. The striated ducts were absent. Myoepithelial cells had the common criteria of contractile elements. Unusual forms of their relations to the secretory end-pieces and intercalated ducts were observed. The morphology of the von Ebner's glands of camel was compared with the analogous glands of other species and with other major salivary glands.

Keywords: *Von Ebner's glands, myoepithelial cells, ultrastructure, camel.*

INTRODUCTION

The deep posterior lingual glands (von Ebner's glands) are small lingual salivary glands located under the circumvallate and foliate papillae. Earlier, it has been postulated that their secretion is to wash out taste substance continuously from the vallum and to prepare the taste receptors in the walls of the papillae to receive new stimulus (Ellis, 1959; Bloom and Fawcett, 1975), as well as it has a lipolytic activity on the dietary fat on the stomach (Hamosh and Burns, 1977; Hamosh and Hand, 1978). Recent immunocytochemical and physiological studies revealed that the von Ebner's glands produce IgA and lactoferrin (Moro et al., 1984), lingual amylase (Field et al., 1989) as well as a lipophilic ligand carrier protein called von Ebner's gland protein, VEGP, (Blaker et al., 1993; Spielman et al., 1993;

Kock et al., 1994b; Garibotti et al., 1995). This protein is very important for modulation of taste perception as it is necessary not only for the concentration and delivary of lipophilic sapid molecules (Schmale et al., 1990) but also for control of their access in the gastatory system (Kock et al., 1992). In addition, the von Ebner's gland protein plays other functions as protection of taste epithelium (Kock et al., 1994a) , pheromone transport and lipid binding (Schmale et al., 1993).

Although, the von Ebner's glands were firstly described in man (Ebner, 1873; Baumgartner, 1917), little attention was given to those of the farm animals (Moustafa et al., 1976; El Gindy et al., 1977). On the other hand, ultrastructural investigations were carried out on the von Ebner's glands of rat (Hand, 1970), man (Testa Riva et al., 1985; Azzali et al., 1989a), rabbit (Toyoshima and Tandler, 1986), bat (Azzali et al., 1989b) and bovine (Gargiulo et al., 1995). While, in camel the fine structure of these glands was lacking in the available literature.

Therefore the purpose of this study is to describe the cytological features of the von Ebner's glands in adult camel and to compare them with those of other animals.

MATERIAL and METHODS

The Tongue of seven adult clinically healthy camels of both sexes was obtained from Assiut slaughter house. Via a branch of the lingual artery, three tongues were perfused with Bouin's fluid for the light microscopy. Then small specimens including the circumvallate papilla and the underlying glands were taken and immersed also in the same fixative used, to be prepared for paraffin embedding. 5 µm thick paraffin sections were stained with H & E, alcian blue, PAS and combination of alcian blue-PAS (Mowry, 1956).

For the ultrastructural study, the rest of the samples were perfused with a cold mixture of 2.5% glutaraldehyde and 2.5% paraformaldehyde in 0.1M cacodylate buffer, pH 7.2. Tissue pieces including the von Ebner's glands were subsequently cut into small blocks (1-2 mm) and immersed in the same fixative solution for further 2 hours at 4°C, then after washed in buffer and postfixed in cacodylate-buffered 1% osmium tetroxide for 2 hours. They were dehydrated in graded series of ethanol and embedded in a mixture of Epon-araldate (Anderson and Andre, 1968). Semithin sections

were obtained on a LKB ultratome and stained with toluidine blue and alcian blue-PAS (Boeck, 1984). Ultrathin sections were stained with uranyl acetate and lead citrate (Reynolds, 1963), examined and photographed in JEOL 100 CXII Transmission electron microscope.

RESULTS

Light microscopy:

The deep posterior lingual glands (von Ebner's glands) of camel (Camelus dromedarius) were located under the circumvallate papillae as large groups among the lingual skeletal muscle bundles (Fig. 1). They were consisted of multiple tubuloalveolar secretory portions and an excretory system, that formed of intercalated ducts, excretory ducts and the main duct without interposition of striated ducts.

In semithin sections (Fig. 2), the secretory end-pieces were formed with pyramidal-shaped cells containing rounded nucleus and abundant secretory granules. Myoepithelial cells were identified at the bases of the end-pieces by their elongated nuclei. The intercalated ducts were lined by a single layer of cuboidal or truncated pyramidal-shaped epithelial cells with large nuclei. The large excretory ducts were consisted of two cell layers, basal and columnar or cuboidal epithelial cells, while the main duct was observed lined with stratified cuboidal or columnar epithelium which became stratified squamous at their opening in the gastatory furrow (Fig. 3).

Histochemically (Fig. 4 & 5), the granules of the secretory cells showed intense periodic-acid schiff (PAS) reactivity and slight alcinophilia. These reactions were found in few intercalated duct cells in relativly small amount compared with that of the secretory units. The excretory ducts and the main duct failed to stain. While the secretory products, that observed in the lumina of the secretory unites and ducts exhibited a positive staining.

Electron microscopy:

The secretoy end-pieces of the von Ebner's glands of camel were formed of 5-7 of nearly truncated pyramidal-shaped secretory cells containing abundant secretory granules and somewhat rounded basally located nucleus. These secretory portions were surrounded with myoepithelial cells (Fig. 6,7) and have a central lumen which was provided

with long unevenly distributed microvilli projecting from the apical cell membrane of the secretory cells (Fig. 6,7,8).

Just beneath the lumen the adjacent cells were joined together with zonula occludens and zonula adherens (Fig. 8). Along the nearly straight lateral cell membranes cytoplasmic interdigitations through short processes, that extended into more basally wide intercellular space (Fig. 6,7) were observed in addition to desmosomes (Fig. 8). The lateral intercellular canaliculi were particularly numerous between the secretory cells. They were provided with numerous microvilli and bounded at both ends by zonula occludens and zonula adherens. They were commonly observed containing secretory materials (Fig. 6,9,10). The intercellular canaliculi were sometimes seen communicating with the lumen of the secretory unite (Fig. 10). The basal border of the secretory cells was appeared smooth or slightly wavy and lacking infoldings (Fig. 6,7,11,12). It was attached either to the basal lamina with hemidesmosomes (Fig. 12) or to the interposed myoepithelial cells with desmosomes.

Intracellularly, the secretory cells of the deep posterior lingual glands of camel were characterized by abundant secretory granules filling the apical cytoplasm, supranuclearly located Golgi-apparatus and well-developed rough endoplasmic reticulum. The latter was formed of stacked cisternae paralleling each other in the basal portion (Fig. 11) or distributed among the secretory granules. Few cells were observed containing a greatly distended RER cisternae in addition to the ordinary ones. These distended cisternae contained electron dense materials (Fig. 12). The supranuclearly located Golgi-apparatus was consisted of 1-2 complexes. Each one was formed of 3-5 saccules (Fig. 13). Numerous mitochondria of crista-type possessing long closely packed membranous cristae were randamly distributed throughout the cytoplasm (Fig. 12) or occasionally occured along the lateral cell membranes (Fig. 11). They were mainly appeared elongated or rounded. Moreover, unusual large forms of mitochondria were observed within the cytoplasm of these secretory cells taking nearly the following H-, L-, O-, S-, T- and Y-shapes (Fig. 14 a-f).

Cytoplasmic filaments were noted organized in small bundles mainly in the cell apex and in relation to the secretory granules (Fig. 15). Microtubules were either grouped in small bundles or singly scattered in the cell cytoplasm (Fig. 16). Numerous ribosomes and few lipid droplets were also observed.

The secretory granules which were the more characteristic feature of the secretory cells appeared rounded or ovoid and of varying size occupying most of the cytoplasm. They were consisted of large electron dense core of fine fibrillar or rarely granular material surrounded by an electron lucent marginal zone containing irregularly distributed fine strands. Fusion of these granules was occured only at their marginal zones (Fig. 17). Direct extrusion of them into the lumen (Fig. 18) and into the intercellular canaliculi (Fig. 6,9,10) was commonly observed.

The nucleus of the secretory cells was rounded or ovoid containing a prominant nucleolus, large amount of euchromatin as well as marginal and chromatin islands (Fig. 6,7,12).

The intercalated ducts represent the beginning of the excretory system. They were lined with a single layer of 5-6 cuboidal or truncated pyramidal cells surrounding a somewhat wide central lumen and enveloped by well developed myoepithelial cells (Fig. 19). The transition between the secretory end-pieces and the intercalated ducts was gradual, where it was difficult to determine the point at which the intercalated duct cell begin (Fig. 20). The most characteristic features of these cells were the large nucleus and abundant cytoplasmic filaments. These filaments were arranged singly or in small bundles crossing the cell in all directions but mostly supranuclearly located. Numerous mitochondria, small profile of RER (Fig. 21) as well as ribosomes and Golgi-apparatus were also observed. In addition some intercalated duct cells contained few secretory granules resemble nearly those of the secretory cells (Fig. 19).

The apical cell membranes of the intercalated duct cells were provided with small unevenly arranged microvilli (Fig. 19,20,21) and joined together with zonula occludens and zonula adherens (Fig. 22). Desmosomes in addition to the ill-developed cytoplasmic interdigitations that more basally interposed were observed along the nearly straight lateral cell membranes. The wavy basal border was attached to the basal lamina or to the myoepithelial cells with hemidesmosomes (Fig. 24) or desmosomes respectively.

The nucleus was rounded or ovoid occupying most of the cell (Fig. 19), nuclei with some indentations were also observed. They contained large amount of euchromatin, eccentric nucleoli, marginal and chramatin islands.

The myoepithelial cells:

They were generally observed surrounding the glandular end-pieces (Fig. 23) and the intercalated ducts (Fig. 24) locating between the basal border of the linning cells of these structures and the basal lamina to which they were attached with many hemidesmosomes. They were exhibited the common features of myoepithelial cells as elongated cell body containing the flattened nucleus and many long cytoplasmic processes. These cells were characterized by the presence of bundles of myofilaments, mitochondria, small profile of RER, numerous ribosomes and few lipid droplets.

In addition to the above mentioned distribution of the myoepithelial cells, another unusual relations to the secretory units and to the intercalated ducts were also noted. A myoepithelial cell was observed surrounding with their cytoplasmic processes a secretory cell and the nearby located intercalated duct cell, where their processes were extended into the intercellular space inbetween these cells and/or surrounded their basal border at the same time (Fig. 25). A second form is that, one myoepithelial cell was noted surrounding with their processes two closely located secretory unites (Fig. 26) or an intercalated duct and a nearby secretory unit at the same time (Fig. 27) or the transition between these structures and the closely located secretory unit (Fig. 20). For each of the already mentioned relations one continuous basal lamina was observed surrounding these structures. Another relation was observed, where a myoepithelial cell was located in the interstitial connective tissue paralleling to the basal border of the intercalated duct cells and that of the secretory cells at the same time. In this condition, the basal lamina of the intercalated duct was reflected directly up on this myoepithelial cell or form finger like processes from one side and that of the secretory unit do the same from the opposite side. Consequently, the three structures (intercalated duct, myoepithelial cell and secretory unit) were surrounded by only one continuous basal lamina (Fig. 28).

DISCUSSION

The present investigation revealed that the deep posterior lingual glands (von Ebner's glands) of one humped camel (Camelus dromedarius) were located under the circumvallate papillae. Similar to that observed in the von Ebner's glands of rat (Hand, 1970), man (Azzali et al., 1989a), bat (Azzali et al., 1989b) and bovine (Gargiulo et al., 1995), the paranchyma of the deep posterior lingual glands of camel was composed of tubuloalveolar

secretory end-pieces and an excretory system, which formed of intercalated ducts, excretory ducts and a main duct. The latter opens in the vallum which surrounds the circumvallate papillae.

In accordance with Moustafa et al. (1976) in the same animal as well as Samar et al. (1991) in man, the granules of the secretory end-pieces as well that of few intercalated ducts of the von Ebner's glands of camel showed intense PAS reactivity and slight alcinophilia. On the other hand, studies concerning the carbohydrate histochemistry of these glands give contradictive results. Only PAS positive reactivity was demonstrated in the deep posterior lingual glands of man (Shin & Pak, 1960; Azzali et al., 1989a) and of bat (Azzali et al., 1989b), while Ceballo Salobrena (1975) failed to demonstrate any reactivity in these glands of man. With regard to the problem of classification of the von Ebner's glands. They were considered as serous (Testa Riva et al., 1985: in man; Gargiulo et al., 1995: in Bovine) or seromucous ones (Toyoshima and Tandler, 1986: in rabbit) depending only on their ultrastructure criteria. According to the histochemical classification of the salivary glands by Shackleford and Wilborn (1968), the deep posterior lingual glands of camel were considered as seromucous glands. This was stated by Moustafa et al. (1976) in the same animal, Azzali et al. (1989a) and Samar et al. (1991) in human. Similar conclusions were obtained in the parotid glands of man (Riva and Riva-Testa, 1973 and Riva et al., 1982).

The ultrastructural findings of the secretory cells revealed abundant secretory granules in the apical cytoplasm, well developed supranuclear Golgi- apparatus and basally located rough endoplasmic reticulum which in general agree with the findings of Hand (1970) in rat, Testa Riva et al. (1985) in man and Gargiulo et al. (1995) in Bovine. According to Testa Riva et al. (1985) and Azzali et al. (1989a) in man, it is generally accepted that, these cytological features account for an intense metabolic activity and consequently suggest a proteinaceous secretion of the von Ebner's glands of camel. Blaker et al. (1993); Spielman et al. (1993); Kock et al. (1994b) and Garibotti et al. (1995) supported this suggestion, that the von Ebner's glands produce large amount of lipophilic ligand carrier protein called von Ebner's gland protein (VEGP), which may be essential for the regulation of taste sensation. This protein plays a role in binding and presenting lipophilic gustatory molecules to the taste receptors and it is essential for the effective cleaning the furrows of the vallate and foliate papillae of lipophilic tastants, which otherwise will cause long-lasting taste sensation (Schmale et al., 1990; Kock et al., 1992).

Like that of von Ebner's glands of other species (Hand, 1970; Testa Riva et al., 1985; Gargiulo et al., 1995) as well as some major salivary glands (Tandler et al., 1969; Salem et al., 1995), the basal plasma membrane of the secretory cells of the deep posterior lingual glands of camel lacks folds. This indicate a low salivary flow (Azzali et al., 1989b). A support of this suggestion has been provided by Tandler et al. (1969) who found a correlation between rapid flow of saliva and the number of the basal folds in the secretory cells.

The present study revealed that, the secretory cells possessed abundant intercellular canaliculi. Similar results were reported in rat (Hand, 1970) and man (Testa Riva et al., 1985) as well as in parotid glands of donkey (Salem et al., 1995). The canaliculi were observed containing secretory materials and communicating with the central lumen. This may indicate their possible role in the process of excretion as reported by Azzali et al. (1989b).

The present investigation revealed unusual large forms of mitochondria (H-, L-, O-, S-, T- and Y- shapes) which did not recorded in the available literature neither in the von Ebner's glands of other spieces nor in the major salivary glands.

The metabolic activity of the cells depends up on the number of mitochondria and their cristae (Rhodin, 1974). In the present study, these unusual forms of mitochondria may lead to amplifying their surface area than the ordinary ones and this indicate a high metabolic activity of the von Ebner's glands of the studied animal.

Similar to that mentioned by Testa Riva et al. (1985) in humen, the secretory granules in the present work were consisted of electron dense core of fine fibrillar materials surrounded by marginal zone contains fine strands. Shackleford and Wilborn (1970 b) have interpreted these filamentous structures as mucin molecules which confirms the carbohydrate histochemistry with the ultrastructure in the deep posterior lingual glands of camel.

It is generally accepted that the excretory duct system of the major salivary glands perform an essential role in the formation of the final saliva by ion transport (Kaladelfos and Young, 1974) and or by adding a secretory material to it (Testa Riva et al., 1981). The excretory system of the von Ebner's glands of camel, unlike that of the major salivary glands, is made up of intercalated ducts, excretory ducts and main duct. However, the striated

ducts were absent. Similar findings were reported in the von Ebner's glands of other animals (Hand, 1970; Azzali et al., 1989a; Azzali et al., 1989b; Gargiulo et al., 1995). The absence of the striated ducts was also observed in human labial glands (Tandler et al., 1970), in human (Black, 1977) and rat (Pinkstaff, 1980) palatine glands, in cat zygomatic (Nogueira, 1966) and sublingual glands (Tandler and Poulsen, 1977). It is accepted that their absence is responsible for a production of isotonic saliva. This type of saliva may be very essential for the taste process, as it act as a milie where the interaction between the taste receptor cells and sapid molecules takes place. It can be suggested that this isotonic salvia not effect the taste cell depolarization and consequently the tasting process as a whole.

The general ultrastructural criteria of the intercalated duct cells of the von Ebner's glands of camel resemble greatly those of the von Ebner's glands of other mammals (Hand, 1970; Testa Riva et al., 1985; Azzali et al., 1989a; Gargiulo et al., 1995), as well as those of the major salivary glands (Shackleford and Wilborn, 1970b; Tandler and Poulsen, 1976; Van Lennep et al., 1977 and Salem et al., 1995). Some intercalated duct cells contain few secretory granules as mentioned by the above authors in the von Ebner's glands as well as in mammalin submaxillary (mandibular) glands (Dorey and Bhoola, 1972b), in that of rat (Qwarnstrom and Hand, 1983) and in donkey parotid gland (Salem et al., 1995). In accordance with Testa-Riva et al. (1981) these intercalated ducts seem to play a role in saliva formation by adding secretory materials to it.

The myoepithelial cells were observed surrounding the secretory unites and the intercalated ducts. Like that of other von Ebner's glands, the myoepithelial cells in the present study have the common features as that of major salivary glands. It is generally accepted that the myoepithelial cells as contractile elements (Tandler et al., 1970) exert a pressure on the secretory units as well as the intercalated ducts in order to expul the secretory materials into their lumina (Azzali et al., 1989b), or play a role in the regulation of the flow of metabolities to the glandular cells (Ellis, 1965).

In the present study, the myoepithelial cells have unusual relations to the glandular units as well as to the intercalated ducts, where one myoepithelial cell can surround two units together either two secretory units, a secretory unit and a closely located intercalated duct or the transition between these structures and the closely located secretory unit with a continuous basal lamina. Also the myoepithelial cell was founded locating in the interstitial C.T. between a secretory unit and the intercalated duct at the

same time, where a continuous basal lamina envelope the three structures together. From the above mentioned relations, it could be accepted that a myoepithelial cell do its contractile action at the same time on two closely located units whatever galndular or intercalary ductal cells. In addition this myoepithelial cell may has a regulatory function on the glandular portion and the duct system of studied glands, therefore this point needs further investigation.

Concerning the basal lamina, it would be clear that it surrounds not only a single unite but also it can extend to envelope more than one together.

In conclusion, the von Ebner's glands of camel seems to have the general morphology resemble those of other spieces. Moreover, they were considered as seromucous glands, having a characteristic secretory granules and unusual forms of mitochondria. In addition to the unusual relations of the well developed myoepithelial cells for both the secretory unite and intercalated duct.

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LEGENDS

Fig. 1: Camel tongue: longitudinal section of the circumvallate papilla (P) surrounded by a deep vallum (arrow) in which opens the main duct (arrowhead) of the deep posterior lingual glands of camel. Groups of glands (g) among the striated muscle bundles (m). H & E. X 10.

Fig. 2: Semithin section of the von Ebner's glands of camel showing the secretory portions and their lining cells contain secretory granules and large nucleus. Toluidine blue. X 250.

Fig. 3: Photomicrograph of the distal part of the vallum surrounding the circumvallate papilla (arrow) showing the main duct (asterisk), groups of glands (g). H & E. X 25.

Fig. 4,5: Photomicrograph of the von Ebner's glands showing (4) PAS + ve and (5) alcian blue - PAS + ve reactivity in their secretory end-pieces. X 400.

Fig. 6,7: Electron micrograph of the secretory portion and their lining cells of the von Ebner's glands of camel showing secretory cells arranged around a central lumen (L) which contains secretory materials (asterisk). Microvilli (Mv), secretory granules (Sg), intercellular space (Is), intercellular canaliculus containing secretory materials (arrow), nucleus (N), myoepithelial cells (My), basal lamina (Bl). (6) X 5400 & (7) X 8438.

Fig. 8: Apical portions of four secretory cells demonstrate zonula occludens (Zo), zonula adherens (Za) and desmosome (D). Lumen provided with microvilli (Mv), secretory granules (Sg). X 28,000.

Fig. 9,10: Electron micrograph of intercellular canaliculi (arrow) that provided with microvilli (Mv) and communicated with the central lumen (L) (Fig. 10). Zonula occludens (Zo), zonula adherens (Za), secretory granules (Sg), mitochondria (M). (9). X 28000 & (10). X 8000.

Fig. 11: A secretory cell of the von Ebner's glands of camel showing numerous parallel stacked RER cisternae in the basal portion and mitochondria (M) along the lateral cell membranes. Intercellular space (Is), secretory granules (Sg), nucleus (N), basal lamina (Bl). X 15200.

Fig. 12: A secretory cell revealed greatly distended RER cisternae (asterisk) in addition to the ordinary ones (arrowhead). Mitochondria (M), lumen with microvilli (Mv), secretory granules (Sg), zonula adherens (Za), desmosome (D), nucleus (N), hemidesmosomes (arrows), basal lamina (Bl). X 12000.

Fig. 13: A secretory cell demonstrating Golgi apparatus (Ga). Secretory granules (Sg), mitochondria (M), nucleus (N). X 49000.

Fig. 14 a-f: Electron micrograph demonstrating the unusual shapes of mitochondria (H-, L-, O-, S-, T- and Y-shapes) within the secretory cells of the von Ebner's glands of camel. a & e X 28000; b,c,d & f X 40000.

Fig. 15: Electron micrograph demonstrating cytoplasmic filaments (arrows) in relation to the secretory granules (Sg). Lumen contains secretory materials (asterisk,. zonula adherens (Za), desmosomes (D). X 28000.

Fig. 16: Electron micrograph showing microtubules within the secretory cell (thin arrows). Secretory granules (Sg), mitochondria (M). X 40000

Fig. 17: Electron micrograph of the secretory granules of the von Ebner's glands of camel showing electron dense core (asterisks) and the fine strands in the marginal zone (arrowheads) and the point of their fusion (double arrows). Zonula occludens (Zo), zonula adherens (Za), desmosome (D), microvilli (Mv), lumen (L). X 40000.

Fig. 18: Exocytosis of secretory granules (Sg) into the lumen (L). Microvilli (Mv), zonula occludens (Zo), zonula adherens (Za). X 62100.

Fig. 19: Electron micrograph of an intercalated duct of the von Ebner's glands of camel showing truncated pyramidal-shaped cells, large nucleus (N) and myoepithelial cell (My). Secretory granules (Sg), straight lateral cell membranes (arrows), lumen (L), basal lamina(Bl). X 5400.

Fig. 20: A transition between the secretory portion and the intercalated duct. Nucleus (N), secretory granules (Sg), lumen (L), basal lamina (Bl). Myoepithelial cell surrounds one unit (My1) or extends to enclose a nearby secretory unit (My2) with a continuous basal lamina (arrows). X 54000.

Fig. 21: The apical portion of an intercalary ductal cell demonstrating cytoplasmic filaments (F), mitochondria (M) and RER cisterna (arrowhead), nucleus (N). Lumen (L), microvilli (Mv). X 20000.

Fig. 22: Apical portions of two intercalary ductal cells showing zonula occludens (Za), zonula adherens (Za), and desmosome (D). Lumen (L). X 40000.

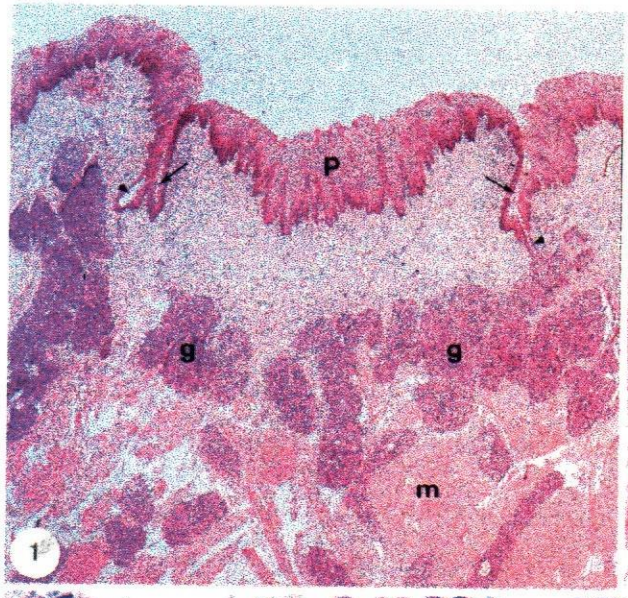
Fig. 23,24: Myoepithelial cells and its process (asterisk) located between the basal lamina (Bl) and the basal border of the secretory cells and the intercalated duct cell respectively. Nucleus (N) of myoepithelial cells, myofilaments (F), mitochondria (M), RER (arrowhead), hemidesmosomes (HD) (23). X 10000 & (24). X 28000.

Fig. 25: A myoepithelial cell (My) and it's processes located between the basal lamina (Bl) and the basal border of a secretory cell (Sc) and that of the intercalated duct cell (Idc). Secretory granules (Sg), lumen (L). X 10000.

Fig. 26: A myoepithelial cell (My) surrounds two secretory unites (A&B). One continuous basal lamina (arrows), nucleus of the secretory unite (N1), nucleus of the myoepithelium (N2). X 5400.

Fig. 27: A myoepithelial cell (My) surrounds both the intercalated duct (left half) and the closely located glandular portion (right half) at the same time. Continuous basal lamina (arrowheads). X 4000.

Fig. 28: Electron micrograph showing myoepithelial cell (My1) located in the interstitial C.T. between the secretory unit (right corner) and the intercalated duct (left corner). One continuous basal lamina (arrows) enclosing the three structures. Finger like process (arrowhead), lumen (L) of the intercalated duct and its myoepithelial cell (My2). Interstitial c.t. (asterisks), nucleus (N) of the secretory unit. X 7830.



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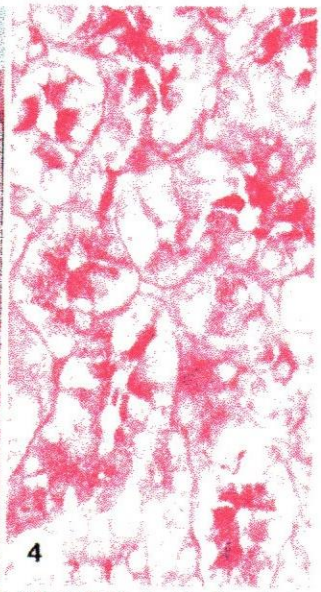

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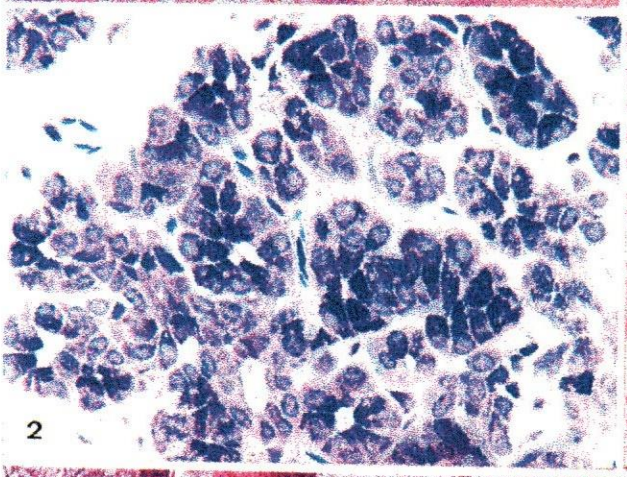

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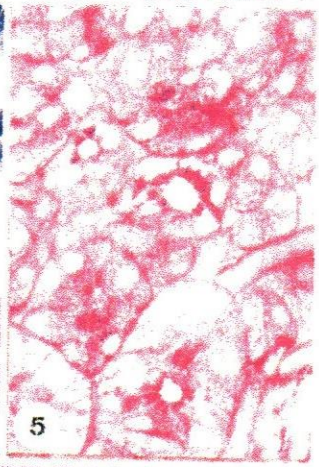

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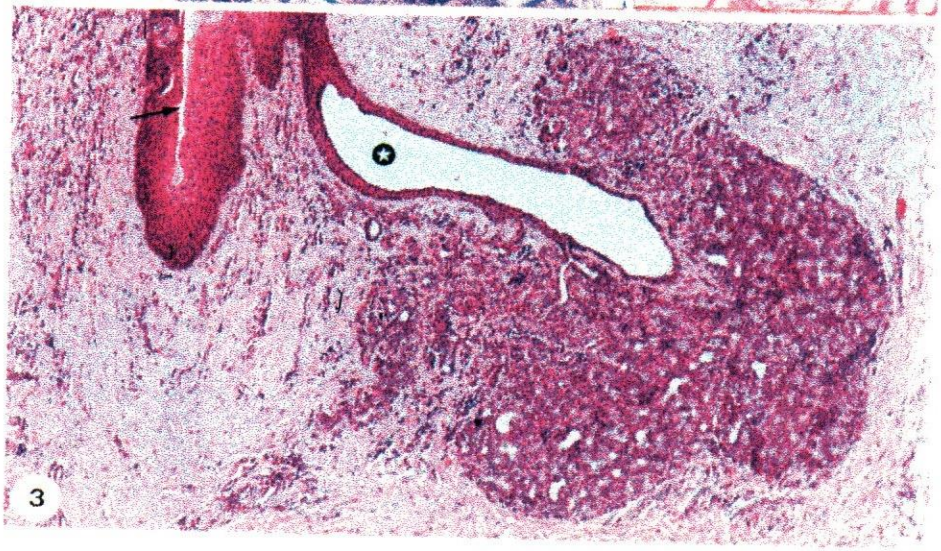

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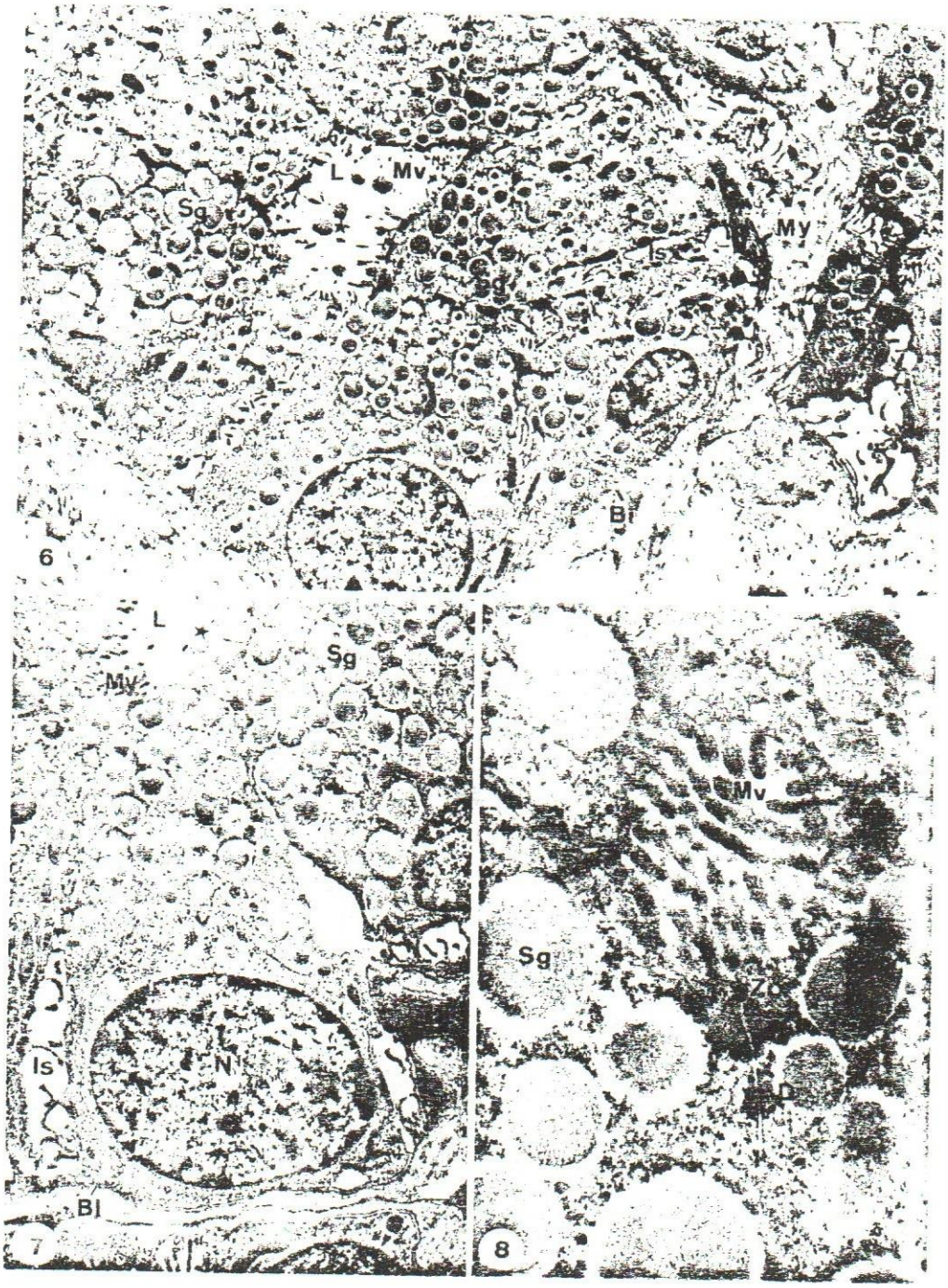
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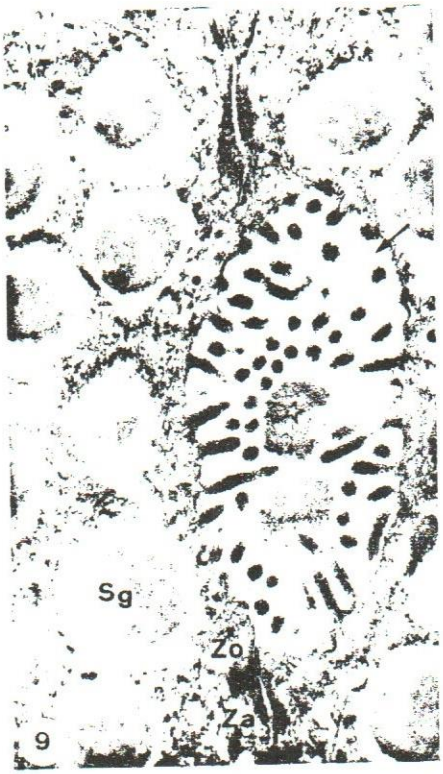

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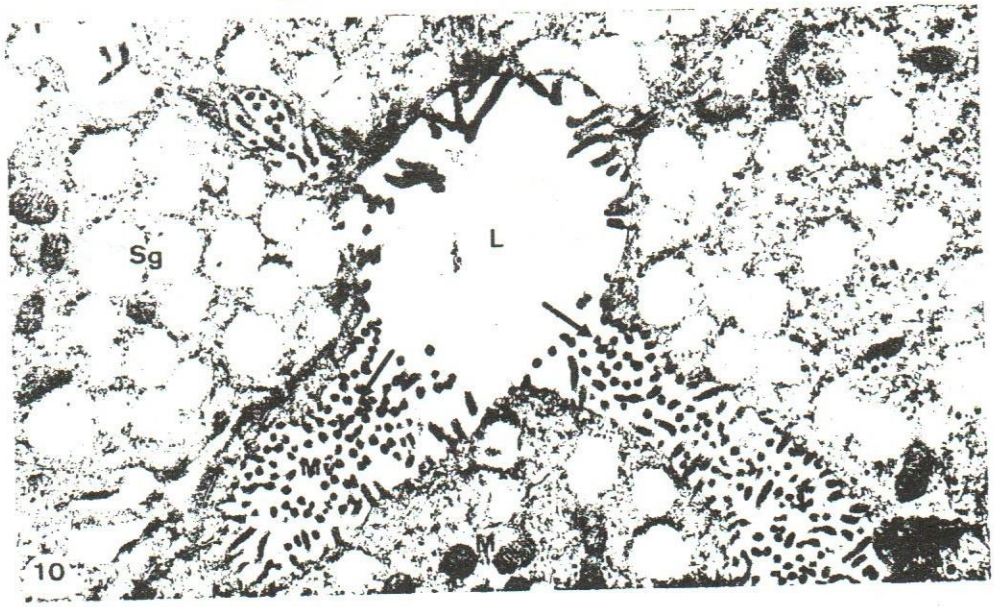

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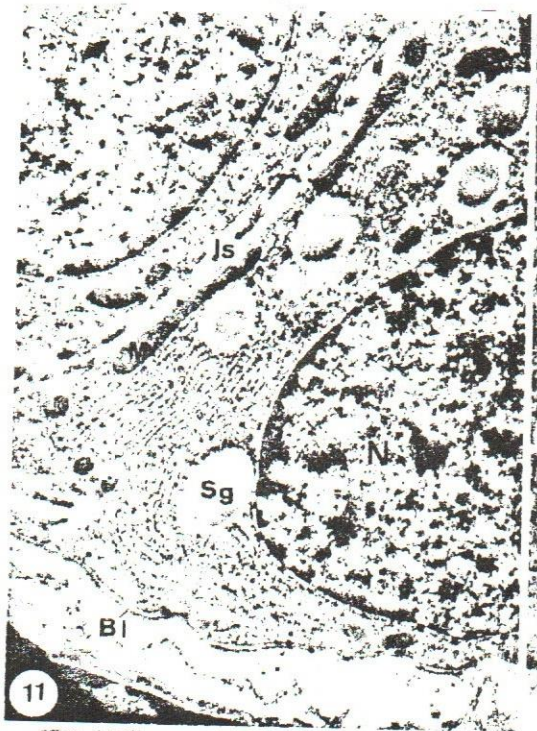

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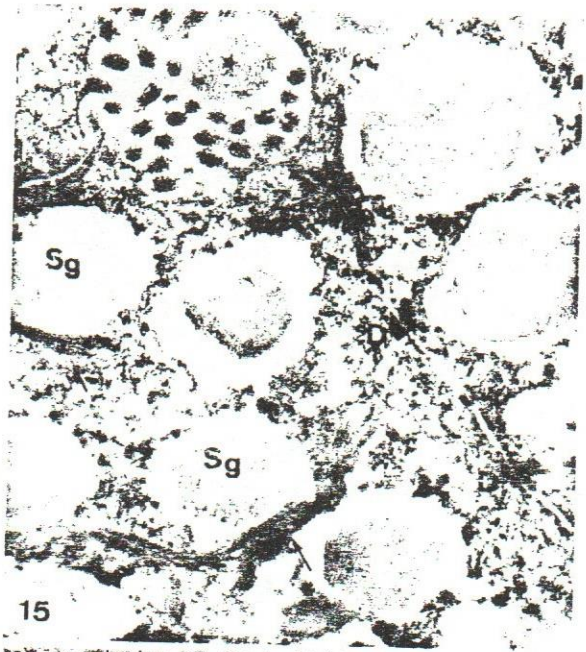

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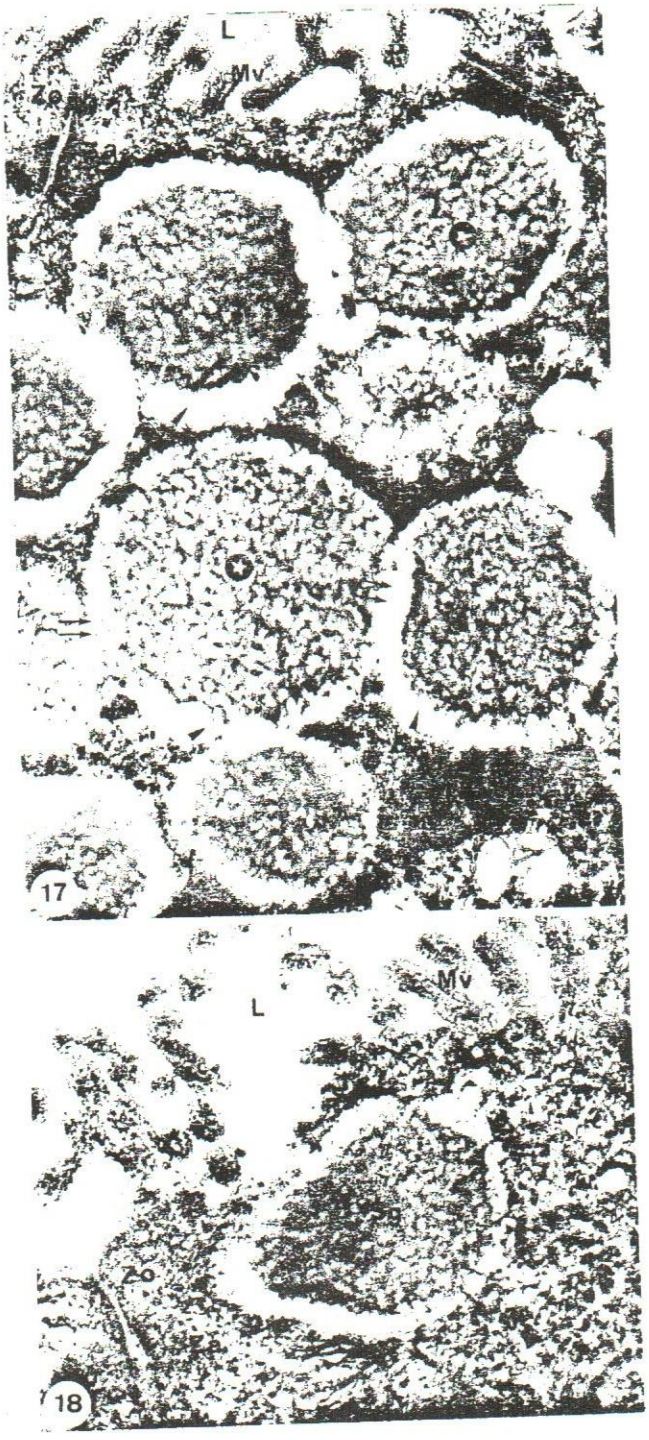
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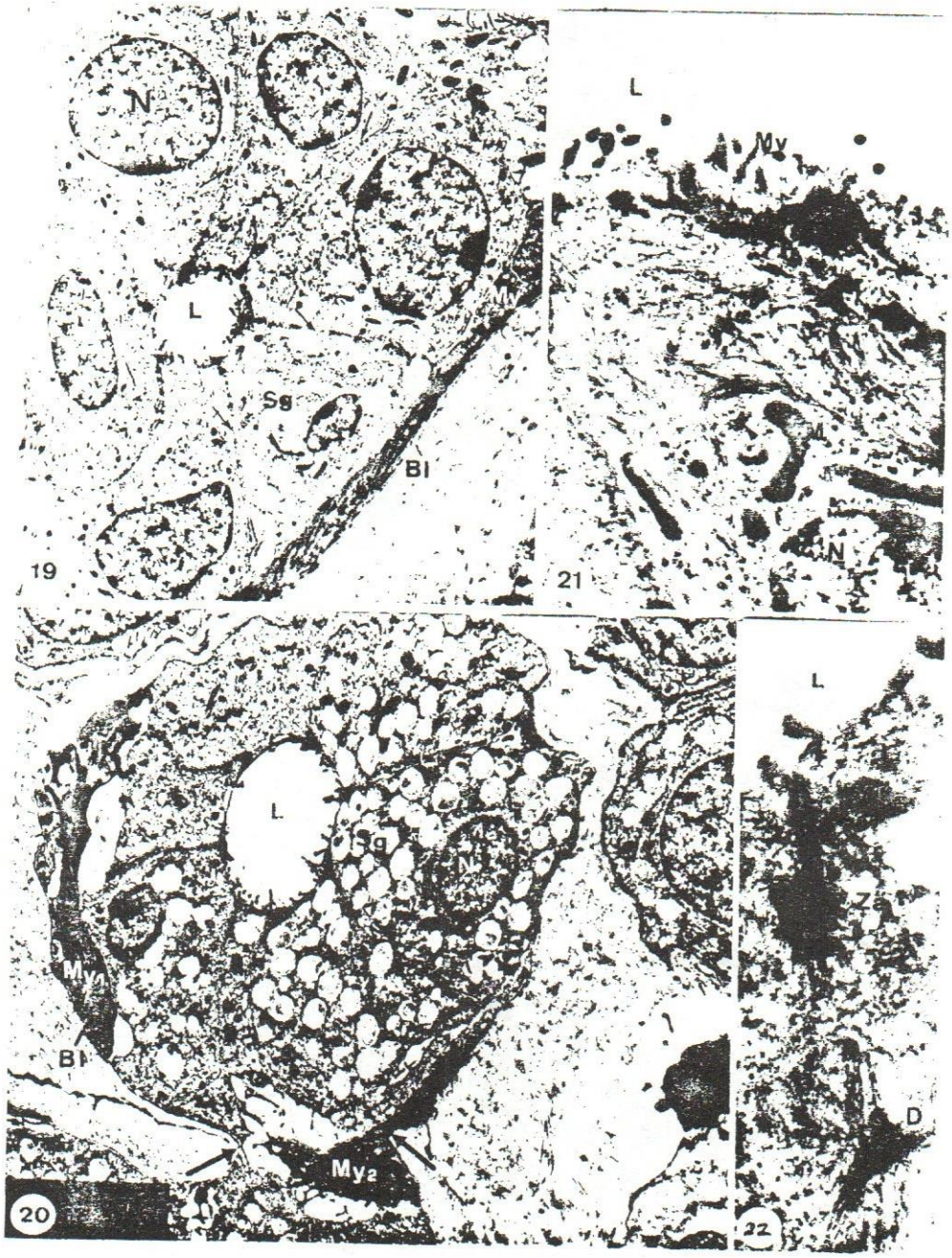
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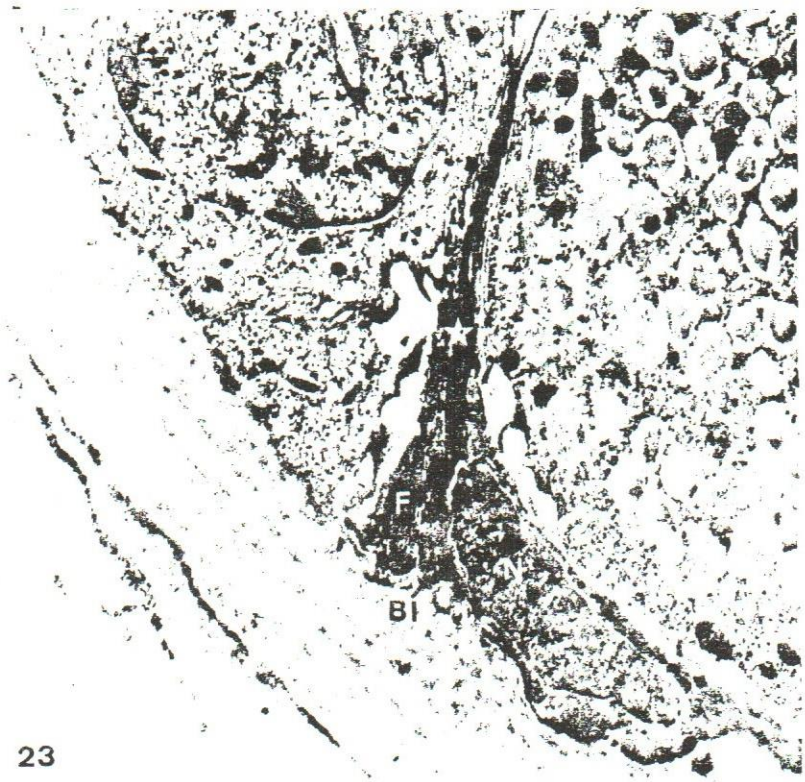

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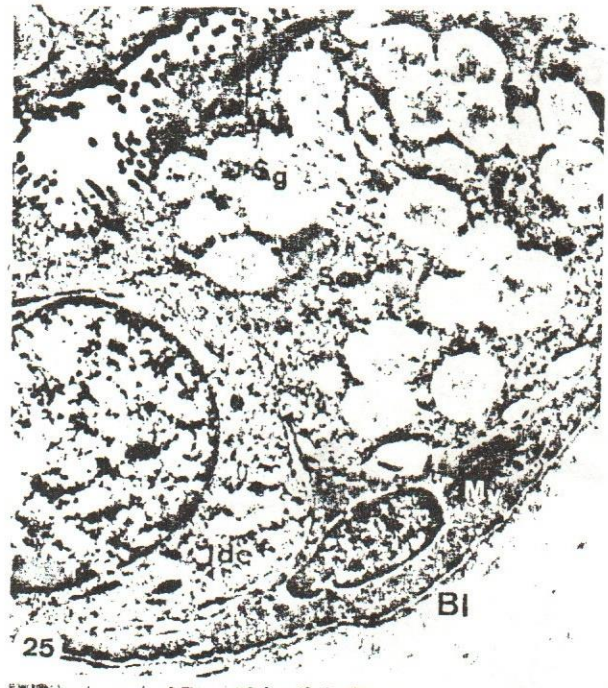

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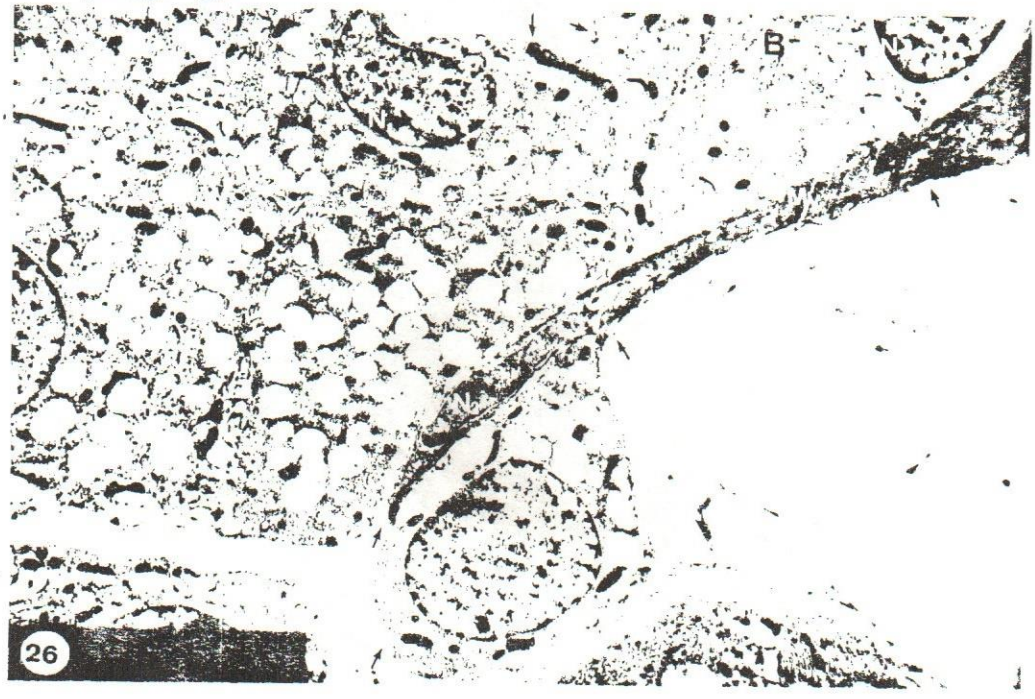

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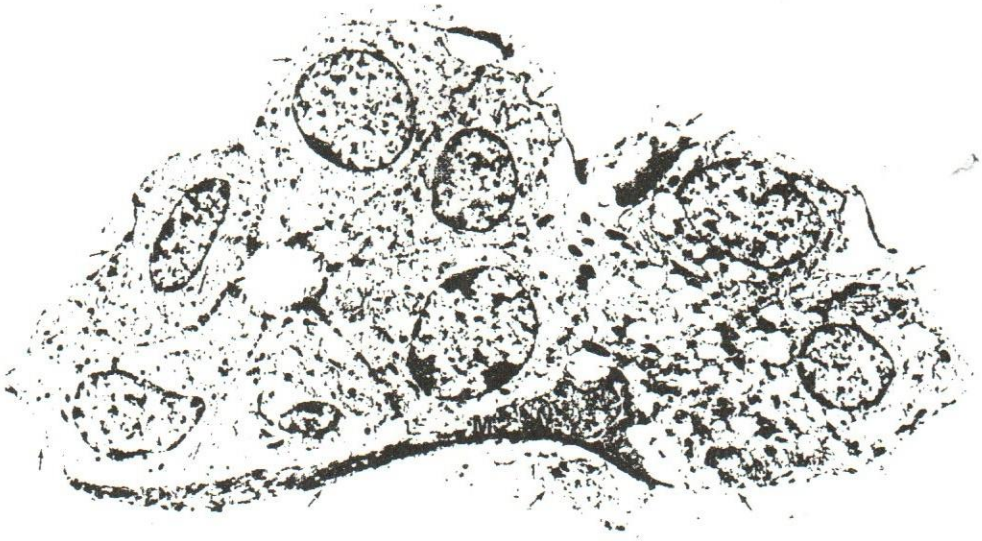

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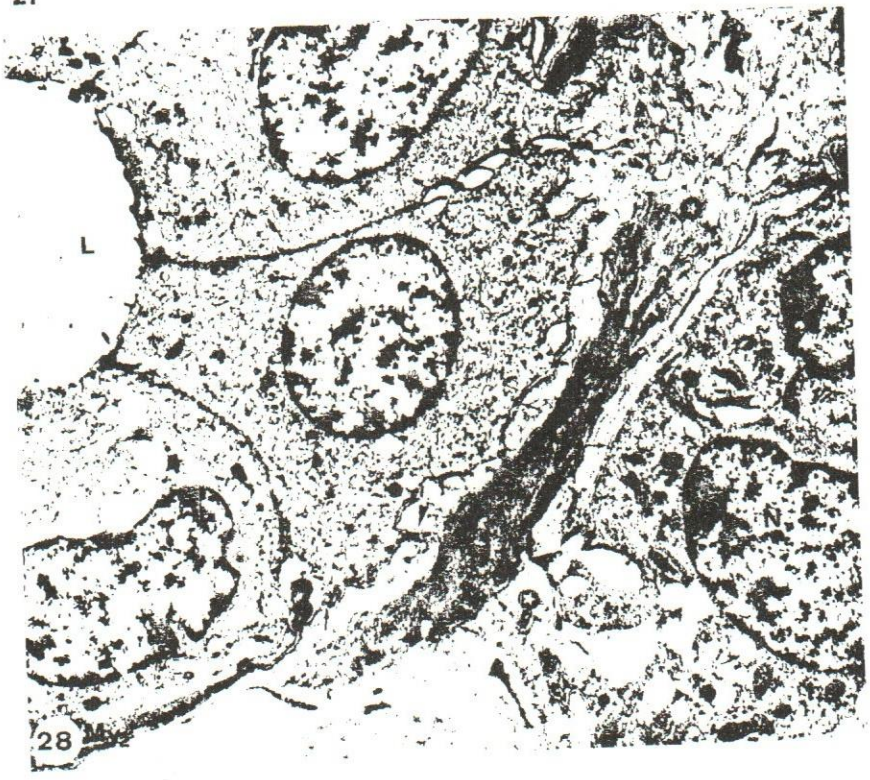

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