Non-keratinocytes of Egyptian Camel (*Camelus dromedarius*)

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Abstract

The skin of five male Egyptian camels (*Camelus dromedarius*) between 10 and15 years old and five male camels between 3 and5 years old were collected and prepared for transmission electron microscopy to study the non- keratinocytes. The melanocytes of camel skin were more numerous in adult camels than in young ones, with a higher number of melanin granules in adults. Merkel cells of camel skin had lobulated nuclei mainly in adult camels, which had also a higher number of dense cored granules than the young ones. But intranuclear rodlets were observed only in young camel skin. The Langerhans cells of adult camel skin were greater in number than in young ones. Round nuclei of Merkel cells were seen only in adult skin. Langerhans cell granules were detected but without a clear racquet shape: rod shapes only could be detected in cross, oblique and longitudinal sections and they were surrounded by a trilaminar membrane. The Langerhans cell granules were few in number inside each cell. All these findings might suggest that the skin is well adapted to protect the animal against harmful effect of the ultraviolet rays of the Egyptian desert environment. This effect mainly increased with age.

Key words

Non-keratinocytes, Melanocytes, Merkel cell, Langerhans cell, camel, skin.

Introduction

In prior years the skin of camels has been examined because of the importance of the integument in body temperature regulation in an animal adapted for desert life (Lee and Schmidt-Nielsen, 1962; Ghobrial, 1970).It represents a key site for the regulation of water balance and thermoregulation in desert-adapted mammals (Pfeiffer et al.,2006). At the histological level, the epidermis can be considered relatively thin in the camel (Lee and Schmidt-Nielsen, 1962).

Melanocytes are derivatives of neural crest ectoderm located in the basal layer of epidermis. They have spherical nuclei, ribosomes and endoplasmic reticulum (Frappier and Eurell 2006). Melanocytes lack desmosomes and tonofilaments but they possess long branching processes that extend between keratinocytes (Nanci and Tencate, 2008). Melaninis synthesized within melanocytes as small structures called melanosomes. In normal skin the ultrastructure of melanosomesis usually related to the type of melanin they produce (Hearing et al., 1973 & Jimbow et al., 1979).

The Merkel cell, first described by Merkel in 1875, is a receptor-like cell widely distributed in the epidermis, in the oral epithelium and in the dermal sensory corpuscles of various vertebrates (Munger, 1975& 1977).The Merkel cell is an epidermal cell with neuro-endocrine properties. It is currently considered to be of epithelial origin (Moll & Franke, 1984). Winkelmann (1977) found that the Merkel cell is a neural crest migrant to the skin, and it possesses a characteristic intranuclear-rodlet, cytoplasmic membrane bound granules, and spiky projections;it is usually associated with nerve terminations. Numerous spiny processes extending from the Merkel cell are intercalated with adjacent keratinocytes, which may detect and amplify movement of adjacent cells. These spiny processes contain a rigid core of parallel microfilaments interrelated with cytoplasmic filament bundles located beneath the cell membrane (Garant et al., 1979). The synaptic contacts of Merkel cell with nerve endings and accumulation of the specific cored granules in the cytoplasm seem to indicate that the cell releases some neurotransmitter (Tachibana and Nawa, 1980), Straile et al. (1975), described the intranuclear rodlet of the Merkel cell as similar to that of other neuronal cells. Merkel cells are sometimes considered as touch receptors and they have been identified as isolated cells in the dermis without obvious neural connections (Troy and Callender, 1994). Merkel nerve endings are mechanoreceptors in the mammalian skin. They consist of large, pale cells with lobulated nuclei forming synapse-like contacts with enlarged terminal endings of myelinated nerve fibers. Cytoskeletal filaments consisting of cytokeratins and osmiophilic granules containing a variety of neuropeptides are found in Merkel cells (Halata et al., 2003).

Langerhans cells occupy only the suprabasal layers; all of the basal layer clear cells as seen with conventional staining routines are melanocytes, (Breathnach, 1980). They cannot be observed quite commonly in the basal layer by both light and electron microscopy. He added, that the term “nonkeratinocytes” specifies an epidermal cell that is not of prime ectodermal lineage and that does not undergo keratinization or desquamation. On the other hand Snell (1964) stated that the dendritic cells in the basal layer of epidermis of the black guinea-pig could be

recognized by the fact that they were lying free between adjacent keratinocytes and the basement membrane and did not possess desmosomes or hemi-desmosomes. The cytoplasm contained notonofilaments but many mitochondria and there was a well-developed Golgi complex. He added that they were non-pigmented cell with a deeply indented nucleus and characteristic rod-shaped granules in the cytoplasm. The dendritic processes were well developed. Jimbow et al., (1969) distinguished them from surrounding keratinocytes by the clear cytoplasm, devoid of tonofilaments and the absence of desmosomes along the plasma membrane, as well as the indented nucleus, and numerous rod and racquet-shaped granules. Some of these rod-shaped granules open to the extra cellular spaces. The Birbeck granules are membrane bound, rod shaped 15-50 nm long, 4 nm wide, with a central linear density and faint striations radiating from the linear density to the limiting membrane. Those granules are of unknown function. These granules are also called Langerhans granules and vermiform granules. Langerhans cells participate in the cutaneous immune response and migrate from skin to lymph nodes. They possess surface receptors common to macrophages and function as antigen presenting cells to T or B lymphocytes. Langerhans cell serves to fix and process cutaneous antigens (Siena et al., 1995).Ginhoux et al., (2006) reported that Langerhans cell are stem cells that originate from pluripotent hematopoietic progenitor cells in the bone marrow. As immature cells Langerhans cell migrate to non- lymphatic tissues, such as skin, where they finish their maturation by expression of specific molecules and formation of the Birbeck granules (Koch et al. 2006). The Birbeck granules, characteristic structures in the Langerhans cell, are described as para-crystalline, membrane-bound, disc-shaped bodies, located preferentially between the cell membrane and the Golgi apparatus (Holibka 1998). Langerhans cells belong to the skin-associated lymphatic tissue (SALT), (Streilein et al., 1999). They are antigen presenting cells derived from monocyte precursors in the bone marrow (Gorosova et al., 2008). Exposure to ultraviolet- B radiation impairs cellular immune responses. This immunosupression seems to be associated with Langerhans cell migration (Kolgen et al., 2003). The immunosupression caused by ultraviolet radiation is associated with the disappearance of antigen-presenting cells (Langerhans cells) from the epidermis (Sontag et al., 1995).

Aim

Despite the work that has been done in other species, there is insufficient information about camel non-keratinocytes, their migration and location in the skin. Therefore this study aimed to demonstrate the distribution and locations of Melanocytes, Merkel cells, and Langerhans cells in the skin of the camel in or-

der to better understand their ultrastructure and their involvement in the skin function and protection of camel related to the desert environment. This understanding may have significance in veterinary therapies for this species, an economically important one in the Middle East.

Material and Methods

The present study was done on the skin of five male Egyptian camels (*Camelus dromedarius*) of 10-15 years'age and five male camels of 3-5 years' age. The specimens were collected from Kom-Hamada slaughterhouse. Specimens were taken from examined camels for any pathological changes and only the apparently healthy ones were selected. Specimens were mainly taken from the sides of the back portion 10 cm under the hump.

Fresh skin samples were collected, fixed in 10% buffered neutral formaldehyde (Bancroft and Stevens, 1979) for 48 hours, and then dehydrated in ascending grades of ethyl alcohol. They were cleared in xylene and embedded in 3 changes of paraffin wax. The paraffin blocks were cut at 5 um thickness and stained by hematoxylin and eosin (Harris, 1900).

Pieces of $1MM^2$ were cut from the skin and quickly fixed in 6% solution of phosphate buffered gluteraldehyde pH 7.4 for 6 hrs. at 4ºC, (McDowell and Trump, 1976).

After initial fixation, the tissues were washed in several changes of cold (4ºC) 0.1 M phosphate buffer every 15 minutes for 2 hrs.

The tissues were post fixed in a 1% solution of osmium tetroxide in cold (4ºC) 0.1 M buffer pH 7.2 for 2 hrs. Then, they were rapidly dehydrated through ascending grades of ethyl alcohol then transferred to propylene oxide and placed in a 1:1 mixture of propylene oxide and epoxy araldite, (Hayat,1986).

Semi- thin sections (1µm) were cut firstly and stained with toludine blue and viewed with light microscope to select the suitable areas for the electron microscope examination.

The ultrathin sections (60-100 nm) were cut by a glass knife with LKB microtome, and then they were stained with uranyl acetate followed by lead citrate (Hayat, 1986).These sections were examined with Joel 100 CX electron microscope operating at 80Kv.

Results

Melanocytes of the camel epidermis were spherical to oval in shape and located mainly in the basal layer of the epidermis. They had branching processes extended between neighboring keratinocytes (Fig.3). The cytoplasm of the melanocytes had numerous melanin granules (Fig.1) with different shapes and electron densities. Some granules were oval in shape and others were elongated. Three types of melanin granules could be recognized: elec-

tron dense granules, electron lucent granules, and mixed granules containing electron dense and electron lucent particles (Fig.4). Some melanin granules were surrounded by a halo of ribosomes (Fig.5). Sometimes melanin granules could be observed among tonofilaments of keratinocytes, and a few of them were enclosed by a membrane (Fig.6). Free ribosomes and some rough endoplasmic reticulum were observed in the cytoplasm of melanocytes (Fig.5). No desmosomes could be seen between melanocytes. The nuclei of melanocytes were oval in shape with clumps of condensed chromatin and indented nuclear envelop (Fig.7). There was no difference in the shape and structure of melanocytes in young and adult camel skin except the higher number of cells in the adult camel skin (Fig.1) compared to young camel skin (Fig.2) and the more numerous melanin granules in the adult melanocytes (Fig.8).

Merkel cells were oval or rounded and mainly located in the basal layer of the epidermis. Merkel cells were unstained with light cytoplasm (Fig.1). Some free ribosomes, mitochondria, lysosomes and vacuoles could be seen in the cytoplasm of Merkel cell. Occasionally we could find melanin granules, mainly in adult camels (Fig. 9&10). The nuclei were ovoid with some lobulations which were more clear in the adult animals as well. Merkel cell granules were electron dense cored and membrane bounded, were relatively uniform and mainly concentrated at the periphery of the cytoplasm (Fig.11). These granules were few in young aged skin and numerous in aged ones. Intranuclear rodlets could be seen mainly in young camel skin (Fig.12).

Cytoplasmic extensions of Merkel cells were short. The cytoplasm contained dense-cored granules mainly concentrated in the cytoplasmic processes. Round perinuclear aggregates of cytoplasmic intermediate filaments and microfilaments may be seen (Fig.13).

Langerhans cells were located basally and suprabasally in the epidermis (Figs.1&2). Their cytoplasm was electron lucent, lacked tonofilaments and no desmosomes could be seen along the cell membrane (Fig.14). The cytoplasm contained specific granules with a trilaminar-membrane. These granules were mainly seen in cross section and sometimes in longitudinal section (Figs.15&17). The cytoplasm contained the usual cell organelles such as mitochondria, Golgi apparatus, lysosomes, rough endoplasmic reticulum and free ribosomes (Fig.16). Langerhans cell granules were mainly found in the periphery of the cells. No melanin granules could be seen in the cytoplasm. Cytoplasmic processes were observed in the intercellular spaces between keratinocytes and recognized by the light cytoplasm. The nuclei of Langerhans cells were ovoid, indented or kidney-shaped and sometimes lobulated (Fig.18&19). The cells of adult epidermis did not differ too much from those in the young ani-

mals, but the number of cells in adult skin was greater than that in young ones, and the oval or sometimes round nuclei were seen only in adult skin (Fig.19).

Discussion

In the present study we found that melanocytes of the epidermis of young and adult camel were spherical and oval in shape and located in the basal layer of epidermis. In human skin, Yamaguchi (2007) observed that melanocytes were localized at the dermal / epidermal border in a regularly dispersed pattern, each melanocyte in the basal layer of the epidermis functionally connected to underlying fibroblasts in the dermis and to keratinocytes.

Melanocytes of young and adult camels had several processes containing numerous melanin granules extended between neighboring keratinocytes. Snell and Bischitz (1959) found the same results in Guinea pig epidermis in which dendritic processes of melanocytes were sandwiched between adjacent keratinocytes.

No desmosomes were found between melanocytes and adjacent cells, Birbeck (1962) revealed that the absence of desmosomes and lack of adhesions between melanocytes and adjacent cells might be explained by melanocytes' thrusting their processes between keratinocytes. We detected some melanin granules among tonofilaments of keratinocytes. Charles and Ingram(1959), postulated a cytocrine secretion of melanin granules from the melanocytes to keratinocytes secondary to the breakdown of cell membrane.

We observed that melanin granules had different shapes and densities. Electron dense granules and mixed granules containing electron dense and electron lucent parts (in addition to electron lucent granules) were found in young and adult camel skin. Charles and Ingram(1959) noticed in human melanocytes a periodic structure in granules consisting of alternating dense and light bands.

The most important mechanism of skin protection from UV rays is stratum corneum thickening and melanin synthesis by melanocytes (Diffey, 1997 and Watab et al., 2004). This presumably explains the increased number of melanocytes in adult camels and also the numerous melanin granules at this age. An older animal is subjected to a lot of sun light during the long sunny days in the desert environment. Because UV radiation leads to the increasing of differentiated melanocytes in skin by the induction of tyrosinase, it can also be predicted that mitotic melanocytes activity is accelerated (Magnus,1976).

In this study Merkel cells were clear oval or rounded cells and mainly located near the basal layer of the epidermis. Hashimoto, (1972) reported that Merkel cells might found individually in the basal layer of epidermis or occasionally above the basal layer. He added that the nuc-

leus was usually lobulated and in our study, the nuclei were ovoid with some lobulations which were clearer in the adult age.

The intranuclear rodlet of the Merkel cell, which was first described by Fortman & Winkelmann (1973), is similar to that of other neuronal cells. They were rarely seen in the nuclei of Merkel cells, and then only in young camel skin and could not be found in adult camel skin.

Merkel cell granules were electron dense and membrane bounded, relatively uniform and mainly concentrated in the cell side and in the cytoplasmic processes. These granules were few in young skin and numerous in old ones. These granules were recorded by Hashimoto, (1972) and described as membrane –surrounded dense granules which may be derived from Golgi saccules. Troy and Callender, (1994) found that the dense-cored granules of Merkel cells were characteristically concentrated in the cytoplasmic processes of the cells, while Breathnach and Robins, (1970) & Halata et al., (2003) found that they were accumulated near the junction with the nerve fiber. In our study we could not find nerve fiber attachment with the epidermal Merkel cells as which previously reported by Halata & Munger, (1981) when they found the same result, on very rare occasions in dermal Merkel cells. This may suggest that epidermal Merkel cells of camel may be not largely involved as mechanoreceptors and they may be acting mainly as endocrine cells. Cells in the skin with a similar appearance as Merkel cells, but without contact to nerve terminals, are probably part of a diffuse neuroendocrine system and do not function as mechanoreceptors. Probably these cells rather than those acting as mechanoreceptors are the origin of a highly malignant skin cancer (Halata et al., 2003). The Merkel cell was presumed to be involved in not only mechanoreception but also endocrine or paracrine functions (Yoshie et al., 1990).

On the other hand, Moll et al., (1986) suggested that in subsequent stages of skin development some epidermal Merkel cells detach from the epithelium and migrate into the upper dermis where some of them may associate with small nerves.

In this study, occasionally we could find melanin granules in the cytoplasm of Merkel cells, and this agreed with Hashimoto, (1972) who reported that Merkel cells contained lysosome-like dense bodies and transferred to melanosomes.

The surface of Merkel cells is equipped with protoplasmic protrusions anchoring them between keratinocytes (Halata and Baumann, 2000) and this agreed with the results obtained in this study in which Merkel cells of camel epidermis had short cytoplasmic processes intertwined in between the keratinocytes. These appeared as light areas of cytoplasm containing the dense-cored granules.

Occasional desmosomes might connect the Merkel cell to the neighboring keratinocytes in camel epidermis. This result agreed with the result of Hashimoto, (1972). The presence of desmosomal contacts between Merkel cells and keratinocytes was interpreted as support for the ectodermal origin hypothesis of Merkel cells (Munger, 1965). Merkel cells were also highly adapted for detection of movement in adjacent keratinocytes, as well as movement of the epithelium with respect to underlying connective tissue, (Garant et al., 1979).

Langerhans cells of the epidermis of camel were similar to those described in other mammals (HollisandLyne, 1972; Wolff, 1972; Khalil et al., 1982 and Romano and Balaguer, 1991) including the electron lucent cytoplasm, without tonofilaments, desmosomes or melanosomes with a dendritic processes and the indented or occasionally lobulated nucleus. Langerhans cells of camel were located in the basal and suprabasal layer of the epidermis and this agreed with Khalil et al., (1982) in cattle skin; and Romano and Balaguer (1991) in swine skin, but disagreed with the result of Hollis and Lyne (1972) in sheep skin where it observed only in the basal layer.

Romano and Balaguer (1991) observed that swine epidermal Langerhans cells possessed the specific trilaminar rod or racquet-shaped (Birbeck) granules in varying numbers, but not as numerous as those reported in man. On the other hand, in our study the Langerhans cell granules were found in the skin of camels but not with a clear racquet shape. We reported only rod shaped granules with cross and longitudinal sections with a trilaminar membrane. So we suggest that camel skin has rod shaped Langerhans cell granules. No single descriptive term could explain the full range of shapes assumed by the granules of Langerhans cell. Therefore, a more adequate term would be simply “Langerhans cell granule” which implies the variety of shapes that might be encountered (Sagebiel and Reed,1968). In camel skin Langerhans cells granules were not numerous and may be fewer in number than those of swine as described by Romano and Balaguer (1991). The low number might be due to the UV rays in the desert environment in which the camel lived. Silberberg et al., (1976) found that Langerhans cells migrate from skin to lymph nodes under normal conditions and this migration may be accelerated in an immune reaction. According to Oaklander et al., (2003),the number of Langerhans cells reportedly increased in inflamed human skin and it was not known whether this increase occurred when chronic pain was due to neural injury rather than tissue injury. He added that the Langerhans cell count did not vary according to gender and age. Loss of epidermal innervations did not influence the number of Langerhans cells. While studies in humans had shown a decreased Langerhans cell

density with age, it is difficult to control for the effect of ultraviolet light in human studies, since ultraviolet light has a significant effect on Langerhans cells (Choi and Sauder, 1987). Bacci et al., (2001) gave a possible explanation that ultraviolet rays impair ultraviolet B radiation susceptible mice by immobilizing Langerhans cells transiently in the epidermis and upper dermis, thereby preventing their timely migration to draining lymph nodes.

The number of Langerhans cells in adult camel skin was greater than that of young ones but this result disagreed with the result of Choi and Sauder (1987), where they found that aged mice had approximately two-thirds the number of Langerhans cells that young animals did. Although the aged animals demonstrated increased variability in their responsiveness there was no overall difference in cutaneous immunoreactivity between the two age groups.

Oaklander et al., (2003) said that the number of Langerhans cells is unrelated to the presence or severity of pain, while Oota (1999) showed that Langerhans cells play an essential role in the differentiation of the epidermis. On the other hand, Gorosova et al., (2008) found that Langerhans cells seem to participate in skin disorders related to hypersensitivity and even tumor transformations. Distribution of these cells may play a role in disease predispositions and knowledge of the physiology and pathophysiology of Langerhans cells opens possible targeted treatments in veterinary medicine.

Conclusion

From this study we can conclude that:

1- Melanocytes of camel skin are more numerous in adult camels than in young ones, with a higher number of melanin granules in adults; and this suggests a skin protection mechanism from the excessive ultraviolet rays from the sun light in the desert which increases melanocyte differentiation and accelerates their mitotic activity.
2- Merkel cells of camel skin had lobulated nuclei mainly in adult camels, which had also a higher number of dense cored granules than the young one. But intranuclearrodlets were observed only in young camel skin which in addition to the absence of nerve endings suggests that Merkel cells of camel are not largely involved as mechanoreceptors but are more likely endocrine cells.
3- The Langerhans cells of adult camel skin were greater in number than in young ones and this may be due to the bad effect of the ultraviolet rays with a long exposure time. Round nuclei were seen only in adult skin. Langerhans cell granules were detected but without a clear

racquet shape, so they might be rod shaped only; and they were surrounded by a trilaminar membrane. The Langerhans cell granules were few in number and this might suggest the harmful effect of the ultraviolet rays of the Egyptian desert environment.

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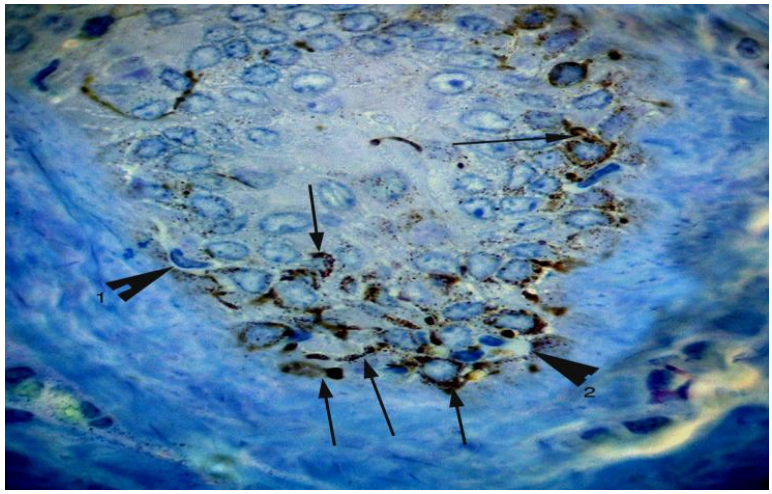


Fig (1): A photomicrograph showing the high amount of melanin granules (arrows) in the epidermis of adult skin camel, the Merkel cell (arrow head 1) and the Langerhans cell (arrow head 2). (Toludene blue stain, semithin section. Mic.Mag. X 1000).

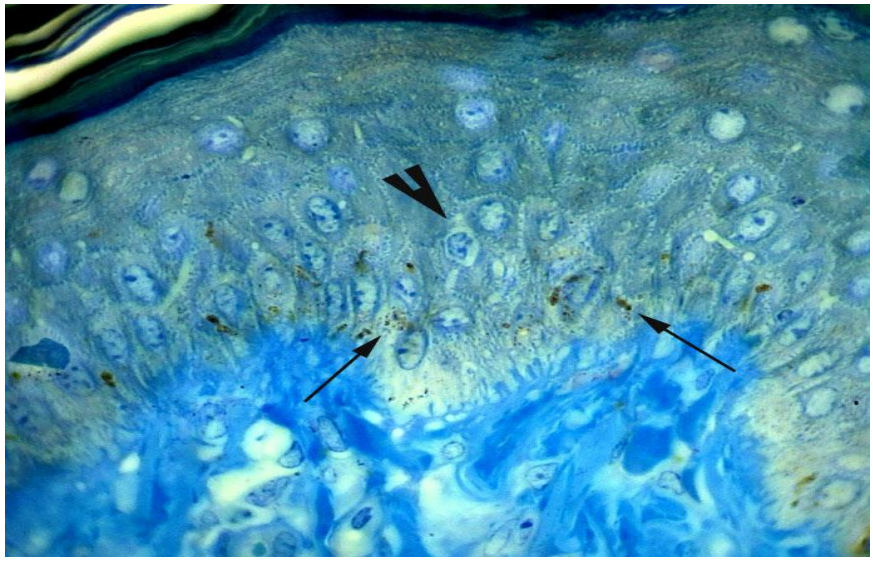


Fig (2): A photomicrograph showing the low amount of melanin granules (arrows) in the epidermis of young skin camel, and the Langerhans cell (arrow head). (Toludene blue stain, semi-thin section. Mic. Mag. X 1000).

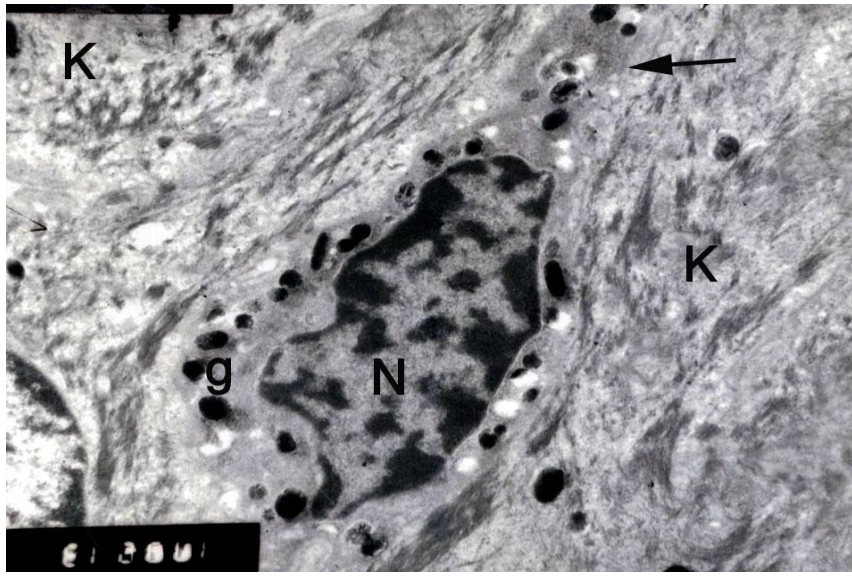
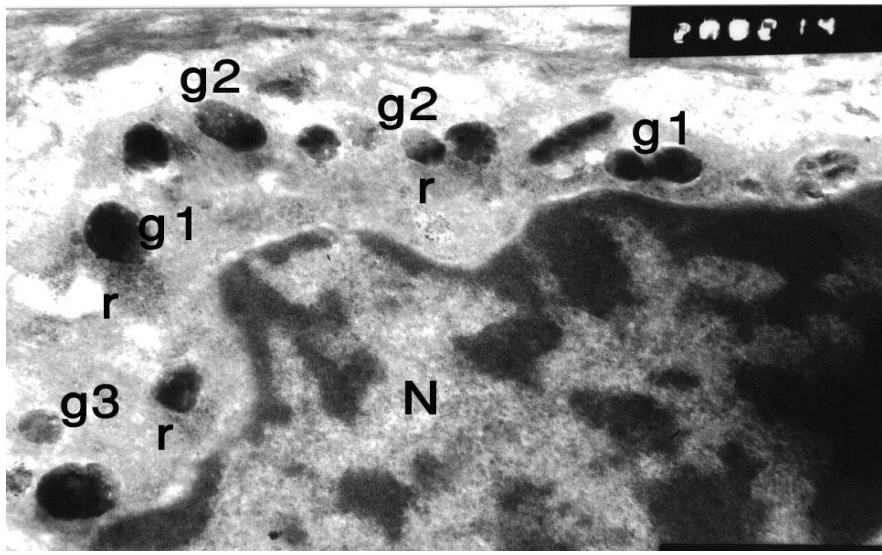
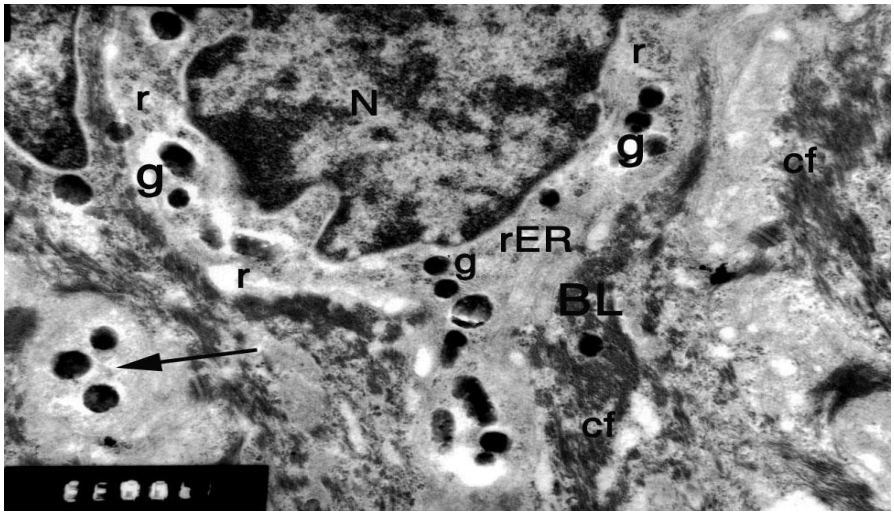


Fig (3): Transmission electron micrograph of the skin of young camel showing one melanocytes with a dendritic process (arrow). Many melanin granules (g), the nucleus of the cell (N) and keratinocytes (K) around it.(Mic. Mag. X 10000).



Fig(4): Higher magnification transmission electron micrograph of the previous melanocyte denoting three types of melanin granules, electron dense granules (g1), mixed melanin granules (g2) and electron lucent granules (g3). Note a hollow of ribosomes (r) surrounding melanin granules, nucleus (N). (Mic. Mag. X 20000).



Fig(5): Transmission electron micrograph of another melanocytes in the skin of young camel, lying on the basal lamina (BL). The cell contains numerous melanin granules (g) of different shapes, sizes and electron densities. Few rough endoplasmic reticulum (rER) and some free ribosomes (r) could be seen inside the cytoplasm. The cell has a cytoplasmic process (arrow) with the same granules. The nucleus (N) is indented and collagen fibers (cf) under the basal lamina could be seen. (Mic. Mag. X 13000).

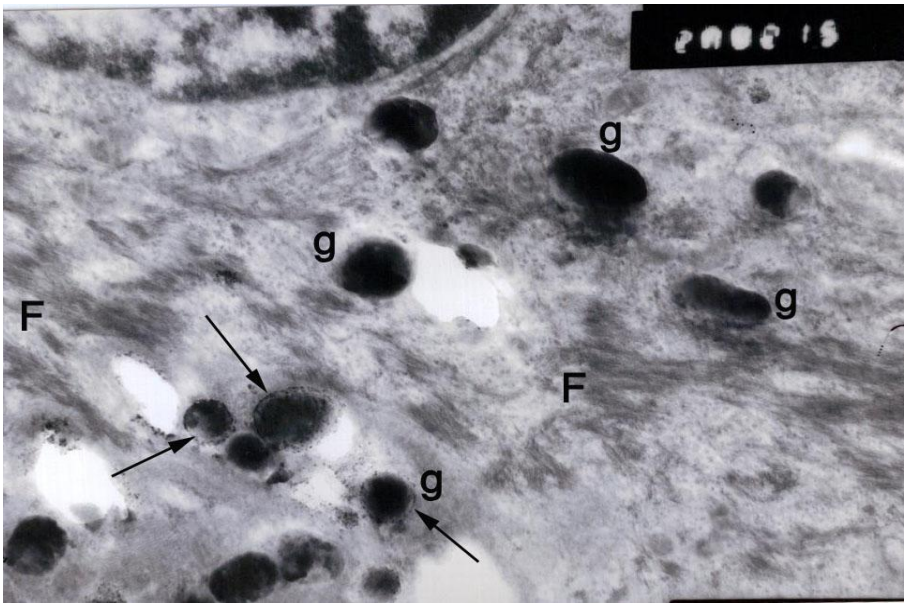


Fig (6): Transmission electron micrograph showing the lower part of one melanocytes from the skin of young camel and some melanin granules (g) are found among the tono-filaments (F) of the keratinocytes. Note that few melanin granules are enclosed by a membrane (arrows). (Mic. Mag. X 15000).

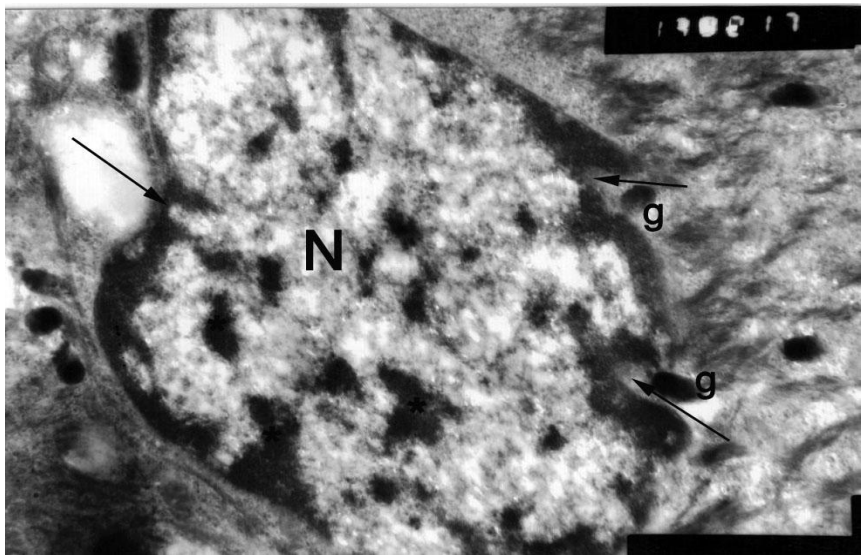


Fig (7): Transmission electron micrograph of a young camel epidermis showing a melanocytes having an oval nucleus (N), with clumps of condensed chromatin (asterisks) and indented nuclear envelop (arrows). Few melanin granules (g) could be seen. Note the absence of desmosomes. (Mic. Mag. X 13000).

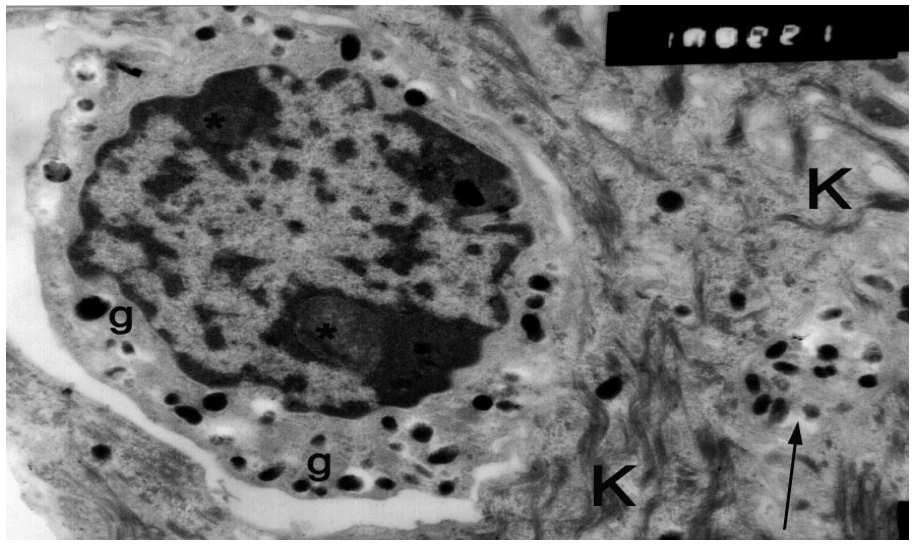


Fig (8): Transmission electron micrograph of the adult camel skin melanocytes showing numerous melanin granules (g) of different shapes, sizes and electron densities, the nucleus having large clumps of condensed chromatin (asterisk). Cytoplasmic processes of melanocytes (arrow) are found between the keratinocytes (K). No desmosomes could be found between the keratinocytes (K). No desmosomes could be found between the melanocytes and the neighboring cells. (Mic. Mag. X 10000).

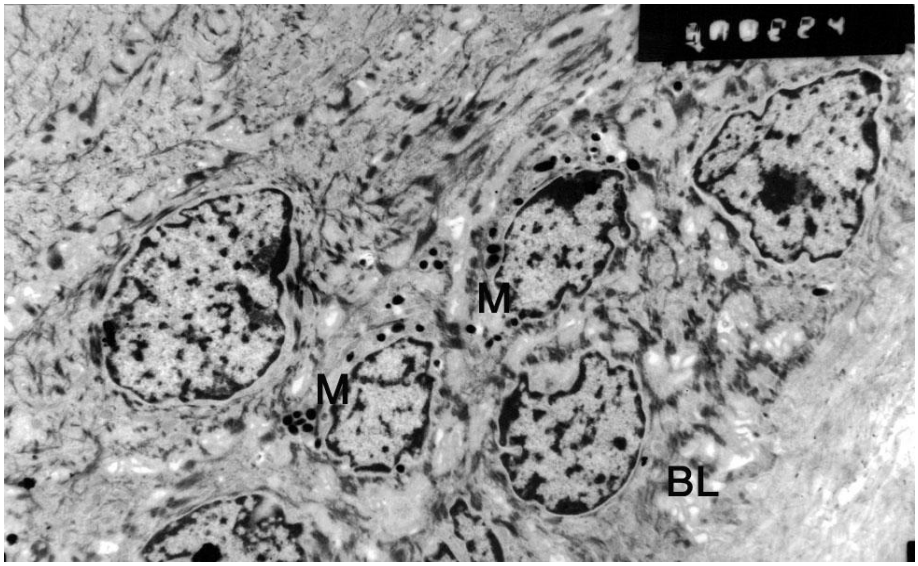


Fig (9): Transmission electron micrograph of the adult camel skin showing many epidermal cell laying on the basal lamina (BL). Two Merkel cells (M) could be recognized from their cytoplasmic dense granules and the ovoid lobulated nuclei. (Mic. Mag. X 5000).

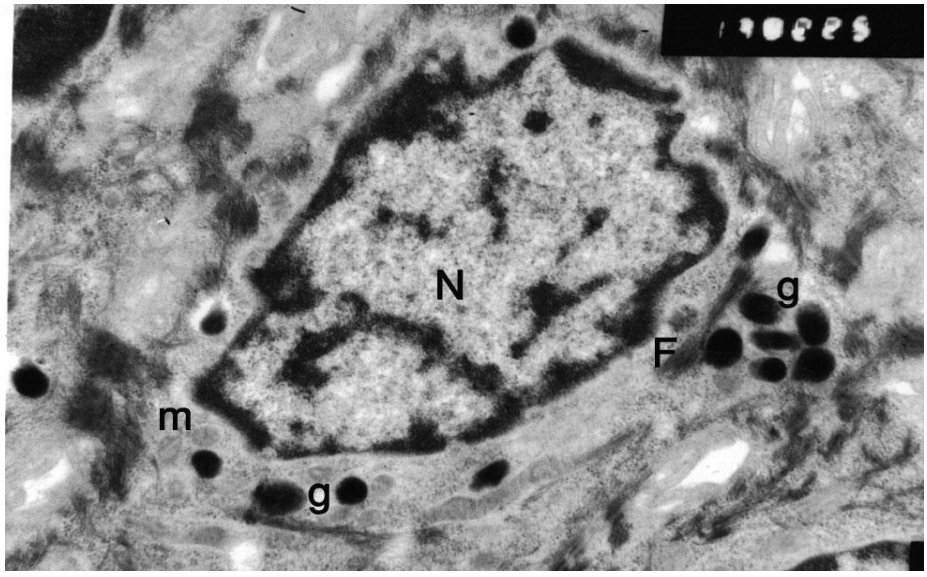


Fig (10): Transmission electron micrograph of one Merkel cell of an adult camel epidermis, showing the ovoid nucleus (N), cytoplasmic electron dense granules (g), some mitochondria (m) and cytoplasmic filaments (F). (Mic. Mag. X 13000).

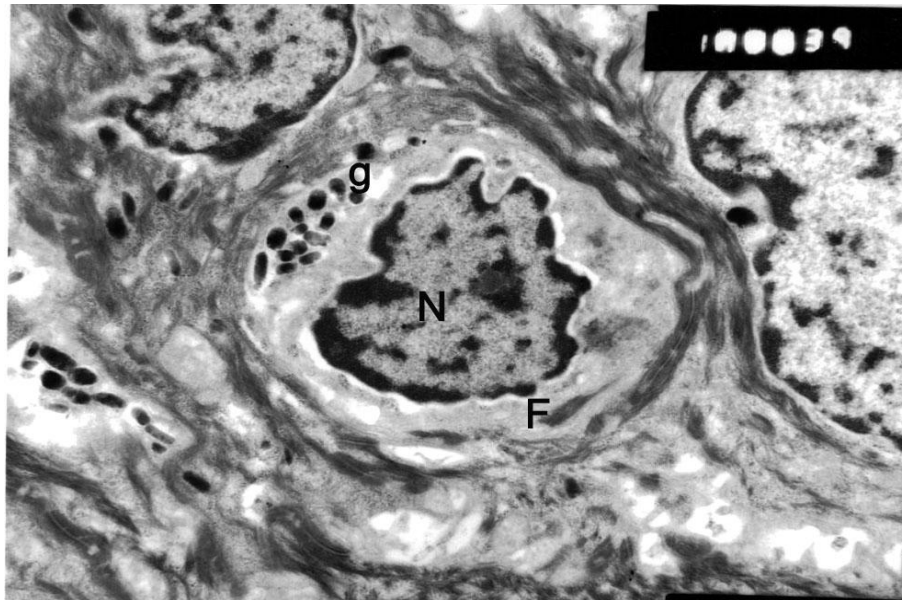


Fig (11): Transmission electron micrograph of the adult camel epidermis, showing Merkel cell with an ovoid lobulated nucleus (N) and light cytoplasm. Electron dense cytoplasmic granules (g) are found at one side of the nucleus. Cytoplasmic intermediate filaments (F).(Mic. Mag. X 10000).

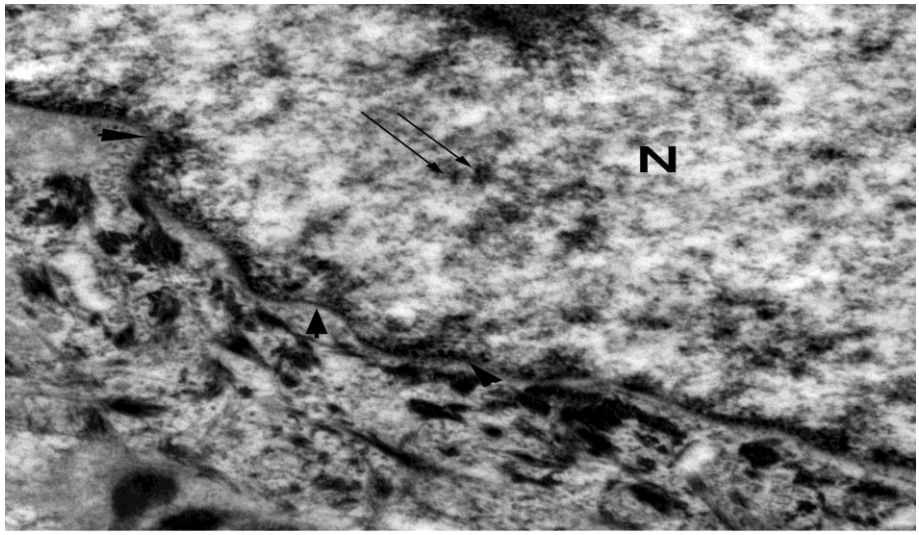
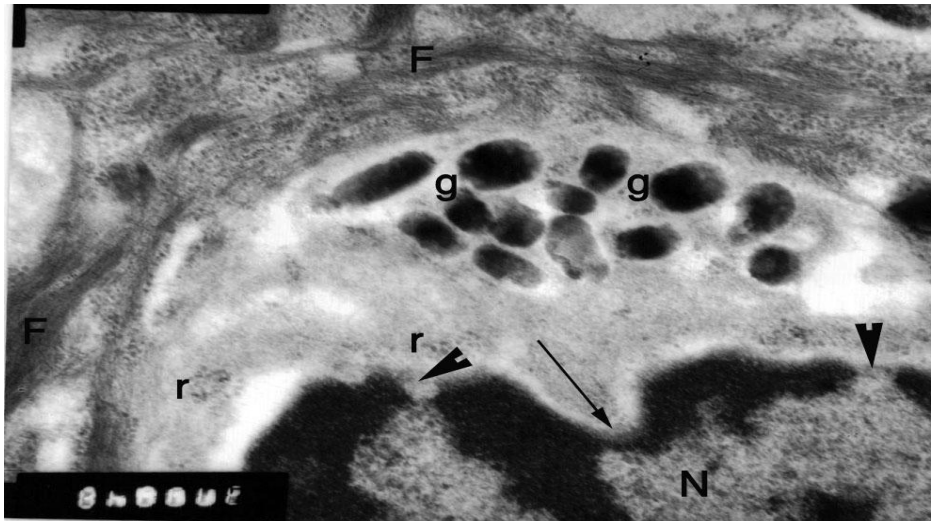


Fig (12): Transmission electron micrograph of the skin of young camel showing part of Merkel cell having a nucleus (N) with undulated nuclear envelop (arrow heads) and two nuclear rodlet (arrows). (Mic. Mag. X 10000).



Fig(13): High magnification transmission electron micrograph of Merkel cell of adult camel epidermis, showing part of its nucleus (N) with clear indentation (arrow), light cytoplasm with electron dense cored granules (g) and free ribosomes (r). Note the nuclear pores (arrow heads) and the filaments (F) of keratinocytes. (Mic. Mag. X 13000).

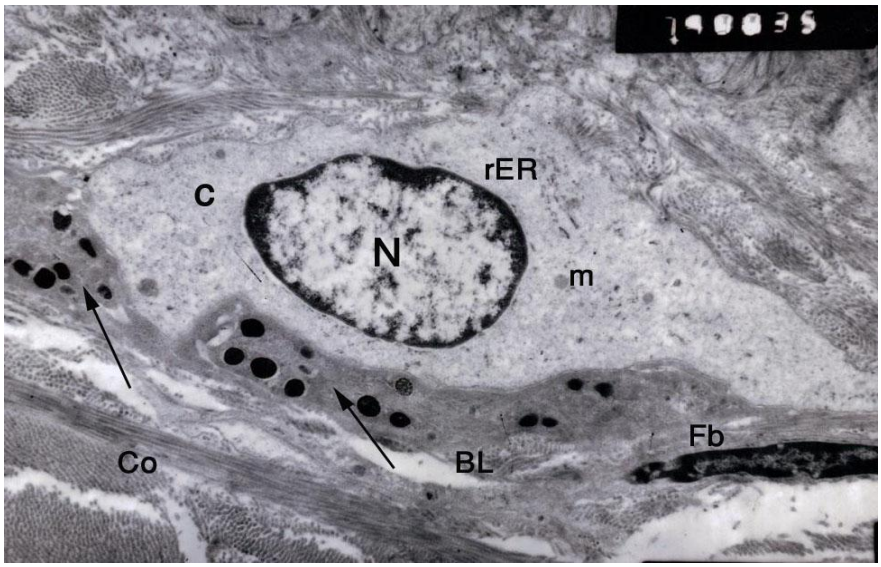


Fig (14): Transmission electron micrograph of the young camel epidermis showing Langerhans cell just above the basal lamina (BL), the cytoplasm (C) is clearly light with some few mitochondria (m) and rough endoplasmic reticulum (rER). The nucleus (N) is oval. Note the dark cytoplasmic cell processes of melanocytes (arrows), the fibroblast (Fb) under the basal lamina and the collagen fibers (Co). (Mic. Mag. X 7500).

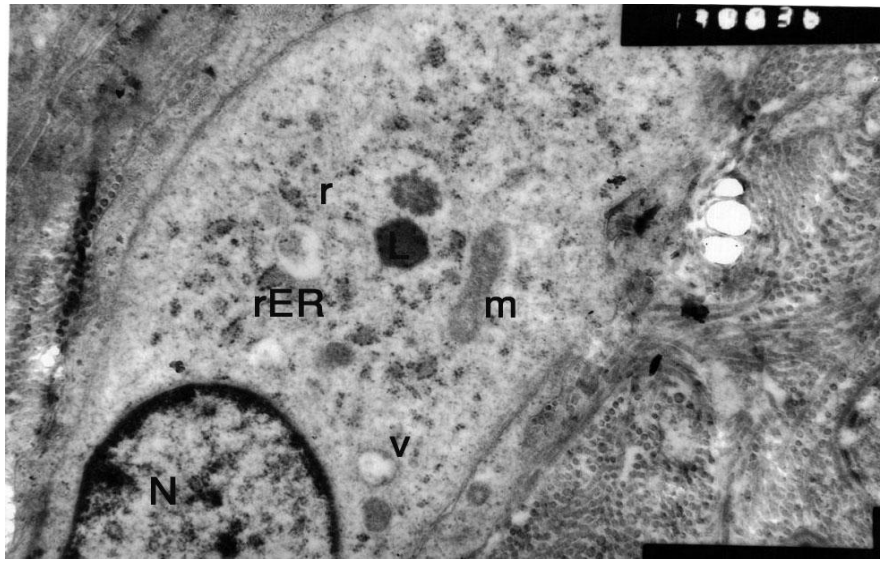


Fig (15): Transmission electron micrograph of Langerhans cell in the epidermis of young camel, showing part of the nucleus (N), light cytoplasm containing lysosomes (L), rough endoplasmic reticulum (rER), free ribosomes (r), mitochondria (m) and some membranous vesicles (v). (Mic. Mag. X 13000).

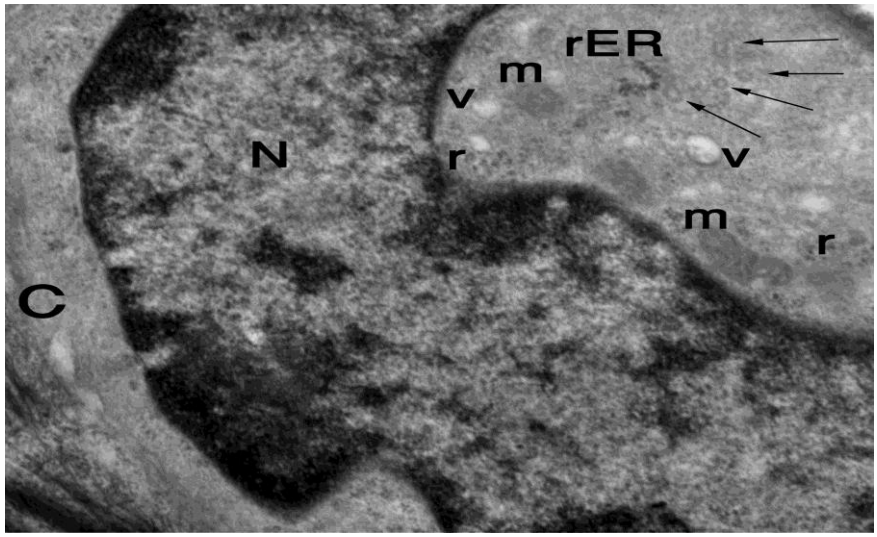


Fig (16): Transmission electron micrograph showing Langerhans cell in young camel basal epidermis, having electron lucent cytoplasm (C) containing specific Langerhans cell granules (arrows) in a transverse section with a limiting trilaminar unit membrane. The nucleus (N) is nearly kidney-shaped. Mitochondria (m), rough endoplasmic reticulum (rER), free ribosomes (r) and some vesicles (v) could be noticed in the cytoplasm. (Mic. Mag. X 10000).

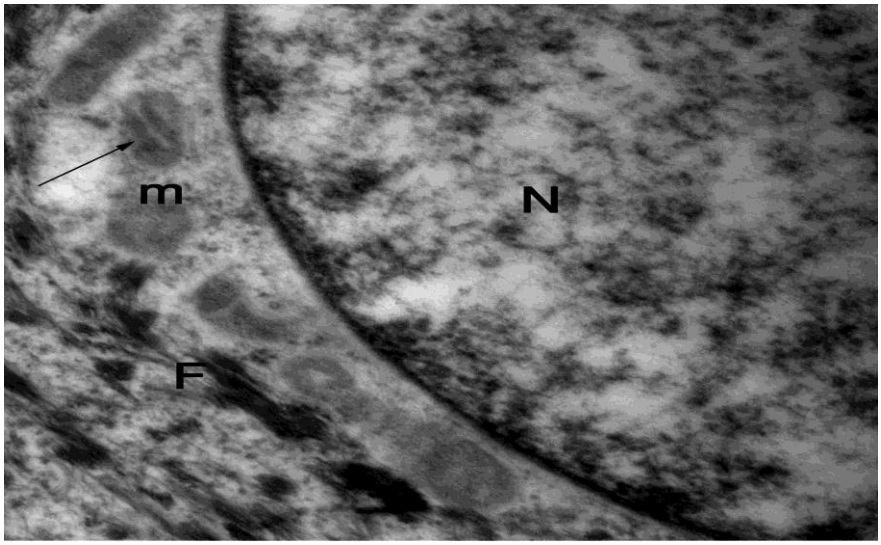


Fig (17): Transmission electron micrograph of Langerhans cell in young camel epidermis, showing an oblique section in its specific granules (arrow), mitochondria (m), part of the nucleus (N), and cytoplasmic filaments (F) from the neighboring cell. (Mic. Mag. X 13000).

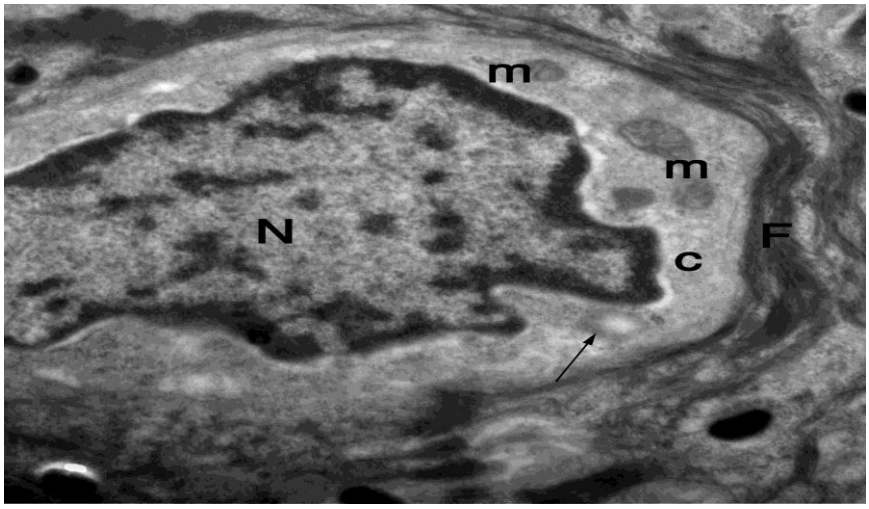


Fig (18): Transmission electron micrograph of the adult camel epidermis denoting, the electron lucent cytoplasm (c), cross section in the specific Langerhans cell granules (arrow), mitochondria (m), nucleus (N) and filaments (F) from the neighboring cell. (Mic. Mag. X 7500).

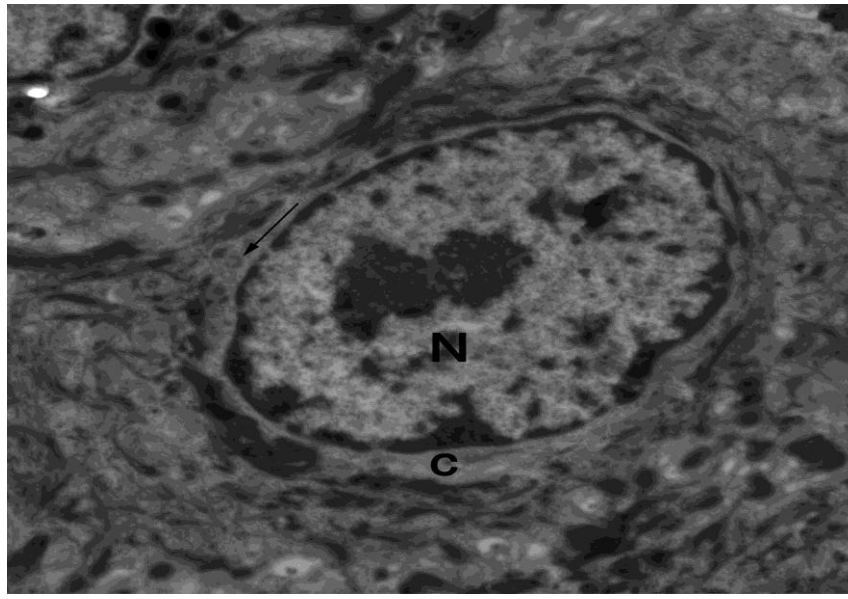


Fig (19): Transmission electron micrograph of Langerhans cell of adult camel epidermis showing, the cell with light cytoplasm (c), round to oval nucleus (N) and one specific granule (arrow). (Mic. Mag. X 5000)