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The epididymis is composed of two structures: namely ductuli efferentes originating from the rete testis and constituting a part of the caput epididymidis, and ductus epididymidis which is connected with the ductuli efferentes and forms the corpus as well as cauda epididymidis.

It has been said that ductuli efferentes function not only to transport the sperm, but also in secretion and absorption.

The absorbing function of ductuli efferentes was first postulated by MÖLLEN-DORFF (1920) who confirmed that the aggregations of vital dyes, such as trypan blue, were stored in the epithelial cells after the intramuscular injection. It takes several days for sperms to pass through the epididymal canal (MASON and SHAVER 1952) and the sperms gradually gain the ability for fertilization during this phase. The fact suggests that the sperm is influenced by epithelial cells during the passage of the canal. ALLEN and SLATER (1957) reported that epididymal canal and its secretion have two functions, namely these serve for a differentiation of active sperm by giving a useful nutriment to the sperm and also contribute to the maintaining of the adequate environment for the sperm.

WINDLE (1960) described that the sperm first acquires the autonomic motility within the epididymal canal. YOUNG (1929, 31) found that the change of fertilizing ability of the sperm is not due to the specific activities of epididymal secretion, but the duration stayed in the epididymal canal is important for the maturation of the sperm.

There are many opinions concerning the roles of secretion of the epithelium but its nature seems still to be investigated further.

The present paper deals with the fine structure of the human ductuli efferentes as revealed by electron microscopy and presents some evidences for the absorption and secretion of the epithelial cells based on the morphological standpoint.

I. Materials and Methods.

The materials were obtained from a fetus (8 month) as well as adults (21, 24, 49, 51, 67 and 73 year old patients). The materials which seemed to be histologically normal, were used for the observation.
The materials were cut into small pieces as soon as possible, and then immersed in the 6% glutaraldehyde solution for about 2 hours. After brief washing in MILLONIG's buffer, the materials were postfixed in MILLONIGs 1.0% OsO₄ fixative for about 2 hours (MILLONIG 1962), dehydrated through graded ethanols and embedded in Epoxy-resin.

Thin sections were cut on a Porter-Blum microtome and were stained by lead according to the methods of WATSON (1958) or MILLONIG (1961), or by uranyl acetate and studied with a HITACHI HU 11-A type electron microscope.

II. Observation.

The epithelium of the ductuli efferentes is composed of ciliated and non-ciliated cells (Figs. 1, 2, 6, 7). Both cell types usually have similar form and size, though the ciliated cells occasionally show spindle or bottle-like shape. These cells intermingle each other and rest upon an even basement membrane (Fig. 1).

The lateral cell wall, in general, shows a few interdigitations but becomes more irregular towards the basal portion of the epithelium. Although these features are almost the same in both adult and fetal epithelia, various granules found in the cytoplasm are somewhat different between the both.

Cytoplasmic matrix of the non-ciliated cells is slightly denser than that of the ciliated (Fig. 2). Nucleus of non-ciliated cells, having often deep indentations, is usually elongated and found in the basal part of cell (Fig. 1). On the other hand, oval or spherical nucleus locates in the center in the case of the ciliated cells.

A. Fetal ductuli efferentes.

The non-ciliated epithelial cells are columnal in shape and usually found in groups, and the ciliated epithelial cells intervene between them (Fig. 1). The cell surface is covered by slender microvilli measuring 0.14—0.15μ in diameter in which homogeneous cytoplasm containing occasional minute vesicles is observed (Figs. 1, 2, 5). Sometimes, the free cell-surface shows mushroom-like protrusion on which irregular and coarse microvilli are recognized (Fig. 1). Apical cytoplasm is homogeneous in appearance, and tubular invaginations of surface plasma membrane traverse this area. Most of these tubular invaginations contain material of moderate density. In some cases, the blind end of invagination shows the dilatation and seems being transformed into the vesicles.

Well developed endoplasmic reticulum (ER) is found being scattered throughout the cytoplasm (Fig. 2). Most of them are granular element and tubular or vesicular forms are situated in the supranuclear zone. In the infranuclear zone, they show cisternal form and often surround the mitochondria.

Mitochondria generally scatter throughout the cell but most of them are located in the supra- and infranuclear zones (Fig. 1). They are oval or rod-like in shape in the mentioned zones and are of long slender form in the lateral sides of the nucleus. Mitochondrial cristae are usually rectangular to the long axis of mitochondria and arranged in parallel with each other.
Fig. 1. Fetal ductuli efferentes. The epithelium is composed of ciliated cells (Cc) and non-ciliated cells (Ncc). The free surface of non-ciliated cells is covered by microvilli (M). Nucleus (N) of non-ciliated cell with one or two nucleoli (NI) are located in the basal part of the cell. Note the deep indentation (Di) of the nucleus. The epithelium rests on the basement membrane (Bm) and is surrounded by fibroblasts (Fb) and smooth muscle fibers. C: Cilia. Mt: mitochondria. L: luminal surface. Tb: terminal bar. Er: endoplasmic reticulum. ×6,400
Fig. 2. Section through the apical region of the fetal epithelial cells. The cilia (C) of a ciliated cell are shown in both longitudinal and cross sections. The cytoplasm of a non-ciliated cell with microvilli (M) on its free surface shows free ribosomes (R) in clusters, while the apical cytoplasm of the ciliated cell contains fine fibrous component. Terminal bar (Tb) is prominent between adjacent epithelial cells. Insert reveals a transverse section of the basal body (Bb) having triplet fibers arranged in the characteristic pattern. Mb: multivesicular body. Er: endoplasmic reticulum. Rt: rootlet. ×19,500. Insert: ×78,000
In the apical cytoplasm, multivesicular bodies containing numerous dense vesicles and limited by an unit membrane are often recognized. The vesicles in the multivesicular bodies show similar density and shape to the vesicles found in the apical cytoplasm or around the multivesicular bodies. Some of the multivesicular bodies are in contact with the tubular invaginations, a fact suggesting a certain relationship between the both structures.

The Golgi apparatus composed of vesicles, lamellae and vacuoles is usually observed in the supranuclear zone. Oval or elongated mitochondria (Mt) with transverse cristae, regular outlined dense bodies which are classified as granulated bodies (Gb) and dark bodies (Db) are located in supranuclear zone. G: Golgi apparatus. N: nucleus. Av: agranular vesicle. L: luminal surface. ×22,000

Inserts: (a) Rootlet with cross-banding. A fine subbanding is discernible. ×29,000
(b) Granulated bodies. The bodies are limited by a membrane and contain fine granules and lamellar or homogeneous structures. ×15,000

The Golgi apparatus composed of vesicles, lamellae and vacuoles is usually observed in the supranuclear zone. Some of the Golgi vesicles contain material of moderate density. Both vesicles and lamellae are especially well-developed. The dilatation of the lamellae at one end is often recognized, suggesting their transformation into vacuoles. Golgi zone is usually surrounded by a number of mitochondria, as seen most clearly in the transverse section.

Cytoplasmic matrix of these cells is denser than that of the ciliated cells and free ribosomes scatter within it (Fig. 2). Fine filaments running parallel to the axis of the cell are occasionally discernible in the juxtanuclear zone.
The nucleus is oval or spherical in shape and located in the basal part of the cell (Fig. 1). Its diameter is approximately equal to the width of the cell. Sometimes the deep indentations are recognized. The chromatin is condensed along the periphery of the nucleus and one or two nucleoli are seen (Fig. 1).

The ciliated cells.

The ciliated cells are provided with cilia and microvilli which intervene among the former (Figs. 1, 2, 3, 4). Cilia, 0.26 to 0.3μ in diameter (0.28μ on an average), have microtubules which are arranged in regular pattern and run parallel to the axis of the cilia (Figs. 2, 3, 4). These peripheral tubules are consisted of the doublet tubules and seem to end at the top of the cilia without fusing each other, because, in the transverse sections, the arrangement of filaments becomes irregular and its number decreases gradually towards the tip of the cilia.

On the other hand, at the base of each cilium, central tubules terminate at the level of a little above the cell surface and peripheral tubules are continuous to the basal bodies (Fig. 4).

The basal body (Figs. 2, 3, 4) is cylindrical in shape, approximately 0.4—0.45μ in length, and its wall is composed of 9 triplet microtubules (Fig. 2). These tubules are embedded in a material denser than that of ciliary tubules. In cross section, the arrangement of 9 triplet tubules is polarized so as to show a wheel pattern (Fig. 2 insert).

A dense basal foot of triangular form, 0.1—0.28μ in length, protrudes from the lateral side of each basal body (Fig. 4). They are usually arranged in the same direction. Occasionally, fine granular basal granules are encountered in the cavity of the basal body (Fig. 4 insert.).

From the proximal ends of the basal bodies which terminate in blind ends, brush-like rootlets extend to the supranuclear zone and rarely up to the lateral sides of the nucleus (Figs. 3 and 4). The rootlets are composed of minute tubules which gather into a bundle. Distal portion of the rootlets shows a cylindrical form and often contain basal granules or ribosomes. The cross-striations, about 700Å interval, can be observed along their length (Figs. 2, 3, 4). In addition, one clear band can be seen in each striation (Figs. 3 and 4). Cross striation become gradually obscure toward the peripheral portions of the rootlets (Fig. 3).

The mitochondria are large and abundant (Figs. 2 and 3). They are usually oval and occasionally elongated. Mitochondrial matrix is denser than in non-ciliated cells. Mitochondria are usually found in the supranuclear zone and the rootlets terminate close to them.

From the supranuclear to the apical zone, especially close to the mitochondrial accumulation, one can recognize several rounded, ovoid or pear-like dense bodies approximately 0.25 to 0.5μ in diameter (Figs. 3 and 4). These granules may be classified into three groups according to their morphology. They are found within the cytoplasm apparently indifferent to one another.

1. Granulated bodies (Figs. 3 and 4): This type of granule is the smallest in diameter of the three types and contains homogeneous fine granules of moderate density in its matrix. The granulated bodies are limited by a single membrane and usually possess a clear zone between the membrane and matrix. Sometimes, there are
Fig. 4. Apical region of the fetal ciliated cell. Two cilia are shown in longitudinal section. The peripheral (Pt) and central tubules (Ct) are clearly recognized. The latter disappears at the level of a little above the cell surface. Peripheral tubules of cilia are directly connected with those of basal bodies (Bb) which are embedded in slightly denser matrix. The basal bodies extend a triangle-shaped basal foot (Bf) on one side. Some basal bodies contain numerous fine particles (Bg) in their cavity as shown in an insert. Rt: rootlet. Db: dense body. Gb: granulated body. De: Desmosome. Cs: cross striation. M: microvilli. ×80,000. Insert: ×62,500
irregular clear areas in the matrix.

2. Dark bodies (Figs. 3 and 4): These are largest in diameter and characterized by the dense homogeneous matrix. A part of the matrix often involves fine granules similar to those found in the granulated granule.

3. Lamellated dense granules (Fig. 3): These are round in shape and contain concentric lamellae which are similar to those of myelin figures.

In addition, one can observe diverse transitional forms. For example, a granulated body may contain a lamellar structure or clear area in its matrix (Fig. 3).

The endoplasmic reticulum is generally poorly developed. Agranular vesicles of various densities are observed at the apical region of the cell (Figs. 3 and 4) and granular cisternal form of the reticulum is found in the perinuclear and infranuclear zones. This is, in general, less in number than in the non-ciliated cells.

Golgi apparatus, composed of vesicles and dilated lamellae, is located in the supranuclear portion and mitochondria are often found close to it (Fig. 3)

The nucleus is located in a more apical portion of the cell than in the non-ciliated cells. The nucleus is round or ovoid in shape and shows a smooth outline, in which homogeneous chromatin and a nucleolus of irregular shape are recognized.

Fig. 5. Apical portion of an adult non-ciliated cell (Type I). Numerous microvilli (M) of similar length and diameter, cover densely on the free surface. The plasma membrane between microvilli penetrates into the cytoplasm as tubular invagination (Ti) which contains the material of moderate density. Since clear vesicles (V) are sometimes found close to the tubular invaginations, these two structures may have some relationship. L: luminal surface. Tb: terminal bar. ×22,000
B. Adult ductuli efferentes.

Generally, the structure of the adult epithelial cells is much more complex than that of fetal cells. The complexity of the free cell surface as well as lateral surfaces and the differentiation of cytoplasmic structures are clearly observed.

Non-ciliated cells.

Various morphological differentiation is seen as the cell surface of each cell. Based on these findings, non-ciliated cells are classified into three groups.

Type I (Fig. 5).

The free cell surface is covered by the microvilli of similar size and height, which are arranged densely or loosely. Surface cell membrane between microvilli penetrates into the cytoplasm and forms the tubular invaginations which contain the material of moderate density (Figs. 5 and 8). Some of these are connected with the vacuoles. On the bases of these findings, this type of cell seems to be related to the absorptive function.

The tubular invaginations usually possess only homogeneous density, but their proximal ends are occasionally dilated and contain several small vesicles similar to those scattered in the apical cytoplasm (Fig. 8).

In addition to the tubular invaginations, agranular vesicles of various sizes having less density are seen in the apical region. These are considered as pinocytotic
vesicles and seem to be related to absorptive function of the cells (Fig. 8).

Endoplasmic reticulum is well developed throughout the cell and mostly consists of granular elements, which are usually of cisternal form and intimately surround the mitochondria.

In the lateral side of the nucleus or in the basal portion of the cell, one can observe irregular-shaped bodies which contain heterogeneous or homogeneous material often with a peripheral condensation.

Peculiar configuration bodies limited by unit membrane are rarely found in the cytoplasm (Figs. 9 and 10). They are usually ovoid, 0.9—1.2 μ in diameter, and contain dense matrix of various structures. For instance, they contain vesicles, granules and membranes, lamellated structures, or membranes similar to the cristae of mitochondria.

Type II (Figs. 6 and 11).

The free cell surface is covered by coarsely arranged irregular microvilli. Their tips are dilated like a small ballon which suggests a microapocrine secretion (Figs. 6 and 8).

Tubular invaginations and micropinocytotic vesicles are, however, poorly developed. This type of cell contains many diverse granules which may be classified

Fig. 7. Adult non-ciliated cells classified as Type III. Apical portion of the cell protrudes into the lumen (L) and contains an amorphous cytoplasm, which may represent an apocrine secretion. A few microvilli (M) can be seen on the surface of the apocrine processes, but towards the terminal bar they gradually increase in number. Numerous vacuoles (V) with various densities, which are regarded as secretion granules are found in the supranuclear zone and gradually increase in size and volume towards the free surface of the cell. ×2,600
into five forms as describe below.

A-granules: These granules are round and measured about 2 μ in diameter, 4 μ maximum. They are located in the apical part of the cell and shows variable densities (Figs. 6 and 11).

B-granules: They are formed by accumulation of many high density granules and may be called as the multigranular dense bodies (Fig. 11).

C-granules: The granules are round and contain fine granular material in certain portion of the matrix (Fig. 11).

D-granules: The granules are round and contain scattered dense particles within their matrix of homogeneous density (Fig. 11).

E-granules: These are irregular, heterogeneous dense bodies, each of which contains vesicles and granules of various densities and sizes (Fig. 11 insert).

Type III, (Fig. 7).

The apical portion of the cell, as a whole, protrudes into the lumen and represents a cystic appearance. This may indicate the apocrine secretion of the cell.

The free surface of the protrusion usually shows a smooth outline, but, towards the periphery of the cell, the surface becomes more and more irregular and microvilli gradually increase in number.

The protruding portion shows a clear cytoplasm and contains a few formed ele-
ments. Occasionally, vesicles and tubular invaginations are encountered.

In the apical cytoplasm, one can observe numerous round or spherical vacuoles having less dense materials and irregular shapes, measuring 2.5 μ in maximum diameter. The vacuoles gradually increase their size toward the apical surface, some of which contain a less dense material. The density of the vacuole is often quite variable and differs even in the adjacent cells. This fact may suggest the difference of their functional phase. Heterogeneous granules are sometimes visible in the apical parts.

The unit membrane limiting some of the vacuoles is broken, their content seems to spread into the cytoplasm. It seems possible that this mechanism plays some role in the formation of apocrine secretion.

The structure of Golgi apparatus does not differ significantly among the cells just described, and are located in the supranuclear zone. The Golgi apparatus is better developed than in the fetal cells. Some of its lamellae show a dilatation at their ends and suggest their transformation into the granules found in their vicinities.

The endoplasmic reticulum is well developed throughout the cytoplasm. The vesicular and tubular form of the granular reticulum is usually found in the apical part of the cell, some of which are close to the vacuoles and suggest the intimate relationship between them. Cisternal forms of the granular reticulum often surround the mitochondria very closely. In addition, ribosomes are occasionally attached to a
peripheral portion of the Golgi lamellae, that indicates a close relationship between
them. The epithelial cells of type I and occasionally of type II show a cillum (flag-
gellum) on their free surface among the microvilli (Fig. 11). In this cillum, 0.25μ
in diameter, one can observe incomplete filaments and occasionally a cross-striated
rootlet. Furthermore, a centriole is recognized rectangular to the axis of the cillum.

ciliated cells: (Figs. 12 and 13)
The adult ciliated cells does not much differ in structure from the fetal ones as
compared with the case of the non-ciliated cells.
The structure of cilia and rootlets is almost the same as in the fetal cells.
Small amounts of free ribosomes are found in cluster throughout the cytoplasmic
matrix of lesser density than that of non-ciliated cell. There are numerous microves-
sicles and a few multivesicular bodies in the apical cytoplasm (Fig. 12).
Although granular endoplasmic reticulum is usually not well-developed, several
layers of cisternal granular reticulum are occasionally found at the supranuclear re-
gion and cover the nucleus (Fig. 13).
Ovoid or rod-like mitochondria are relatively large in size and located mainly in
the supranuclear region, close to the rootlets of the cilia (Figs. 12 and 13).
Dense bodies similar in structure and distribution to those of the fetal cells can
be observed. Their diameter, in general, is slightly larger and reaches up to 1.5μ
(Fig. 12). In addition, large irregular dense granules measuring 3μ in maximum
The content of the granule is heterogeneous with the accumulations of various dense granules and amorphous substance. The epithelial cells of ductuli efferentes rest on the basement membrane and are surrounded by interstitial tissue, in which fibroblasts and smooth muscle cells are recognized (Fig. 14).

Unmyelinated nerve fibers and mast cells characterized by many round specific granules are also encountered. These cells are surrounded by densely-packed collagen fibrils (Fig. 14).
BENOIT (1926) who studied the mouse ductuli efferentes with the light microscope described that mitochondria of non-ciliated cells were liquefied to be finally secreted into the lumen. On the other hand, he mentioned that the mitochondria of ciliated cells were of special significance for the ciliary movements. TANAKA (1942) reported that in the case of mouse, mitochondria became recognizable on the 20th and the large granules on the 25th day after birth. However, the staining properties of the large granules are similar to those of mitochondria, so it is difficult to distinguish the large granules from mitochondria morphologically. It is possible that these granules are derived from mitochondria although one cannot decide whether this is really the case or not, because of the difficulty in observing their actual transformation. MÖLLENDORFF (1920) was the first who mentioned the absorptive function of this duct. MASON and SHAVER (1952) observed that the trypan blue was stored in epithelial cells after its injection directly under the tunica albuginea of hamster testis, and thus confirmed the absorptive function of these cells.

Electron microscopic studies of the ductuli efferentes was first made by BURGOS (1957) in hamster and LADMAN and YOUNG (1958) in guinea pig. No one has reported so far about the fine structure of human ductuli efferentes.
YOUNG emphasized the absorptive function of the non-ciliated cells based on the electron microscopic observations and on the changes in the testicular weight after the ligation of the ductus.

The present observation revealed some hitherto unreported features of the ductular cells. It is assumed that the epithelial cells perform not only absorption but also secretion, because their morphological features are similar to those of apocrine secretion described in the submandibular gland (KUROSUMI et al. 1961) or in the horse sweat gland (KUROSUMI et al. 1963). The structures of the apical parts of the type I non-ciliated cells are similar to those of the renal convoluted epithelial cells (PEASE 1955, RHODIN 1961, SJÖSTRAND and RHODIN 1953). The relationship between tubular invaginations and vesicles or vacuoles seems to suggest, as mentioned by BENNETT (1956), the transport mechanism by which particles, molecules and ions are carried. As it was shown in the kidney by TRUMP (1961), intravenously injected trypan blue appears within the vesicles of proximal convoluted epithelial cells, and as the fluid and substances enter into the invaginations they are dilated to become vacuoles. These facts were considered to indicate the absorptive function of the convoluted cells (DE ROBERTIS et al. 1960). Hence, it may be reasonable to think that type I cells may have a function similar to those of the proximal convoluted tubular cells.

BURGOS (1960) recognized that microvilli of the ductular cells are covered with

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![Image](image-url)
a less dense amorphous material (extraneous coat) which is composed of mucopoly-
saccharide. This material also filled the invaginations. He also observed that, when
the colloid particles are introduced into the rete testis, they are found in the in-
vaginations and vesicles. Similar amorphous materials has been observed in the
oviduct at the follicular phase (FREDRICSSON and BJORKMAN 1962). It was
assumed that these amorphous materials participate in pinocytosis. The present ob-
servation could not discern a distinct extraneous coat covering microvilli, but the
moderate dense material observed in the invaginations can be regarded to correspond
to the amorphous materials mentioned by BURGOS.

Concerning the fat absorption of the rat jejunum PALAY and KARLIN (1959)
described that at the apical surface of cells, the pinocytotic vesicles containing fat
particles gradually enlarge and some of them become to be attached by the ribosomes
to their membrane. These findings were taken to indicate that the invaginations are
continuous with the endoplasmic reticulum. Fat droplets are finally released from
the lateral cell wall into the intercellular spaces. Although, in the non-ciliated cell,
neither well developed basal infoldings as in the renal tubule nor the intercellular
spaces which are the passage of absorbed materials in the case of intestinal epithelium
are observed, it may be assumed that they have absorptive function. Numerous
vacuoles in the supra or infranuclear zone seem to be local dilatation of endoplasmic
reticulum as suggested by LADMAN and YOUNG.

Peculiar configuration bodies are rarely seen and their densities and morpholo-
gical features are different from those of absorbed materials. They are rather similar
in appearance to granules of type II cells, although their character is obscure. Po-
lyplike microvilli of the type II cells contain less dense, homogeneous materials which
are released into the lumen by the pinching off mechanism. They may belong to the
type III category in KUROSUMI's (1961) classification of secretion mechanisms.
This type of secretion was described in the choroid plexus (DEMPSY and WISLOCKI
1955, MAXWELL and PEASE 1956, VAN BREEMEN and CLEMENTE 1955)
and in sweat gland (KUROSUMI et al. 1963). Microapocrine secretions in this cell
type of ductuli efferentes, however, are seen only in a few cases. The cells mostly
show secreting granules of various densities and structures in the supranuclear zone.
These granules gradually move to the apical regions and then come into contact with
surface cell membrane to release their content into the lumen. This namely corre-
sponds to type IV of KUROSUMI's classification, and has been recognized also in the
oviduct (BJORKMAN and FREDRICSSON 1961) and parotic epithelial cells (PARKS
1962). LADMAN and YOUNG (1658) demonstrated rounded secretion granules which
exist free in the lumen, but, in the present observation, such granules were only
recognized when the tissue was poorly preserved and cell membrane was broken. It
has been reported that the gastric parietal cells (KUROSUMI et al. 1958), sweat
glands (IJIIMA 1959) and thyroid gland are provided with the secreting mechanism
of both microapocrine and eccrine.

Although most of the secreting granules are homogeneous rounded granules (A-
granules), matrix of the B-granules (multigranular dense bodies) is similar to that of
A type and less dense granules of B type have the similar features as E type small
vacuoles. Further, compact B type granules are similar to type E granules. These
facts seem to suggest the relationship of various granules with each other.

Secreting granules found in the type III cell which corresponds to KUROSUMI's type II, are less dense and have more irregular outline compared with type I and II cell granules. Similar secretion mechanism is found in the striated ducts of the parotid glands (PARKS 1962), sweat glands (KUROSUMI et al. 1963), Goblet cells (PALAY 1958) and gastric parietal cells. Macroapocrine projections found in this type of cell are formed by the materials released into the apical cell portion from the vacuoles: Apical cell surfaces originally provided with microvilli are pushed by the increased materials, and consequently the microvilli disappear. JENNINGS and FLOREY (1959) observed, by the injection of radioactive Na$^{35}$SO$_4$ into the guinea pig, movement of secreting granules in the Goblet cells and recognized that they are discharged into the lumen passing through the Golgi zone and secretion granule. Synthesis of the secreting materials is performed at the granular endoplasmic reticulum and they move into the Golgi zone. There, they are formed into secreting granules and gradually move into the apical cell portions. One can recognize from such observation the intimate relationship between Golgi lamellae and secreting granules.

KUROSUMI and his co-workers (1961) mentioned that, in the apocrine secretion of rabbits submandibular organ, secreting materials are first formed within the mitochondria, and then are released into the surrounding cytoplasm. This type of secretion mechanism can not account for the mitochondria observed in this study. Rupture of the membrane of the secreting granules in the neck of the apocrine projections, may be caused by the artifact, but one may suppose that gradual accumulation of the materials would stretch the cell membrane, and resulting in disappearance of microvilli and formation of appocrine projection into the lumen. It is reported that, in the submandibular glands, neck of the apocrine projection shows condensed area which may serve as a demarcation zone. Projections separate at this demarcation zone and are finally discharged into the lumen (KUROSUMI et al. 1961). Although the present observations could not reveal such a demarcation zone in the apocrine projection, existence of a definite narrowness or the neck in the appocrine projection seems to visualize a separating process. It may be thought that the cells afterward turn to the resting stage and become to be provided with the microvilli on the apical surface. Some of the type I cells which have no tubular invaginations and micropinocytotic vesicles, may belong to the resting stage.

Multivesicular bodies, similar to those reported by SOTELO and PORTER (1959) (0.1 —0.6μ in diameter), are measured 0.3—0.6μ in the ciliated cells and 0.5—0.9μ in non-ciliated cells. Difference in size between two cell groups does not seem to due to only the difference in sectioned level. They are surrounded by an unit membrane. Most of them are oval or spherical in shape, but there are also pear-shaped ones. Some of them show a discontinuous membrane, and their content seems to be continuous with adjacent cytoplasm. Multivesicular bodies, as they have been reported in various cell types, such as neuron, intestinal cell, ovum, oviduct and sperm cell, may be regarded as a normal cell component.

Concerning the function of these bodies, they have been said to be related to vesicular formation. Namely, these bodies release their inner vesicles into cytoplasm by rupture of the unit membrane (SOTELO and PORTER 1959). Others postulated
that these bodies are related to the lysosome (NOVIKOFF 1961). PALAY (1958) pointed out that, since multivesicular bodies sometimes had the same density and structure as the granules in the secretory neurons of the gold fish, they would change into the neuro-secretory granules. FARQUHAR and PALADE (1962) thought that these bodies were located where extracellular materials were taken in. In fact, they showed that ferritin were transferred into the multivesicular bodies by pinocytosis. They also described that the bodies became absorptive droplets by accumulation and condensation of captured materials. In the present study, however, none of the findings were obtained as to confirm the above mentioned hypotheses. Sometimes, however, proximal ends of the tubular invaginations are dilated and contain microvesicles. Close to these, one can occasionally observe multivesicular bodies with similar density and size to microvesicles. Even if this finding is interpreted, in this type of cell, as the transformation from the invagination to the multivesicular bodies, the origin of the latter in general is still questionable. There are also multivesicular bodies to the same extent in the ciliated cells which have no tubular invaginations. If multivesicular bodies would contribute to taking in of materials, they should be found mainly in type I non-ciliated cells. It may be also possible to assume that they are not so important in absorptive function, because they are observable in ciliated cells of both fetus and a `ult which are believed to have little absorptive function.

A cilium or flagellum was observed on the free cell surface of the non-ciliated cells. Since they are encountered rather frequently they may be normal constituent of the non-ciliated cell. MUNGER (1958) who observed a cilium on the pancreatic exocrine cell, assumed that it may have a chemoreceptor function.

The cilia of the ciliated cells always move in the same direction and are related to the movement of the spermatozoa and of epididymal secretion. There are no significant morphological differences between fetal and adult ciliated cells except for the increased osmiophilic dense bodies in adult cells.

The fine structure of the cilia of the mentioned cells is similar to those of the trachea and oviduct, but their diameter (0.28 µ) is somewhat larger than reported in the rat's trachea (0.24 µ) (RHODIN and DALHAMN 1956). The microtubules in the cilia run parallel to the longitudinal axis. Though the author once observed in a longitudinal section, a microtubule connected with opposite one at the tip of the cilium, the arrangement of the microtubules in the transverse section become, irregular and their number decreases when they approach to the tip. This means that each microtubule terminates in free end, and it is difficult to assume that they fuse to each other at the top as mentioned by RHODIN and DALHAMN (1955) and OSADA (1963)

Basal bodies were 0.4—0.45 µ in length, longer than those of Lamellibranch mollusc (0.35 µ in length) (GIBBONS 1956). The significance of the large kidney shaped granule, sometimes found in the cavity of basal bodies is not known.

The rootlets are generally well developed in the animals of the lower class, but they are poorly developed in the mammal. It has been said that most of the mammalian epithelial cells lack the rootlets (FAWCETT 1958). In the ciliated cells of the ductuli efferentes, however, the rootlets are considerably well developed and occasionally reach to the lateronuclear beyond the supranuclear zone. They have regular cross-
striations of about 700 Å spacing along their long axis. Between every two of these prominent bands, there is an intermediate stria which is thinner and less dense. These fine striae are variable in number according to the species: 12 in Mollusc (GIBBONS 1956) and 5 in Lumbricus (FAWCETT 1958). BJORKMAN and FREDRICKSON (1961) described that these rootlets are actually observed more widely than had been considered previously, and suggested that they become recognizable by using suitable fixatives and staining methods.

Many hypotheses have been presented concerning the functions of the rootlets: contractile elements, impulse-conducting fibers, anchoring of supporting structures (FAWCETT and PORTER 1954). The rootlets usually run toward the group of mitochondria located in the supranuclear zone or pass through these mitochondria. In the case of the *Amphioxus lanceolatus*, the outer membrane of an elongated mitochondrion runs parallel to the axis of the rootlet while the inner membrane usually forms a crista at the level of every cross striation of the rootlet. OLSSON (1962) described that this intimate relationship between rootlets and mitochondria observed in the lancelet suggests that rootlets are not merely supporting elements of the ciliary apparatus. However, the development of the rootlets varies in animal species as well as in cell types, and the intimate relationship as recognized in the lancelet cannot be observed in other animals. Thus, the significance of the rootlets is still unknown.

Polyplike projections which are often seen at the apical surface of ciliated cells, are similar in structure to the apocrine projections in the non-ciliated cells. Some of them show a narrow neck and suggest the pinching off mechanism. Since features are not recognized in the case of fetus, they may relate to some secreting functions.

Smooth outlined dense bodies of type I, II and III are found equally in both fetal and adult cells. The granulated bodies are similar to those of human and mouse uterine cells (NILSSON 1962, FUXE and NILSSON 1963), rat prostate cells (BRANDES 1963) and of mouse liver cells. NILSSON (1962b) regarded these bodies as lipid granules. He mentioned that some of them show acid phosphatase activity and may be identified as the lysosomes described by DE DUVE (1959). Hence, the granulated bodies may be regarded as lysosomes. DEAMS and RUSSEL (1961) mentioned that granulated bodies are located close to Golgi zone, and WESSEL (1960) reported that they are formed in the Golgi zone. In the present observation they were found in the supranuclear zone. However, no finding was obtained to suggest the relationship between Golgi bodies and granulated bodies. In addition, granulated bodies seem to correspond to storage granules mentioned by DE DUVE (1963). Based on the finding that the Dextran injected intraperitoneally was observed in the dense bodies, DEAMS and RUSSEL suggested that dense bodies could be functionally regarded as the lysosomes. These dense bodies also correspond to the digestive vacuoles, as reported by DE DUVE (1963), which are derived from the lysosomes combined with the phagosomes formed by the endocytic invaginations. Indeed, there is no clear morphological definition of lysosomes and it is impossible to identify them from the morphology alone.

Membrane systems seen in the lamellated dense bodies (of type III) are similar to the myelin figures created artificially from phospholipid by REVEL, ITO and FAWCETT (1951), and it may be postulated that the lamellated dense bodies derive
from phospholipid. Though DIXON (1958) described that decomposition of the lipid granules is caused by the increase of phospholipid. If the lamellated dense bodies are identified as decomposing lipid, it may be possible to suggest that granulated bodies participate in the process of lipid decomposition as mentioned by NILSSON (1962b), because granulated bodies are often located close to phospholipid. The irregular shaped dense bodies cannot be observed in the fetal cells. They are regarded as the lipofuscin pigment and may relate to the aging regressive changes. Their number, however, is different in each cell and does not always increase with age.

These pigments are similar to the granules of the epididymal interstitial cells observed by FAWCETT. Since the similar bodies are recognized in the ovary or adrenal cells, FAWCETT (1960) postulated that these are by-product of the steroid hormon biosynthesis. In the present material, however, this explanation can not be adapted. It is assumed that they are residual bodies or autophagic vacuoles created by the phagosomes as described by DE DUVE (1963).

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IV. Summary.

The fine structure of human ductuli efferentes in fetal and adult epididymis was studied with the electron microscope.

The epithelium of the ductuli efferentes is composed of columnal cells of both ciliated and non-ciliated types.

The morphology of the ciliated cells do not differ significantly between fetal and adult cells. In the supranucelar zone, lysosomes and multivesicular bodies are recognized. In addition, adult cells show waste pigment granules and occasionally a lamellated granular endoplasmic reticulum.

The fine structure of the non-ciliated cells suggests their function in absorption and secretion. Based on the morphological differences in their apical cell surface, the adult non-ciliated cells can be classified into 3 types. It was assumed that type I cells possess absorptive function and those of type II and III contribute to the secretion. Morphological differences by age in the adult cells are hardly recognizable except for senile degeneration.

内 容 自 抄.

成人と胎児の精巣輸出管上皮の微細構造を明らかにし、その機能についての形態的基礎を確立することを目的として、これを電子顕微鏡によって観察した。

精巣輸出管上皮は纖毛細胞と無纖毛細胞の2種の単層円柱上皮細胞より成る。纖毛細胞は精子の移動に役立つものと考えられ、その構造には胎児と成人のあいだにはほとんど差異を認めない。核上部にはlysosome, multivesicular bodyがあり、成人ではそのほかに色素顆粒を有するほか、時に層状をなす粗面小胞体を認める。

無纖毛細胞は吸収と分泌に関するものと考えられる。成人における細胞被面の形態的差異は、細胞の機能に関連するものと想像され、3型に分類できる。
References.

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