Scanning Electron Microscopy of the Rat Exocrine Pancreas

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Received April 1, 1984

Summary. The three-dimensional architecture of the rat exocrine pancreas was studied by scanning electron microscopy (SEM) with the HCl digestion method. The treatment with HCl effectively removed connective tissue elements enclosing the ducts and the acini. Thus their shapes and relations were clearly revealed under the SEM. Furthermore fine surface features of the acinar or ductal cells were also demonstrated.

Although recent studies have suggested that the pancreas might be reticular in architecture due to anastomoses between adjacent ducts or acini, the present investigation confirmed that rat pancreas is a compound acinar (alveolar) gland.

Excretory ducts extended into interlobular spaces, branching dichotomously. Interlobular ducts, which showed an almost constant thickness, issued directly from the excretory ducts, entered the pancreatic lobuli, and branched several times to connect with numerous acini of varying size and shape.

Basal surfaces of the excretory ducts showed conspicuous reticular undulation, while those of the intercalated ducts were smooth except for some areas with fine unevenness near the epithelial cell boundaries. It remains to be elucidated whether these basal structures of the intercalated ducts are involved in their assumed function, i.e., the secretion of water and bicarbonate in pancreatic juice.

The acinar lumen was a narrow secretory canaliculus covered with finger-like microvilli. Intercellular canaliculi branched from the central canaliculus, taking a straight course toward the acinar cell base, and ended blindly. Some canaliculi extended to the close vicinity of the basement membrane, providing a locus minoris resistantiae for the leakage of pancreatic enzymes into blood.

The SEM findings on the canalicular system were confirmed by light microscopic observation of the pancreatic excretory passages stained by the rapid Golgi method, and by three-dimensional reconstruction of the pancreatic acini from serial semithin sections.

The exocrine pancreas has been considered as a compound acinar (alveolar) gland composed of round or tubular acini. However, we have often noticed in tissue sections observed by light microscopy that the acinar lumina of the pancreas diverge in many random directions and that the acinar cells far exceed the ductal cells in number and total volume. It has been difficult to reconcile the exocrine pancreas with a true acinar gland which has been often likened to a bunch of grapes.

The pancreatic ductal system has been studied light microscopically using two
methods: the dye injection method and the Glogi impregnation method. By use of the
dye injection method, two contradictory views on the acinar lumen have been reported.
By injecting a dye (Berlin blue) into the pancreatic duct, LANGERHANS (1869) first
demonstrated that the architecture of the excretory passages of the pancreas represent-
ed a compound acinar gland. He described the narrow central lumen as branching
into secretory canaliculi, which extended between acinar cells to end in a piriform
bulge close to the basement membrane. However, by use of similar injection methods,
SAVIOTTI (1869) and GIANUZZI (1869) observed the secretory canaliculi anastomosing
with each other to form a network along the basement membrane. On the other hand,
the impregnation method originated by GOLGI has been known to stain ductal systems
of some excretory glands. CAJAL and SALA (1891) applied this method to the pancreas.
Their results were consistent with those obtained by LANGERHANS. They did not ob-
serve the anastomoses of secretory canaliculi that SAVIOTTI described.

Recently, reexaminations of the arrangement of the exocrine pancreas have been
made. BOCKMAN (1976, 1978) reconstructed some acinar lumina of the pancreas from
serial paraffin sections, describing frequent anastomoses of the secretory lumina.
BOCKMAN (1980) also made luminar casts of the excretory passage of the rat pancreas
by retrograde injection of a silicone rubber compound. By examining them in a scan-
ing electron microscope (SEM), he confirmed that they formed a three-dimensional
complex network.

In order to elucidate the three-dimensional structure of the pancreas by more direct
methods with less artifactual effects, we removed connective tissue elements from rat
pancreas with the HCl digestion method by EVAN et al. (1976) to observe it under the
SEM.

Moreover, we applied the Golgi impregnation method to the demonstration of the
pancreatic ductal system in order to corroborate the SEM findings by light microscopy.

MATERIALS AND METHODS

Adult male rats of the Wistar strain weighing 150–300 g were used after overnight
food deprivation.

Scanning electron microscopy (SEM)
The rats were perfused through the ascending aorta with Ringer solution and then
with 2.5% glutaraldehyde in a 0.1 M phosphate buffer, pH 7.3. The pancreas was ex-
cised, cut into small cubes, about 5 mm on each side, and immersed in the same fixative
for 3 hr or more at room temperature. In a modification of Evan's method (EVAN et
al., 1976), the tissue pieces were placed in 8 N HCl for 50–60 min at 60°C. After HCl
digestion, the tissue was immersed in 0.03% Triton X–100 in phosphate buffer and ex-
posed to ultrasonic vibrations for 1–2 min to partly disintegrate the acini which can
conceal intercalated ducts and excretory ducts. The extent of the “ultrasonic micro-
dissection” was determined by examination of the specimen under a binocular micro-
scope. Then, the tissue pieces were rinsed in a phosphate buffer, conductive-stained
by the tannin-osmium method of MURAKAMI (1974), dehydrated in a graded series of
ethanol, critical point-dried using liquid CO2, evaporation-coated with gold-palladium
and examined in an SEM.

After fixation as described above, some tissue pieces were conductive-stained with-
out the HCl treatment, and freeze-cracked in isoamyl acetate, critical point-dried and
metal-coated, to be observed also by SEM. A Hitachi S-450 LB SEM was used under an accelerating voltage of 10 kV.

*Light microscopy of Golgi-impregnated specimens*

The other animals were deeply anesthetized with Nembutal and perfused transcardially with Ringer solution followed by a mixed aldehyde fixative (10% neutral formalin and 1.25% glutaraldehyde in 0.085 M phosphate buffer, pH 7.3). The pancreas was excised, and placed in the same fixative for 1–3 days at 4°C. Pieces of tissue were immersed for 5–14 days in a 4:1 mixture of 2.5% potassium dichromate and 1% osmium tetroxide. They were briefly rinsed in a small volume of 0.75% aqueous silver nitrate, and stored for 24 hr in a fresh volume of 0.75% silver nitrate. Then the impregnated specimens were dehydrated and embedded in celloidin. Serial sections were cut at 70–100 μm, mounted on a slide glass and examined by light microscopy.

*Reconstruction of serial sections*

In order to compare our findings with Bockman’s results obtained by reconstruction of serial paraffin sections, we prepared serial sections 1 μm in thickness of Alardite-embedded tissues, with a part of them being reconstructed using cardboard.

**RESULTS**

**Effects of the HCl treatment**

Treatment of the pancreas with HCl was able to effectively remove the interlobular connective tissue, exposing the excretory ducts, intercalated ducts and acini of the pancreas under the SEM. The basement membrane of acinar cells was completely removed by the HCl digestion in 60 min, as was ascertained by transmission electron microscopy (TEM). The optimal time of HCl digestion for observation of surface features of the rat pancreas was 50–60 min, since a longer treatment with HCl caused more frequent artifacts such as numerous pits on the cell membrane and intercellular gaps.

**Architecture of the gland**

Our SEM observation revealed that the exocrine pancreas of the rat was a compound acinar gland. Each pancreatic lobule was composed of numerous acini which connected to a long thin duct, measuring about 5 μm in diameter, by short side branches (Fig. 1). The relationship between the ducts and acini could be visualized after the tissue parts covering them had been removed by ultrasonic microdissection. The architecture of the pancreas can be compared to a tree with many branches bearing acini as fruit. The excretory ducts divided in a dichotomical fashion, with thin intercalated ducts occasionally originating from them and repeatedly branching to connect with acini of varying size and shape (Fig. 2, 3). We could not find any anastomoses among the ducts or among the acini.

**Finer structure of the acini**

The smallest acinus which we observed measured about 8 μm in diameter and looked like a bud (Fig. 4a). More frequently found were those small acini composed of 10–20 acinar cells. They were round or oval in shape and measured 30–40 μm in diameter (Fig. 4b). Most acini, however, were composed of crooked and branching cords of
acinar cells measuring 70-100 μm in a long axis and 30-50 μm in a short axis. They terminated blindly, forming no anastomoses with adjacent cords (Fig. 4c).

At higher magnifications of the basal aspect of the pancreatic acini, we found that the basement membrane was removed by the HCl treatment, and that the adjacent cells interdigitated with one another in a winding pattern reminiscent of a cranial suture. Wavy overlaps of cytoplasmic flaps without connection with the cell interdigitations could be frequently found on the basal surface of the acinar cells (Fig. 5a, b).

The HCl-digested specimens often were artificially fractured along the cell boundaries, revealing the intercellular aspects of the acini (Fig. 6a, b). The lateral surfaces of the acinar cells thus exposed a number of round elevations, which probably corresponded to zymogen granules. Many pits and microplicae were also intermingled there, in contrast to the smooth-looking basal surface. Upright microplicae were arranged along the lateral edges of the acinar cells.

In the freeze-cracked and non-digested specimens, the lateral pits and microplicae, which can be observed after the HCl digestion, were also found. However, the pits in the non-digested specimens were smaller and less sharply outlined than those following the HCl digestion. The flattened microprojections along the lateral cell edges were
shown more clearly by the freeze-cracking method than by the HCl digestion method (Fig. 7a, b).

**Secretory canaliculi**

With the freeze-cracking method, some of the columnar cords of the acinar cells were fractured transversely, showing a narrow secretory lumen at the center with intercellular canaliculi extending from it into the intercellular spaces of the acinar cells (Fig. 7a, b).

We could not find any marked differences of dimension or structure between the central lumen and the intercellular canaliculi. Both of them comprised narrow secretory canaliculi, measuring 0.6-1 \( \mu \text{m} \) in caliber, being provided with finger-like microvilli about 0.1 \( \mu \text{m} \) in diameter. In some places, uniform microvilli, about 0.4 \( \mu \text{m} \) in length, densely covered the surface of the canaliculi. In other places, microvilli were sparse and varying in length from 0.1 to 0.4 \( \mu \text{m} \). The secretory canaliculi in the HCl-treated pancreas were of the same size and structure as in the non-digested pancreas described above, except that their microvilli were shorter.

In the freeze-cracked specimens, a fragment of adjacent acinar cells often remained adhered to a narrow zone of the cell surface along the secretory canaliculus, so that

![Fig. 2. SEM overview of the ductal system of the rat pancreas, after removal of most acini by ultrasonic vibration. An excretory duct \((D)\) branches dichotomously, forming no anastomoses. Arrows: intercalated ducts. \( \times 270 \)](image-url)
it was difficult to follow its complete trajectory (Fig. 7a, b). In the HCl-treated specimens, on the other hand, acinar cells were separated easily along the cell boundaries to show, on their lateral surfaces, the whole extent of the canaliculi represented by narrow grooves provided with numerous microvilli and occasional small pits. The grooves branched from the central lumen, pursued an almost straight course toward the basement membrane without ramification, and terminated in a blind end (Fig. 6a, b).

The distance between the termination of the secretory canaliculi and the basal surface of acinar cells was generally 2-4 \( \mu m \). Occasionally the canaliculi extended so closely to the cell base that a distance of no more than 1 \( \mu m \) separated them (Fig. 6c).

**Finer structures of the ducts**

The excretory ducts measured more than 15 \( \mu m \) in diameter. They became thinner with each new branching. The intercalated ducts, measuring 4-6 \( \mu m \) in diameter, emerged suddenly from the excretory ducts of 15-40 \( \mu m \) in diameter. Most of the intercalated ducts were ramified every 15-50 \( \mu m \) without any decrease in thickness, and followed a bending course (Fig. 2, 3). However, there were some intercalated ducts which took an almost straight 100-200 \( \mu m \) course without any branching.

SEM observation revealed differences in surface features between the excretory ducts and the intercalated ducts. The basal surface of the excretory ducts resembled the bark of pine trees owing to its polygonal and longitudinal furrows which probably correspond to the cell boundaries of the epithelium (Fig. 3, 8a). The epithelial cells of the excretory ducts, however, possessed so many folds and microvilli on their basal surfaces that the cell boundaries were often indistinct. The basal folds often anas-

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**Fig. 3.** Stereo pair of scanning electron micrographs of rat exocrine pancreas. Removal of connective tissue by HCl and ultrasonic vibration has exposed an excretory duct (D), intercalated duct (arrowhead) and three acini. \( \times 540 \)
tomosed with one another to show a reticular appearance (Fig. 8b). In contrast, the intercalated ducts revealed much a smoother surface structure. Their epithelial cells were spindle-shaped and elongated longitudinally. In some places, their basal surfaces showed local undulations near the cell boundaries, due to numerous shallow round pits, measuring about 0.1 μm in diameter, and anastomosing ridges and lying microvilli. The cell boundaries of such an uneven surface sometimes showed wavy interdigitations between the cells (Fig. 8c, d).
Light microscopy of Golgi-stained specimens

The ductal system of the rat pancreas was able to be stained by the rapid Golgi method when the tissues were immersed in the osmium-dichromate solution for 10–14 days, although it was only a small part of the entire ductal system of the pancreatic lobule that was blackened. When a duct branch was stained positively, its every distributary was completely impregnated to its terminal portions.

By this rapid Golgi method, we were able to demonstrate that the pancreatic ductal system took the dendritic arrangement observed by SEM (Fig. 9 a). No anastomoses between adjacent branches were found in our study.

The acinar lumen was composed of thin secretory canaliculi which showed monopodial branching. The main axis was represented by a narrow secretory lumen, which bent in a zigzag course and branched several times. Short side branches were represented by intercellular canaliculi extended from the secretory lumen in various directions (Fig. 9b).

Each canaliculus was extended between the cells as deep as upper half or three quarters the height of an acinar cell, and terminated in a blind ending. Some canaliculi reached extremely close to the basement membrane, so that the zymogen granules gathering around them were found exactly beneath the basal surface of the acinar cells (Fig. 9c).

![Fig. 5. a. Basal surface of rat pancreatic acini treated with HCl. A acinus, ID intercalated duct, V blood vessels. x 4,000. b. Higher magnification of the box in Figure 5a. Neighboring acinar cells interdigitate with each other in a winding pattern (arrows). Wavy overlaps of cytoplasmic flaps (arrowheads) are seen on the individual acinar cells. x 10,000](image-url)
Fig. 6. Intercellular aspects of rat pancreatic acini after HCl digestion.  

b. Closer view of Figure 6a. Intercellular canaliculi (arrowheads) issuing from the secretory lumen (L). They are covered with short microvilli. Arrows indicate an intercellular gap and microplicae arranged along the lateral edges of acinar cells. The lateral surfaces of the acinar cells appear granulated owing to zymogen granules beneath the cell membranes. An acinar cell base is in the upper right portion of this micrograph. ×5,000.  
c. A secretory canaliculus reaching near the cell base (arrowhead).  ×6,000
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Fig. 7. SEM of a freeze-cracked pancreatic acinus of the rat. **a.** Acinar cell base (B) covered with collagen fibrils. L secretory lumen, V blood vessel. ×4,000. **b.** Closer view of Figure 7a. The surfaces of the secretory lumen and intercellular canaliculi are provided with finger-like microvilli. A part of the acinar cell has been broken off and zymogen granules (asterisks) are visible. ×6,800. Arrows indicate microplicae along the lateral edges of the acinar cells in both figures.
Fig. 8. SEM images revealing the basal aspects of the ductal elements of the rat pancreas (after HCl digestion).

a. An excretory duct showing an uneven basal surface with numerous furrows which probably correspond to cell boundaries. ×1,400. 

b. Closer view of the box in Figure 8a. Note the reticular basal folds. ×8,400. 

c. An intercalated duct with a smooth surface. Fine reticular undulations are found along the cell boundaries. ×3,600. 

d. Higher magnification of the upper portion of Figure 8c. Arrowheads indicate the cell boundaries. ×9,000.
Reconstruction of serial sections

A cardboard reconstruction model was made from 60 serial semithin sections, allowing us to obtain a three-dimensional image of a pancreatic acinus fully consistent with that obtained by SEM (Fig. 10). The acinar model was composed of thick twisting and branching cords of acinar cells, through whose axis ran a narrow secretory lumen. Many intercellular canaliculi originated from the central lumen and ended blindly, forming no anastomoses. The surface of the acinar model showed many hemi-spherical elevations which correspond to the individual acinar cell base.

While observing the serial sections, we could find extremely small acini which were composed of only two or three acinar cells with an intercellular canaliculus between them.
DISCUSSION

Architecture of the gland—acinar or reticular?

The present study is the first to demonstrate with the SEM the entire architecture of the exocrine pancreas. We confirmed that the exocrine pancreas of the normal rat is a compound acinar (alveolar) gland.

The pancreatic ductal system of the rat was characterized by long intercalated ducts with many branches and the absence of distinctive intralobular excretory ducts. Thin ducts issued from a thick interlobular duct with a sudden change in thickness and entered the pancreatic lobule. These ducts were identified as intercalated ducts by their consistently small diameters and their characteristic surface features. Each branch of the intercalated duct connected with an acinus. Large crooked tubular acini with some bifurcations were more frequent than the simple round ones which were often compared to grapes. This finding explains the occasional acinar profile of branched cords as observed in light microscopic sections.

We could not find any anastomoses among the excretory ducts, the intercalated ducts or the acini that Bockman (1976, 1978, 1980) demonstrated by reconstruction of serial paraffin sections and by retrograde injection of silicone rubber into the pancreatic ducts.

In reconstructing the serial sections, it is possible that some inadvertent errors might have been intercalated. Whereas Bockman used 7μm thick paraffin sections for reconstruction of the acinar lumen, we used serial semithin sections of 1μm embedded in Araldite. Our results from the reconstructed model of pancreatic acini supported our SEM and Golgi impregnation observations. No anastomosed reticular structure as depicted by Bockman (1976, 1978) could be found in our reconstruction.

Fig. 10. Cardboard reconstruction from serial semithin sections of a pancreatic acinus of the rat. The arrowhead indicates an intercalated duct. The pancreatic acinus is composed of a winding cell cord with a short branch (arrow) and possesses no connections with neighboring acini. Round elevations on the acinar surface correspond to the individual cell base.
As concerns the ductal casts, the reticular anastomoses of the ductal casts of the exocrine pancreas which Bockman observed could not be confirmed in the present study. A similar reticular image of the ductal system was reported in 1869 by Savioitti, who observed it by a dye injection method. He noticed that the intercellular canaliculi were extended along the margin of the acinar cells under the basement membrane and anastomosed with one another to form a three-dimensional network. We believe that both Bockman's and Savioitti's results might have been caused by artifacts, i.e., leakage of the injection materials from the extremities of the intercellular canaliculi approaching each other over the attenuate cell base.

**Secretory canaliculi**

In 1977, Motta first demonstrated SEM images of the rat exocrine pancreas. With the simple fracture technique used at that time, he was unable to show either convincing micrographs of the secretory canaliculi or structures of different surfaces of acinar cells. Fujita et al. (1981) seem to be the first to have demonstrated the secretory lumina.
of the pancreas as narrow canaliculi. They observed the freeze-cracked pancreas of
the dog after stimulation by caerulein, a pancreozymin mimetic peptide. However,
there are some differences between theirs and the present findings. The canaliculi of
the dog which FUJITA demonstrated were larger in caliber than those of our rat by 20–
40% and had a stronger tendency to terminate close to the acinar cell base. The most
noticeable difference was in the surface features of the canaliculi, especially, the shape
of the microprojections covering them. The secretory canaliculi of rat pancreas possessed
finger-like microvilli, which were consistent with those reported in TEM studies
(EKholm, 1962a) both in shape and in size. On the other hand, the canaliculi of the dog
pancreas observed by FUJITA were provided with more irregular-shaped, flattened pro-
jections which may be called microplicae. Most of these differences can probably be
ascribed to species difference, and particularly to the fact that the dog pancreas was
stimulated with caerulein. However, as the grooves with microprojections on the
surface of the dog acinar cells (Plate III–19A) resemble in appearance the microplicae
on the lateral edges of the rat acinar cells which we demonstrated, the grooves which
FUJITA reported are conceived to correspond, at least partly, to the cell edges and not to
the secretory canaliculi.

The secretory canaliculi of the exocrine pancreas as observed under the SEM sur-
prisingly displayed an appearance similar to the bile canaliculi of the liver, with small
caliber, finger-like microvilli and the occurrence of some side twigs which extended
near the cell base. The important difference was that the pancreatic canaliculi did not
form a network like the bile canaliculi.

The portions where bile canaliculi extend close to the perisinusoidal space of Disse
have been assumed to provide a potential pathway for bile regurgitation to blood
(Motta et al., 1978; Motta, 1984). Similarly, amylase and other enzymes of the
pancreas, which always occur in blood, though in extremely small quantities, may
possibly be ascribed to their leakage into circulation in the areas where secretory
canaliculi terminate in close vicinity to the basement membrane. FUJITA et al. (1981)
pointed to this possibility by demonstrating that the secretory canaliculi were conspic-
uously close to the basement membrane after the pancreas was stimulated by caerulein.
On the basis of our SEM and impregnation images of the secretory canaliculi, we also
conceive that “leakage” may somehow occur from their extremities to the periacinar
space, although the precise mechanism of the leakage is unknown.

Other SEM findings
We were able to obtain some additional findings of interest concerning the structure of
the exocrine pancreas by using the HCl digestion method.

The smallest bud-like acini are presumed to represent structures which might
give rise to large acini in regeneration or hyperplasia of the pancreatic tissue. We
also confirmed the occurrence of such acini—composed of a few cells and a single inter-
cellular canaliculus—by reconstruction of serial semithin sections. However, there
may be the possibility that the bud-like structures are involved in the new formation of
islet cells. According to ZWEENS and BOUMAN (1969) and BOQUIST and EDSTROM (1970),
the ductules of the rat pancreas after duct ligation showed numerous buds of seemingly
proliferating cells, some of which were granulated, suggestive of islet cells.

Wavy patterns on the acinar cell base as revealed by SEM probably correspond to
invaginations and interdigitations of basal plasma membrane, which were pointed out
by EKholm (1962a) in his TEM study on the normal rat pancreas. These basal mem-
brane invaginations can not have much effect on the increase of the cell surface in
contact with extra-acinar space, as they occupy only small areas of the cell base. In contrast with the pancreas, the salivary glands of man and some species of monkeys have been known to show numerous slender folds on the whole acinar cell base (Tandler, 1962; Leeson, 1969).

The present SEM observation revealed that the thick excretory ducts possessed on their basal surface many anastomosing folds. They are believed to greatly increase the surface area of the epithelial cell base and probably facilitate the transportation of water and other substances through the cell membrane.

The intercalated ducts, which have been assumed to be the site of the secretion of water and bicarbonate in pancreatic juice (Grossman and Ivy, 1946; Becker, 1962), did not exhibit such conspicuous basal infoldings as have been noted in other electrolyte-transporting tissues, e.g., the renal tubules (Evan et al., 1976) and the striated portion of the parotid gland (Mazuurova, 1983), which revealed under the SEM, after HCl digestion, parallel folds of an “accordion-like” appearance in the whole extent of their basal surfaces. Such an inconsistency was also pointed out by Ekholm (1962b), who observed the rat pancreas under the TEM.

In the present study, however, the intercalated ducts showed undulations of the basal cell surface in areas near the cell boundaries. These structures may possibly be involved in the assumed function of this portion. In his TEM study Ichikawa (1965) demonstrated that epithelial cells of intercalated ducts after secretin stimulation showed more complicated interdigitations of their contact surfaces, and that their basal surfaces also exhibited complex wavy lines when a transverse section was made near cell boundaries (Fig. 12 in Ichikawa, 1965). These focal irregularities of the epithelial cell bases probably correspond to the surface unevenness found in the present SEM study, for they appear similar in dimension and in their relations to the cell boundaries. On the other hand, Fujita et al. (1981) demonstrated by SEM a larger number of villous or laminar microprojections on the basal surfaces of intercalated duct cells in the dog pancreas stimulated with caerulein. This finding by Fujita et al. suggests that the basal aspects of the pancreatic intercalated ducts may change dynamically according to their functional state.

Light microscopy of Golgi-stained specimens

The SEM findings on the pancreatic secretory canaliculi were supported by light microscopic observation of the Golgi-stained pancreatic acini. We were able to demonstrate the entire arborization corresponding to the excretory passages of the pancreas. Although some twigs of the intercellular secretory canaliculi extended extremely close to the basement membrane, they did not anastomose with each other but ended blindly. Our light microscopic observations well coincide with the findings by the retrograde dye injection method reported by Langerhans (1869), and with those of the Golgi method obtained by Cajal and Sala (1891), and Dogiel (1893).

With the rapid Golgi method, the ductal system of the rat pancreas was impregnated continuously from the interlobular ducts to their end portions without damage or distortion, while the retrograde injection method tended to cause distension or breakage of the lumen.

On this occasion, it seems worthwhile to mention that we examined the pancreas of two other species, the guinea pig and rabbit, with the rapid Golgi method and obtained the same results as in the rat.

The present SEM observation combined with the HCl digestion method directly demonstrated that the exocrine pancreas of the rat was a typical compound acinar
gland. The long disputed problem as to whether the excretory passage of the pancreas might be acinar or reticular in architecture has thus been settled. Furthermore, this method was able to reveal the surface features of the acinar and the ductal cells. Luminal views of the excretory passages were also demonstrated in this study. This technique will permit SEM observation of conformational changes in the pancreatic tissues under various hormonal or feeding conditions. Species difference in threedimensional architecture and surface structures of the pancreas also remains to be elucidated.

Acknowledgements. The author is grateful to Mr. S. TAKAHASHI for his invaluable technical assistance in the Golgi staining, and to Dr. T. USHIKI for his cooperation in three-dimensional reconstruction of the serial sections.

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