

# A STUDY BY SCANNING ELECTRON MICROSCOPY OF THE URETER EPITHELIUM OF THE BLACK APE

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## ABSTRACT

The epithelium of the black ape ureter was studied and the following results were obtained.

1. The cell surface of the ureter epithelium was slightly domed.

2. The cell of the epithelium showed irregular sphere or piriform, and the cell process united another one.

3. The surface of the cell is characterized by numerous small ridges.

4. The ridges were observed in a reticular pattern, and it seems to be an arabesque appearance at the luminal plasma membrane.

5. The luminal cell surface showed numerous, irregular, microvilli-like structures.

6. Small cells in the second layer had a smooth appearance and lacked reticular ridges.

7. The ridges and microvilli-like structures of the surface cell in the ureter epithelium are more irregular in shape and distribution than those of the bladder epithelium.

## INTRODUCTION

Several recent studies have investigated the bladder, urethra and upper urinary tract by scanning electron microscopy (SEM).<sup>1-14)</sup> However, investigations on the fine structure of the epithelium of the ureter by SEM are few. The previous observations made by light microscopy have been elaborated by further study. Apart from

a general description of the functional disorder or diseases of the ureter, there is very little information available on the ultrastructure of the transitional epithelium of the ureter. The present investigation is concerned with two aspects of the morphology of the ureter transitional epithelium and its function. In adult mammals, the lining (transitional) epithelium of the bladder and ureter undergoes cell renewal at a very slow rate and has been classified among the expanding cell populations (Leblond,<sup>5)</sup> '64). The present study was undertaken by SEM to examine the detailed surface morphology of the surface cells, cell renewal and the manner in which they adjust to varying degrees of ureter distension. The present study was made to clarify the morphological differences of the transitional epithelium between the ureter of black ape and the urinary bladder of the other animals.

## MATERIALS AND METHODS

The ureter of male black ape (*Cynopithecus niger*) weighing 5 kg was excised under anesthesia. Specimens from the proximal, middle point and distal ureter and from the bladder were obtained. Specimens for light microscopy were placed in a 10 per cent solution of formalin for 20 hours, dehydrated through graded ethanol, embedded in paraffin and sectioned. After being mounted on glass slides the sections were washed with xylene and stained with hematoxylin and eosin. Specimens intended for scanning electron

microscopic study were immersed in a 2.5 per cent solution of glutaraldehyde with phosphate buffer at a temperature of 4C. For observation by conductive staining method the specimens were left in the glutaraldehyde for 1 hour, in a 2 per cent solution of osmic acid for 1 hour, in a 2 per cent solution of tannic acid for 1 hour and again in a 2 per cent solution of osmic acid for 1 hour—always at 4C. They were dehydrated in graded ethanol, which was replaced gradually with benzol, and finally they were immersed in p-dichlorobenzene for 2 hours at a temperature of 60C. After being immersed the specimens were placed at room temperature for 24 hours until sublimation.

### RESULTS

#### 1. The upper part of the ureter near the renal pelvis

The free surfaces of the black ape ureter were slightly domed, and characterized by numerous small ridges. The surface cells of the collapsed ureter showed polygonal or slightly spherical shape. Secretion-like substance adhered to the cell surface. Small polygonal holes were occasionally seen in areas of the interior luminal surface, they were marks of the peeled off surface cell (Fig. 1).

Several layered cell groups were seen in the perpendicularly cut surface to that of transitional epithelium at higher magnification. The cell nucleus was frequently separated from the cytoplasm in the cut surface of the cell. Filament-like fibers were observed in areas of the cytoplasm. According to the figure 2, these cells showed polygonal shape.

#### 2. The middle part of the ureter

Figure 3 showed a transversely cut surface of the ureter. As the ureter epithelium showed 4 longitudinally running plicae, the transversely cut surface of the interior lumen showed a star or acinous form. Irregularly arranged surface cells of epithelium and smooth muscle layers surrounding the lumen were seen (Fig. 4). The transitional epithelial cells seemed occasionally to be raised in protrusion to the surface,

however, the cells unite each other (Fig. 5). According to the figures 6 and 7 showing the transitional epithelium of interior lumen of the ureter, the cells showed an irregular sphere or piriform. The cell process unites another one. A cell may have several processes. The transitional epithelium of figure 8 seemed to be a stratified columnar epithelium. It consists of three layers, the most superficial cells were irregular in shape. However, the cells under the second layer in depth were columnar in shape. A columnar cell united smoothly the surrounding other cells, on the other hand, it combined directly with the upper or lower cell. According to a typical view in the luminal surface of the middle part of the ureter, the surface cells were seen polygonally in shape (Fig. 9). Higher magnification of a part of the luminal cell surface showed numerous, irregular microvilli-like structures (Fig. 10). Separated nuclei having spherical or oval shape and filaments in the cytoplasm were observed in the longitudinally cut surface of the transitional epithelium (Fig. 11).

The muscularis has three smooth muscle layers. The outer and the inner layers are thin and arranged longitudinally. The middle layer is relatively thin and arranged in a circular manner (Fig. 4).

#### 3. The lower part of the ureter near the urinary bladder

In the lower part of the ureter, the free surface of the lumen was distinctly wrinkled and highly irregular. The ridges in the central portion of the surface cell were closer together and appeared to be higher than in the distended state (Fig. 12, 13). It seemed to be an arabesque appearance of the luminal plasma membrane. Nearly all of these small cells in the second layer had a smooth appearance since they showed only sparse microvilli as a surface feature, and lacked reticular ridges (Fig. 13). Figure 14 showed a longitudinally cut surface of the transitional epithelium of the lower ureter. The stratified epithelium seemed to be united one another. In the cut surface of the epithelium, the nuclei flew out from the cell, and the electron conduc-

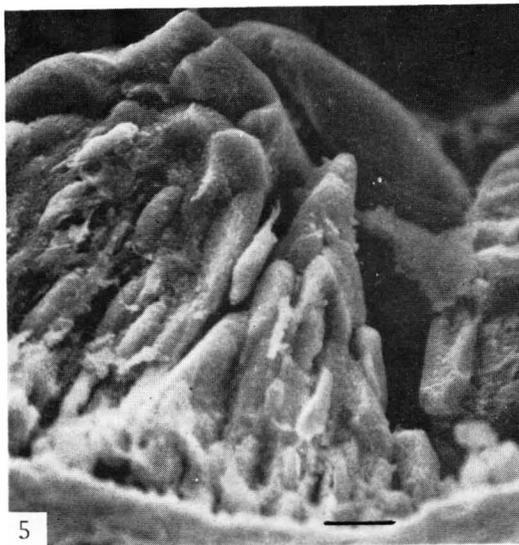
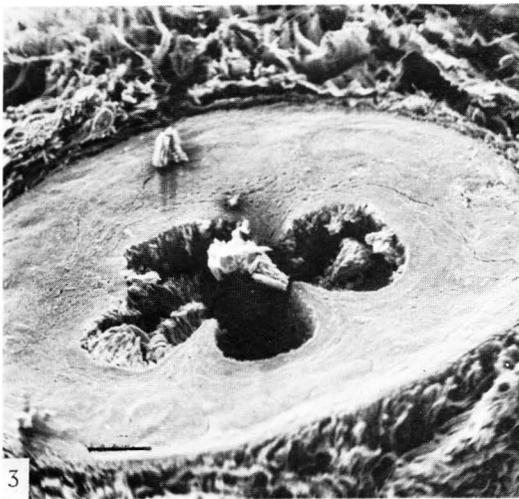
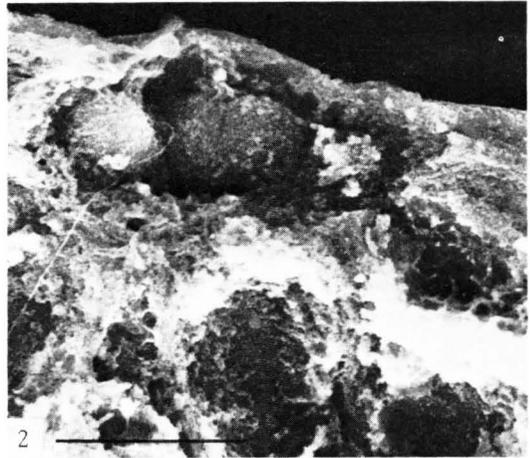
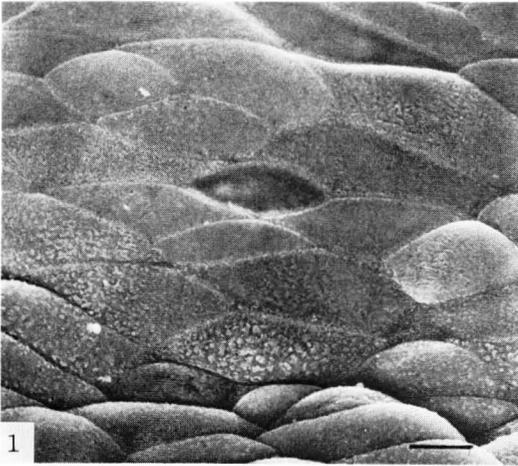


Fig. 1. Upper part of the ureter near the renal pelvis. The free surfaces of the ureter are slightly domed. Bar=10  $\mu$ m.

Fig. 2. Upper part of the ureter. Several layered cell groups are seen in the perpendicularly cut surface. Bar=10  $\mu$ m.

Fig. 3. Middle part of the ureter. A transversely cut surface of the ureter is seen. Bar=100  $\mu$ m.

Fig. 4. Middle part of the ureter. Smooth muscle layers surrounding the lumen are seen. Bar=30  $\mu$ m.

Fig. 5. Middle part of the ureter. Transitional epithelial cells seemed to be raised in protrusion to the surface. Bar=10  $\mu$ m.

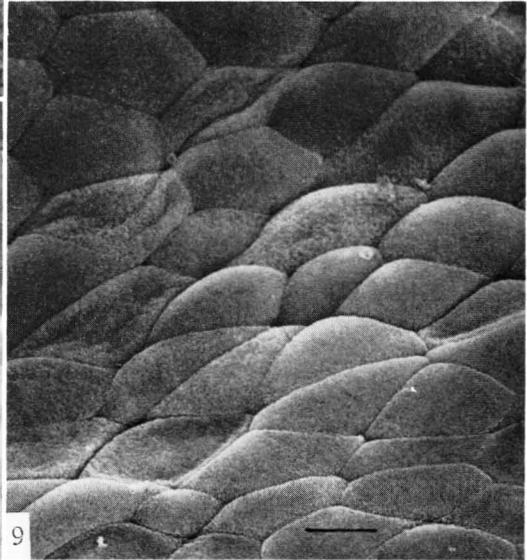
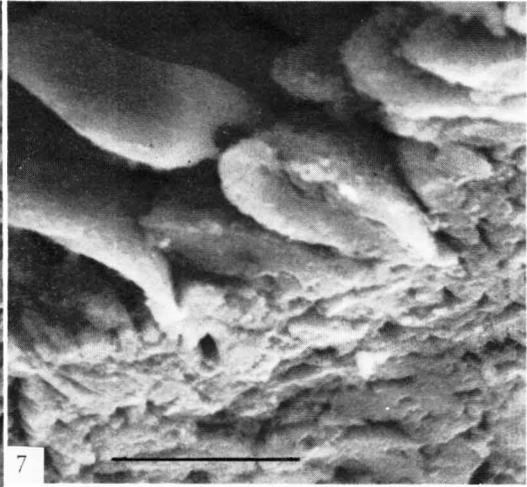
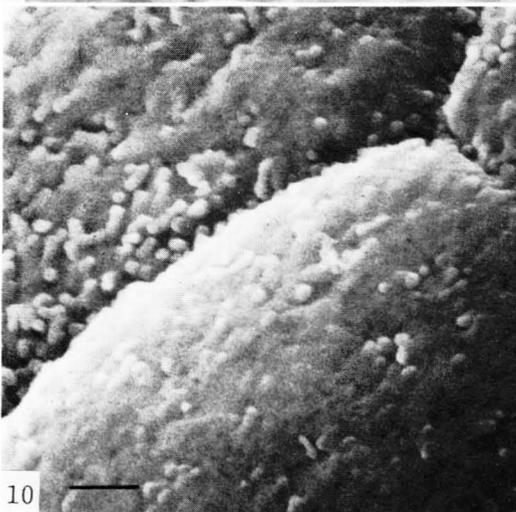
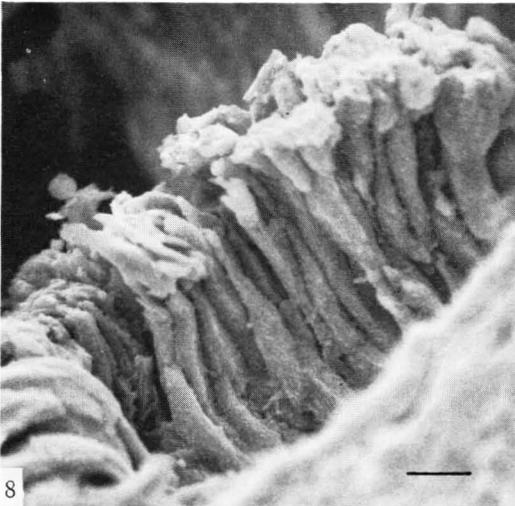
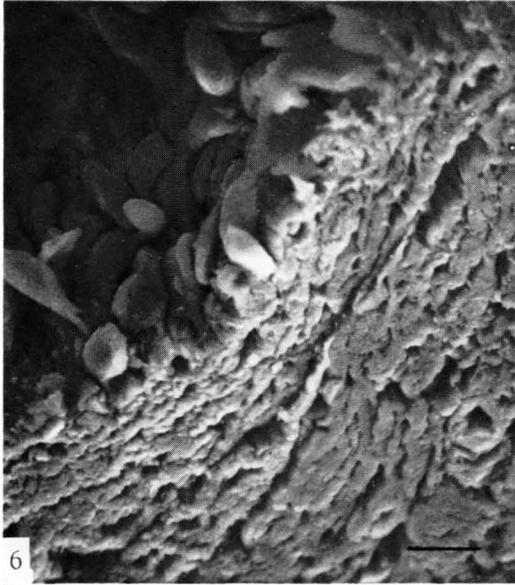


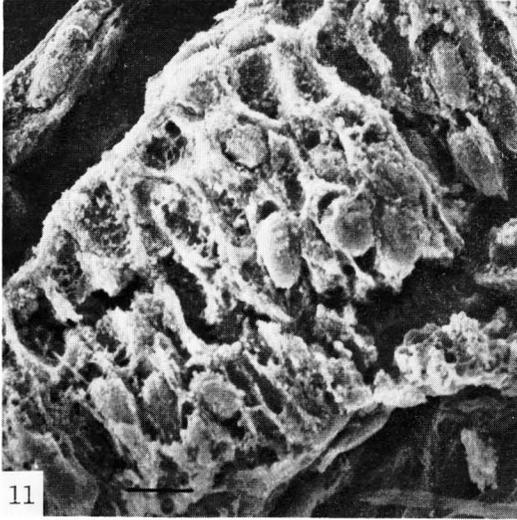
Fig. 6. Middle part of the ureter. The cells in the transitional epithelium of interior lumen showed a irregular sphere or piriform. Bar = 10  $\mu$ m.

Fig. 7. Middle part of the ureter. The cell unites another one. Bar = 10  $\mu$ m.

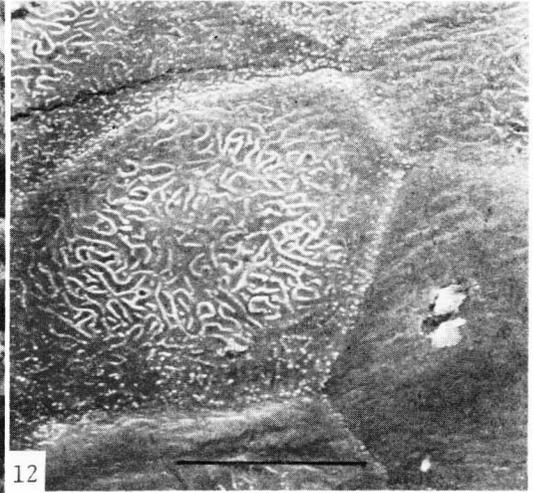
Fig. 8. Middle part of the ureter. The transitional epithelium seems to be a stratified columnar epithelium. Bar = 10  $\mu$ m.

Fig. 9. Middle part of the ureter. Surface cells are seen polygonally in shape. Bar = 10  $\mu$ m.

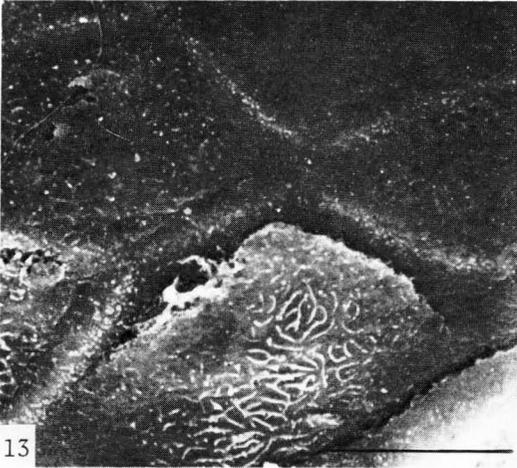
Fig. 10. Middle part of the ureter. A part of the luminal cell surface showed numerous and irregular microvilli-like structures. Bar = 1  $\mu$ m.



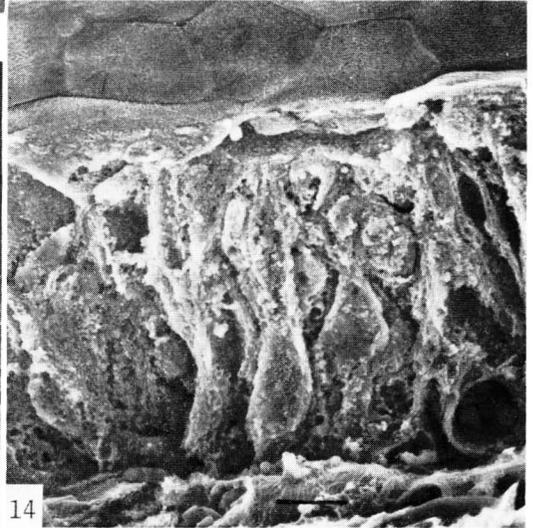
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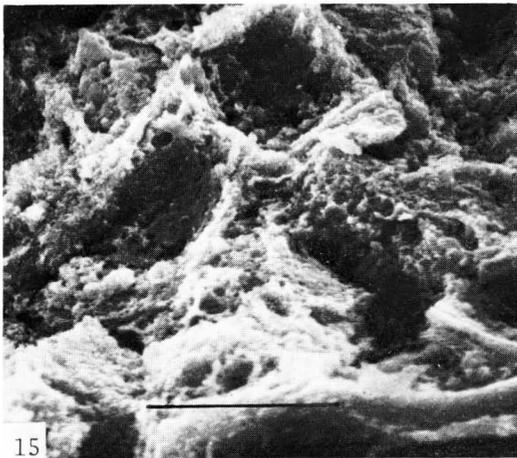
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Fig. 11. Middle part of the ureter. Separated nuclei and filaments are observed in the cytoplasm at the longitudinally cut surface. Bar=10  $\mu$ m.

Fig. 12. Lower part of the ureter. Ridges in the central portion of the surface cell seem to be an arabesque appearance. Bar=10  $\mu$ m.

Fig. 13. Lower portion of the ureter. Smooth surface cells are seen in the ureter. portion. Bar=10  $\mu$ m.

Fig. 14. Lower part of the ureter. A longitudinally cut surface is visible. The stratified epithelial cell seemed to be united one another. Bar=10  $\mu$ m.

Fig. 15. Lower part of the ureter. In the cut surface of the epithelium, the nuclei flew out from the cell. Bar=10  $\mu$ m.

tivity of the peripheral zone near the cell membrane was lower than the central zone of the cell (Fig. 15).

#### 4. The cell surface of the urinary bladder epithelium

The free surface of the epithelial cells exhibited either scanty, short microvilli or a few distinct ridges.

### DISCUSSION

The epithelium of the ureter is of the transitional type. Hitherto, study of the ureter by SEM are few. Investigation of the bladder by SEM has confirmed the numerous observations made in the past by light microscopy (Martin<sup>9)</sup>, '72) and by transmission electron microscopy (Hicks, '65<sup>3)</sup>, 66a, b, Petry and Amon<sup>11)</sup>, '66), that the surface cells of transitional epithelium are some of the largest in the mammalian body. Although the surface cells of transitional epithelium of the black ape vary markedly in size, and their diameters naturally change during physiological state, when the ureter is fixed in moderate distension to obtain flat cell surfaces, some of the cell profiles are found to have an average diameter of approximately 40  $\mu\text{m}$  in SEM preparations by conductive staining method.

In the contracted state, the epithelium as a whole is thrown into several folds, and they vary in number by the part of the ureter. As distension proceeds, the surface folds disappear and the cell surface becomes flat. A system of ridges is present on the flattened cell surfaces, the ridges are observed in a reticular pattern, and the areas of surface enclosed between them are concave in shape. This pattern is thought for the arabesque appearance of the luminal plasma membrane. The ridges are more irregular in shape than those of the urinary bladder.

At the cell margins the ridges are raised. It is considered that the ridges are structures showing limited elasticity. The luminal folding of the ureter epithelium is less than that of the bladder one. The bladder stores urine, on the other hand the ureter transports it.

These observations support the conclu-

sion reached from investigations on isolated segments of luminal plasma membrane, made by TEM, negative staining and freeze-etching (Staehelein et al.<sup>12)</sup>, '72; Chlapowski et al.<sup>12)</sup>, '72).

It was noted that the membrane is composed of plaque, concave surface areas and the ridges which separate them. The significance of the plaques is not clear. However, Wong et al.<sup>13)</sup> stated that the plaques in the bladder epithelium of the guinea pig showed the typical asymmetric membrane structure and contain particles arranged in hexagonal groups.

It was observed that among the general population of the ureter surface cells a small number have a relatively smooth luminal surface. Similar cells, smooth surface and without ridges, reported in bladders of dogs and cats (Mooney and Hinman<sup>10)</sup>, '74). Although relatively smooth, the surface of these cells of the bladder showed the presence of scattered microvilli, and it reported, from a study of fetal material, that this is a feature of immature surface cells (Wong and Martin<sup>13)</sup>, '75). Smooth surface cells in the ureter are considered as immature ones, because they were observed in the trace of fallen surface cells.

Following an autoradiographic study, it was shown by Martin<sup>9)</sup> ('72) that the surface cells of the bladder are slowly replaced from the underlying layer of large piriform cells, and Wolf<sup>14)</sup> ('66) demonstrated by means of a replica technique and TEM that the piriform cells emerge by protruding between the surface cells in "button-like formations". Following a scanning electron microscopic study by us, the presence of piriform cells were recognized in the ureter epithelium. The piriform cells are of immature and their slender portions reach to the underlying cells. It is thought that the piriform cells are slow to reach maturity after emerging.

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## 黒ザル尿管上皮の走査電顕的研究

愛知医科大学解剖学教室

武藤 浩・吉岡 郁夫

黒ザル尿管の上皮が研究され、つぎの結果が得られた。

1. 尿管上皮の細胞表面はわずかにドーム状をなしていた。
2. 上皮の細胞は不規則な球形か西洋梨の形を示し、細胞の突起はお互に結んでいた。
3. 細胞の表面は多くの小さい隆起があるのが特徴である。

4. この隆起は網状の模様として解察され、内腔細胞膜で、からくき模様の外観に見える。

5. 内腔の細胞表面は、多くの不規則な、微絨毛のような構造を示した。

6. 第2層の小さい細胞は、滑らかな外観を持ち、網状の隆起に欠けていた。

7. 尿管上皮の表面細胞の隆起と微絨毛構造は膀胱上皮よりも、形、分布が不規則である。