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Architecture and density of the connective tissue papillae of the human oral mucosa

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INTRODUCTION

The epithelial–connective tissue boundary of the human oral mucosa is a highly variable interface which, owing to the uneven distribution of the projecting connective tissue papillae, can be extremely irregular in some sites and rather smooth in others (Horstmann, 1954; Karring & Löe, 1970). In addition, age and sex variations in connective tissue papillary density have been described (Horstmann, 1954; Shklar, 1966; Löe & Karring, 1971; Karring, 1973). The connective tissue papillae have been regarded by several authors as adaptive structures which enlarge the epithelial–connective tissue interface in order to achieve a broader anchorage for the epithelium and to provide a larger exchange surface for nutritional purposes (Horstmann, 1954; Karring, 1973). Recently, the oral connective tissue has been shown to possess a specific inductive influence on the differentiation of the contiguous epithelium (Karring, Lang & Löe, 1975).

In general, there seems to be no quantitative and detailed information in the literature about the epithelium–connective tissue interface in the various regions of the oral cavity. In view of the possible value of such information in the fields of electron microscopic stereology and oral pathology it was decided to investigate the matter in some detail.

MATERIAL AND METHODS

Biopsy and autopsy specimens of human oral mucosa were obtained from six different sites. Biopsies were taken only from medically healthy subjects with normal mucosa. Autopsy samples were taken from subjects whose oral cavities were unaffected by disease. A total of 106 specimens was collected, comprising 14 biopsy specimens and 92 specimens from 43 autopsies. The biopsies were taken under block anaesthesia (2 % Lidocain and Epinephrine 1:80000) using a 3 or 4 mm cornea trepan and a number 11 scalpel. The autopsy samples were taken with similar instruments with or without wide surgical excision. Every attempt was made to avoid compressing or otherwise injuring the specimens.

Buccal mucosa (8 biopsies and 31 autopsies) was collected from the left cheek of 11–81 year old females and males, in the area opposite the left premolars. Lip mucosa (10 autopsies) from the lower lip of 28–76 year old females and males was collected from left of the middle line. Hard palate mucosa (3 biopsies and 24 autopsies) was

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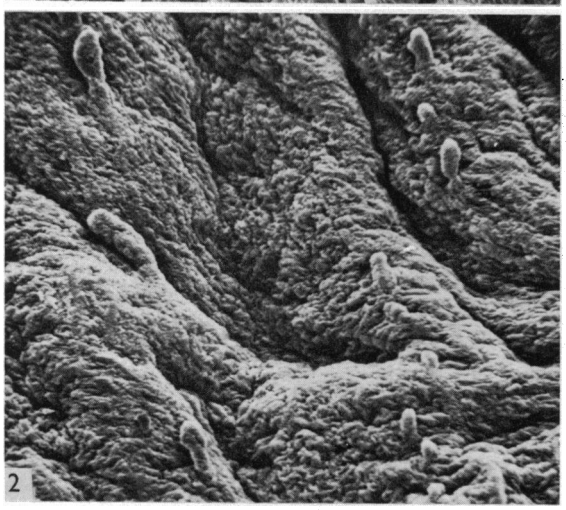
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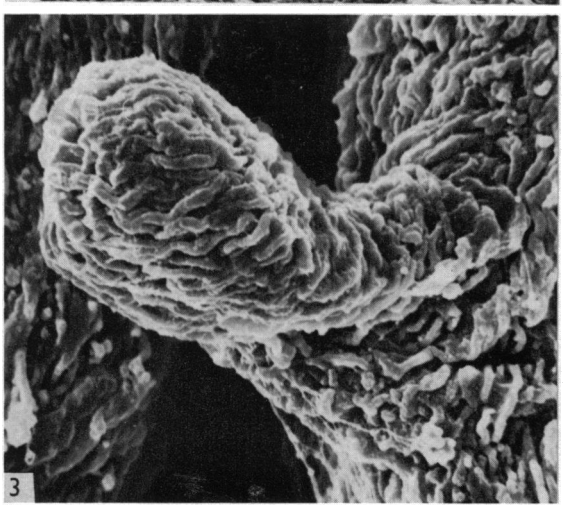
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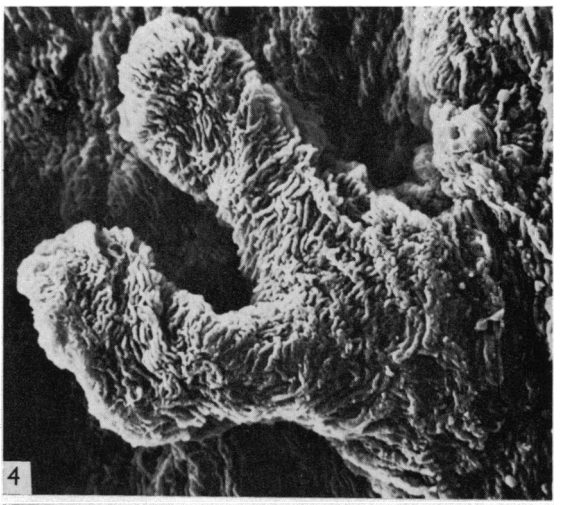
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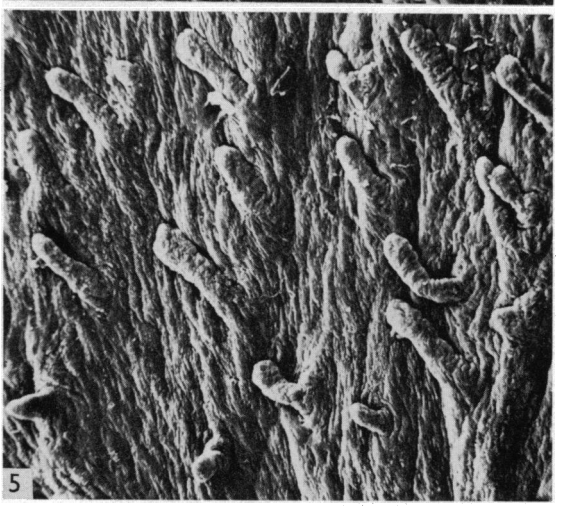
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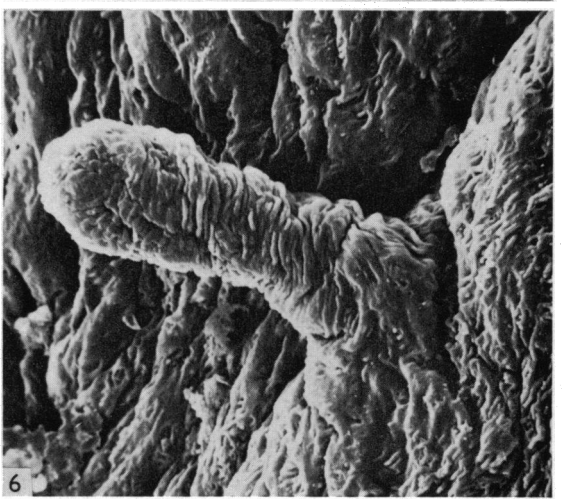
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taken from 32–81 year old individuals of both sexes, and was removed from the left side of the pars glandulosa in an area medial to the molar region halfway between the interdental papillae and the raphe palati. In four cases specimens were taken directly in the middle line at a similar level. Alveolar mucosa (3 biopsies and 10 autopsies) was collected from the vestibular side at the left lower molar region of 32–78 year old females and males. Floor of the mouth samples (10 autopsies) were taken from the paramedian left area of the sublingual mucosa of 47–81 year old persons of both sexes. Eight samples of free and attached buccal gingiva were taken from females and males of the same age group.

Immediately after excision all specimens were transferred to an isotonic solution of phosphate buffered saline containing 20 mM of EDTA (Scaletta & McCallum, 1972). They were washed for 10 minutes at room temperature and incubated in the same solution at 37 °C for 60–90 minutes. The epithelium was then separated from the connective tissue, using two fine forceps and working under a dissecting microscope. Large samples, e.g. tissues from the floor of the mouth, which proved more difficult to separate, were incubated in 2 N NaBr at 37 °C for 20–40 minutes prior to dissection (Papa & Farber, 1971). Both the epithelium and the connective tissue were stretched out on blotting paper, fixed for 2–3 hours in a chilled half-strength Karnovsky fixative containing 2·5 % glutaraldehyde and 2 % paraformaldehyde (Karnovsky, 1965), and post-fixed with 1·33 % osmic acid in 0·067 M s-collidine buffer.

Dehydration in a graded ethanol series at room temperature was followed by a graded iso-amyl acetate series and subsequent drying from liquid CO_2 by the critical point method (Anderson, 1951). The samples were mounted in order to show the basal surface of the epithelium and the de-epithelialized surface of the connective tissue respectively. They were coated with carbon and gold in a Balzers BAE-121 evaporator and examined with a Cambridge Stereoscan 1 or a Philips PSEM 500 electron microscope (SEM).

Following SEM observations, some specimens were placed in propylene-oxide and infiltrated with Epon 812 in order to identify with greater accuracy the surface structures by means of transmission electron microscopy (Meller, Coppe, Susumu & Waterman, 1973). The specimens were contrasted with uranyl acetate and lead citrate and examined with a Philips 201 transmission electron microscope (TEM).

Fig. 1. Papillary body in the floor of the mouth. Parallel plateaux are separated by narrow grooves. Each plateau carries a limited number of solitary short papillae. × 115.

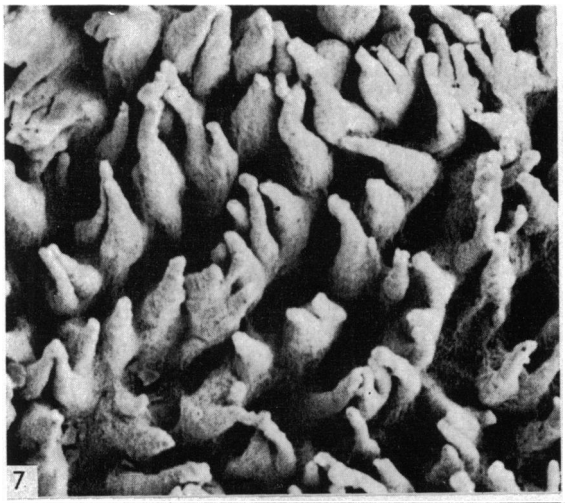
Fig. 2. Papillary body in the floor of the mouth at higher magnification. Note solitary short papillae. × 210.

Fig. 3. Connective tissue papilla in the floor of the mouth. Note protruding villus-like wrinkles of the papillary surface. × 200.

Fig. 4. Bifurcating connective tissue papilla in the alveolar mucosa. Note surface wrinkles. × 1050.

Fig. 5. Papillary body in the alveolar mucosa. Solitary papillae are aligned in parallel rows on a relatively flat connective tissue. Note that density of connective tissue papillae is higher than that in the floor of the mouth (Fig. 1). × 180.

Fig. 6. Solitary connective tissue papilla in the alveolar mucosa. Note the wrinkled appearance of the papillary surface. × 900.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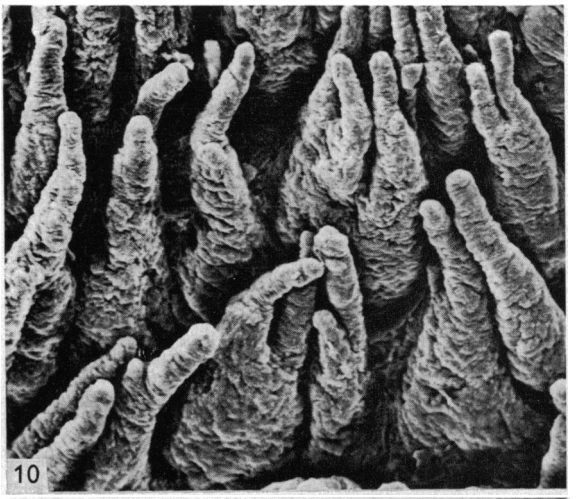
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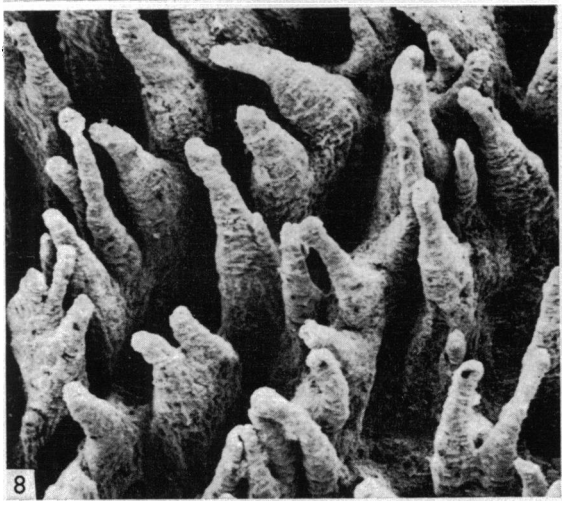
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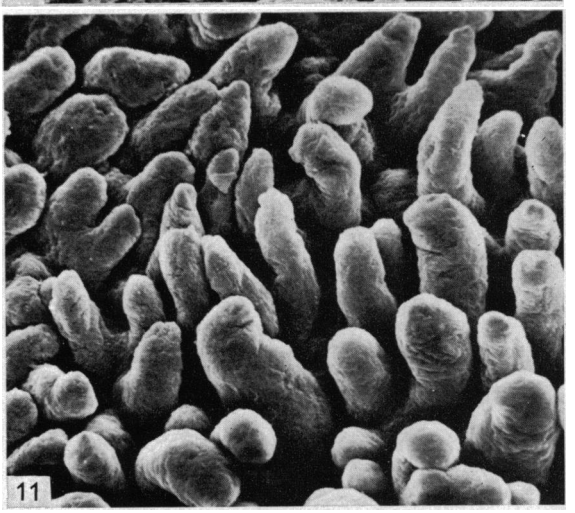
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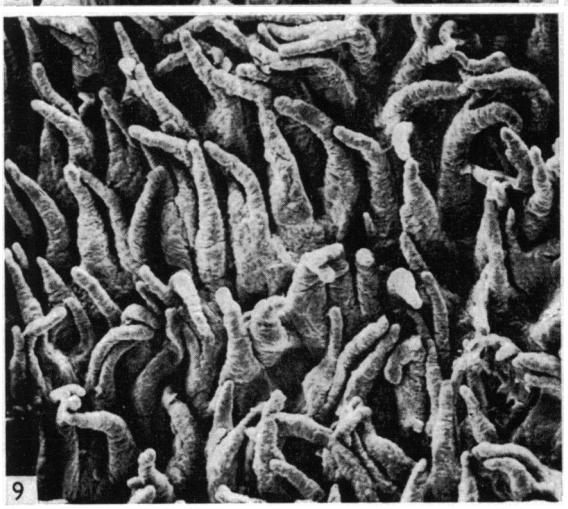
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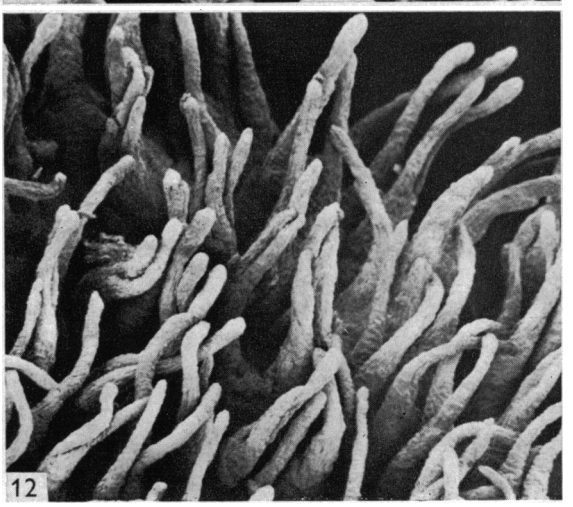
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Some portions of oral mucosa from the different sites were embedded in Epon 812, either before or after epithelial separation. Approximately 1 μm sections were prepared and stained with PAS and toluidine blue (Schroeder, 1973).

Quantitative determinations

The number of papillae per surface unit of de-epithelialized connective tissue and the percentage of the area occupied by connective tissue papillae orifices at the basal epithelial surface were determined in at least six individual cases in each of the six different oral mucosa regions under study. This was achieved by using micrographs of plain surfaces of both connective tissue and epithelium derived from critical point dried specimens. These micrographs were taken with a Wild M7 dissecting microscope at a primary magnification of $\times 16$. Measurements were carried out on at least 2 mm^2 of tissue surface per sample, using a table projector yielding a final magnification of $\times 153$. The total number of connective tissue papillae was counted on the entire specimen surface and the numerical density per 1 mm^2 was calculated. The percentage of papillary orifices on the basal surface of the separated epithelium was measured with a coherent morphometric test system (featuring 891 volumetric test points; Weibel, 1969) by counting the number of points falling on the connective tissue papillae orifices.

Data on epithelial thickness was obtained in part from human biopsy material concurrently under study in this laboratory. Measurements of the vestibular epithelium were provided by Bernimoulin (1975, personal communication); those of the buccal epithelium were taken from Landay & Schroeder (1976); and those of palate epithelium from Meyer & Schroeder (1975).

RESULTS

Except for the specimens which originated from the floor of the mouth, the separation procedure used to split the epithelium from the connective tissue was reliable, easily performed, and always resulted in an exact cleavage along the electron-lucent part of the basal lamina. There was no difference regarding this procedure between the biopsy and the autopsy material. The architecture of the papillary body, the individual connective tissue papillae, and the basal epithelial surface will be described separately for various sites of the oral mucosa, on the basis of scanning electron micrographs, light microscopic sections, and morphometric data.

Fig. 7. Papillary body in cheek mucosa. Rows of parallel connective tissue papillae arise from connective tissue ridges. $\times 40$.

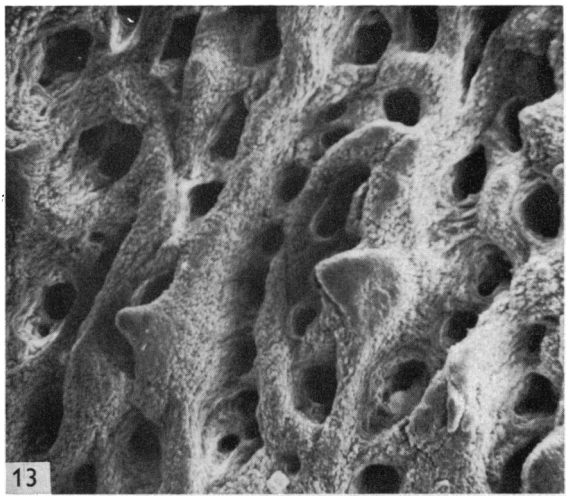
Fig. 8. Papillary body in cheek mucosa as shown in Fig. 7, at higher magnification. Note branching of papillae. $\times 110$.

Fig. 9. Papillary body in cheek mucosa exhibiting a high density of bent and angulated papillae. $\times 85$.

Fig. 10. Papillary body in cheek mucosa as shown in Fig. 9 at higher magnification. Note branching and angulation of papillae giving a wrinkled surface texture. $\times 190$.

Fig. 11. Papillary body in cheek mucosa characterized by flat-tipped, plump papillae. Note bifurcation. $\times 110$.

Fig. 12. Papillary body in cheek mucosa characterized by slender papillae. $\times 110$.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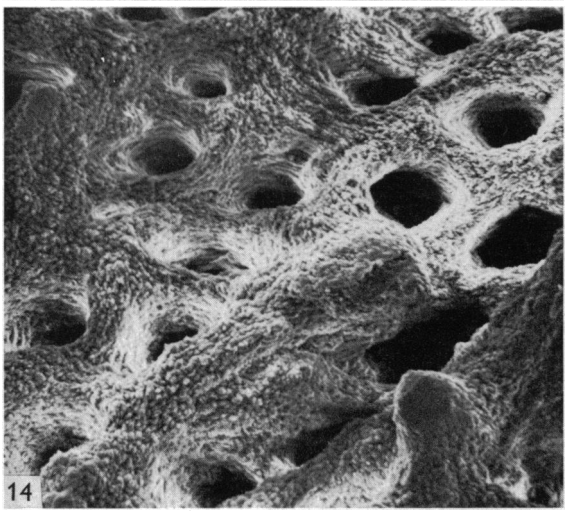
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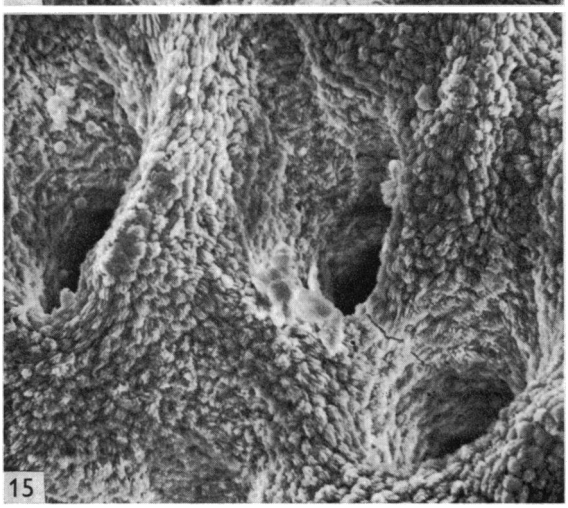
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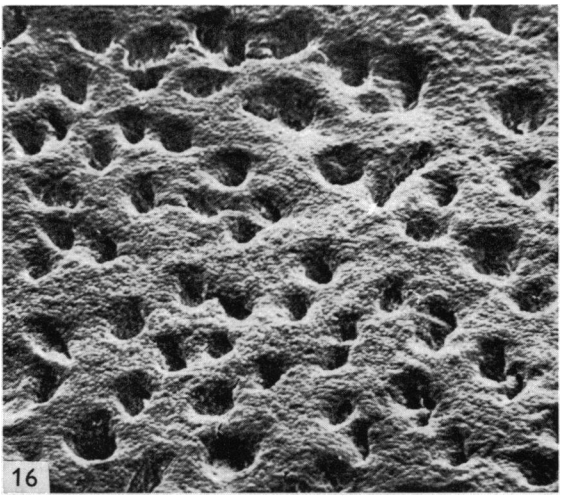
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Floor of the mouth

The subepithelial connective tissue surface exhibited two forms of structural organization, both of them being oriented in the antero-posterior direction. Basically, this surface was structured in the form of flat, about 100 μm wide, parallel running plateaux. These plateaux were separated from each other by narrow, valley-like grooves of approximately 5 μm width (Figs. 1 and 2). Each plateau usually carried the second kind of structure, i.e. one row of connective tissue papillae, which was located approximately along its midline. Large interpapillary spaces were noted. This was reflected very clearly in the morphometric data which showed a very low connective tissue papillae density, i.e. $16 \pm 3/mm^2$ (Table 1). All papillae were small, about 10–50 μm long, slender structures implanted on a base about 8–13 μm wide. Generally, they were straight and finger-like. Branching was rarely seen. These papillae had a wrinkled surface with protruding villus-like protrusions which appeared to be spirally twisted along the axis of the papilla.

The epithelium of the floor of the mouth was thin (86 ± 13 μm) and its basal surface reflected the structure of the papillary body. The percentage of the basal epithelial surface occupied by connective tissue papillae orifices amounted to $2{\cdot}6 \pm 1{\cdot}1$ (Table 1). This interface architecture was only partially represented in semi-thin sections of the floor of the mouth mucosa (Fig. 30).

Alveolar mucosa

The connective tissue papillae were evenly distributed, and frequently aligned in parallel rows on a usually flat subepithelial connective tissue surface (Fig. 5). In some cases, the papillae were situated on longitudinally running ridges or plateaux in a similar way as described for the mucosa of the floor of the mouth. The density of the papillae was $46 \pm 18/mm^2$ (Table 1). The size of the papillae varied markedly, although most of these structures were approximately 100 μm long. They usually had a conical or cylindrical shape and a base about 25 μm wide (Fig. 6). Bifurcations, as well as the wrinkled surface already described above, were characteristic features (Figs. 4 and 6). The epithelium of the alveolar mucosa was thicker (260 ± 40 μm) than that of the floor of the mouth, and the percentage of basal epithelial surface occupied by connective tissue papillae orifices was $7{\cdot}7 \pm 3$. Semi-thin cross sections showed some of the features of the papillary body, including bifurcation and the

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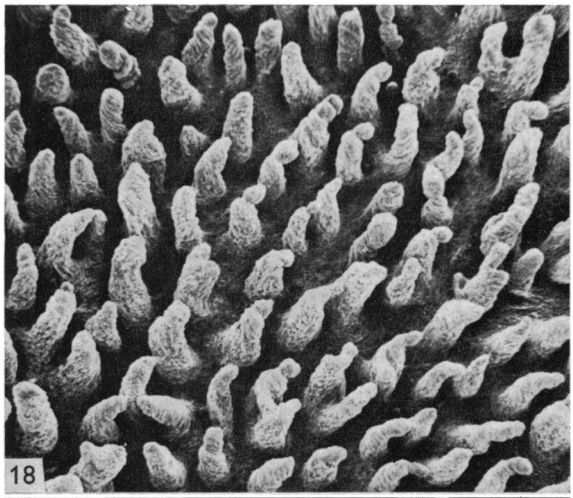
Fig. 13. Basal epithelial surface in cheek mucosa. Rows of orifices are separated by somewhat elevated epithelial ridges. × 120.

Fig. 14. Basal epithelial surface of cheek mucosa characterized by papillary orifices without intervening ridges. × 140.

Fig. 15. Three papillary orifices in the basal surface of buccal epithelium. Boundaries of individual basal cells can be discerned. × 310.

Fig. 16. Basal epithelial surface in the hard palate mucosa. Note somewhat parallel rows of papillary orifices similar to those of cheek epithelium (Fig. 13). × 95.

Fig. 17. Basal epithelial surface in the hard palate. Some of the orifices can be seen to branch intraepithelially. The contours of the individual basal cells can be distinguished. × 185.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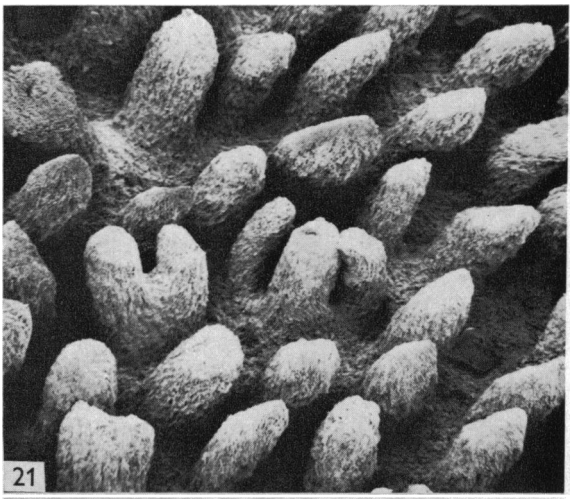
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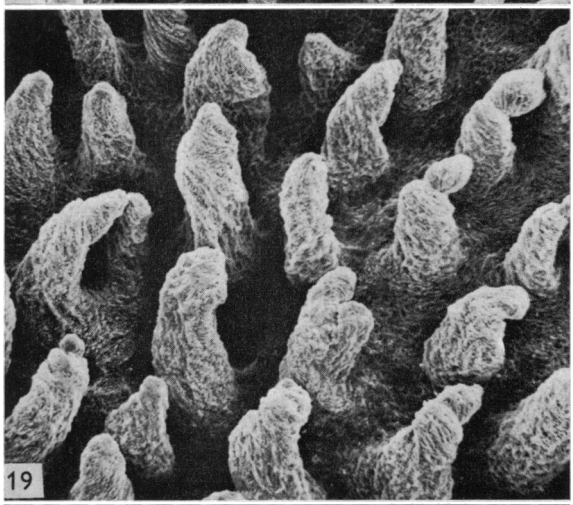
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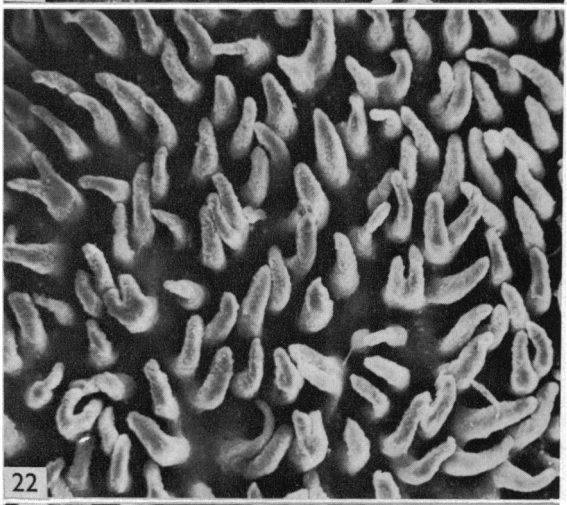
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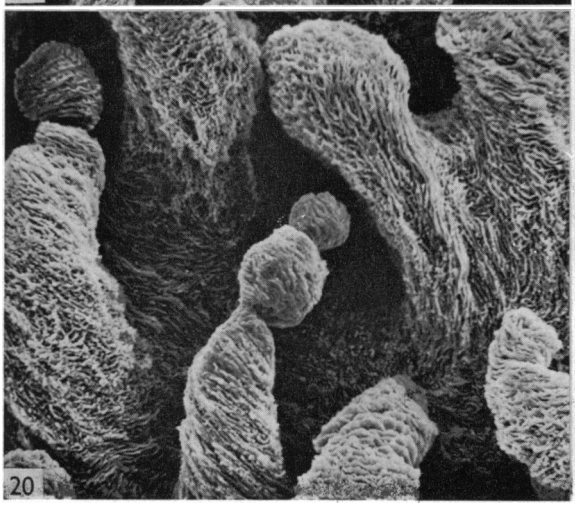
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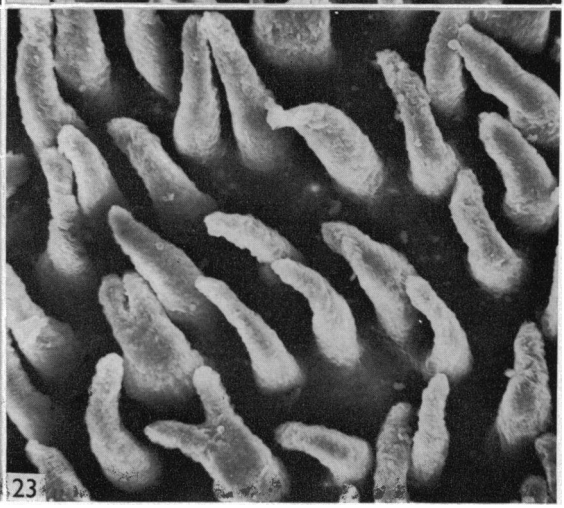
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wrinkled surface contours of the papillae, as well as the height to which these structures penetrated the epithelium (Fig. 31).

Buccal mucosa

This region usually showed a marked regimentation of the connective tissue papillae. The latter were generally arranged in parallel rows (Figs. 7 and 8) which, owing to the high density of the papillae, were occasionally difficult to visualize (Fig. 9). The papillae appeared to arise from a flat connective tissue surface, although in some instances connective tissue ridges supporting the papilla could be seen (Figs. 7 and 8). The connective tissue papillae density was $73 \pm 13/mm^2$ (Table 1).

The connective tissue papillae of the buccal mucosa were about 200 μm long, usually conical, and rested on a broad base of approximately 60 μm. They terminated as narrow tips about 30 μm in width. In 2 out of 23 cases very slender finger-like papillae of cylindrical shape were seen, which were relatively regular in diameter (about 20–30 μm) (Fig. 12). In one case, very regular, broad, cylindrical papillae with a diameter of 60–70 μm (Fig. 11) were observed.

Occasionally the connective tissue papillae were assembled in groups of two or more papillae which rested on a common base. Frequently branching of the papillae was noted (Fig. 8). Often, single or branched papillae terminated with angulations of up to 90° from the papillary axis (Fig. 9). At higher magnification each papilla showed an intensely wrinkled surface (Figs. 8 and 10).

The buccal epithelium, on average, was 480 ± 90 μm thick. The percentage of basal epithelial surface occupied by connective tissue papillae orifices was 19 ± 5. The pattern of papillary rows was reflected in the distribution of epithelial orifices (Figs. 13 and 14). Many of the primary orifices could be seen to branch intra-epithelially.

Semi-thin sections showed the connective tissue papillae to penetrate deeply into the epithelium, frequently approaching the sub-surface layers (Fig. 34). Bifurcations (Figs. 33 and 34) and the wrinkled surface contour of the papillae were demonstrated (Fig. 35).

Hard palate

The papillary body was characterized by a high density of connective tissue papillae which reached $114 \pm 16/mm^2$ (Table 1), and by the alignment of papillary

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Fig. 18. Papillary body in the hard palate mucosa. Regularly distributed parallel rows of connective tissue papillae arising from an apparently flat subepithelial connective tissue. × 100.

Fig. 19. Papillary body in hard palate mucosa as shown in Fig. 18 at higher magnification. The papillae exhibit twisted tips and surface angulation. × 190.

Fig. 20. Connective tissue papillae in hard palate mucosa. Note bifurcation and two knot-like, twisting papillary tips. × 490.

Fig. 21. Papillary body in hard palate mucosa characterized by broad dome-shaped, in part bifurcating, papillae. × 200.

Fig. 22. Papillary body in hard palate mucosa characterized by narrow, finger-like, bending papillae, showing numerous bifurcations. × 90.

Fig. 23. Papillary body in hard palate mucosa as shown in Fig. 22 at higher magnification. Note bifurcations and bending. × 180.


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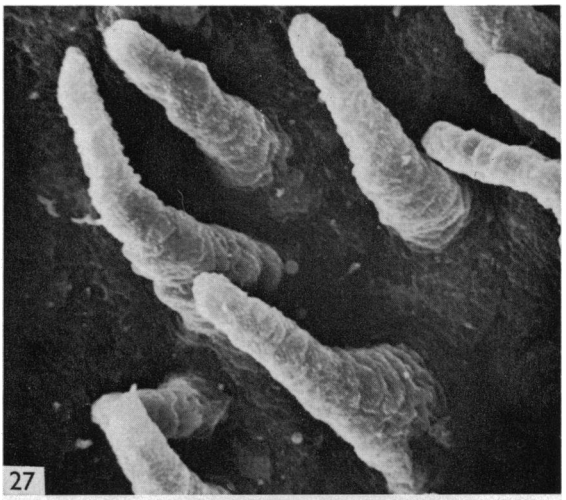
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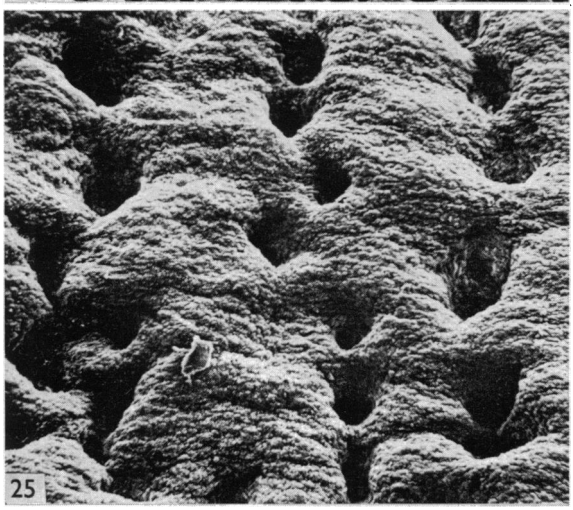
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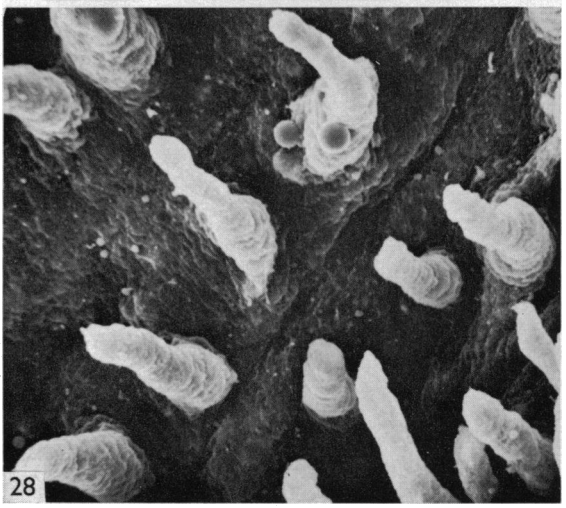
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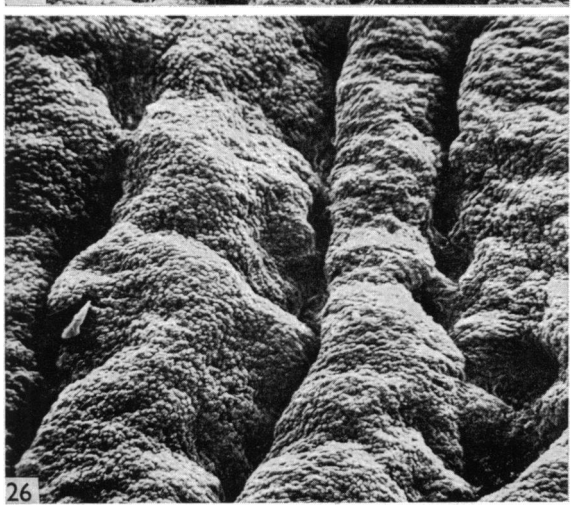
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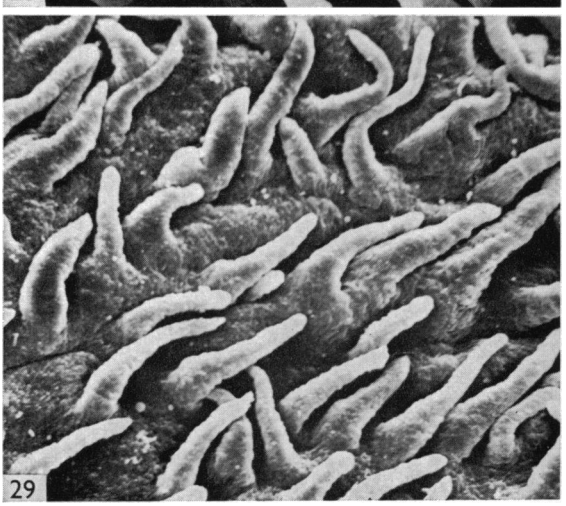
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Table 1. *Quantitative features of oral epithelia and their interface to the connective tissue*

Site	N	Average thickness, ± S.D. (μm)	Height of CTP, $\bar{x}$(μm)	Np/mm², $\bar{x}$ ± S.D.	% basal epithelial surface occupied by CTP, $\bar{x}$ ± S.D.
Floor of the mouth	6	86 ± 13	30	16 ± 3	3 ± 1
Alveolar side of vestibulum	8	260 ± 40*	165	46 ± 18	8 ± 3
Lip	8	370†	245	76 ± 10	15 ± 3
Cheek	23	480 ± 90‡	340	73 ± 13	19 ± 5
Hard palate	13	248 ± 37§	190	114 ± 16	23 ± 5
Attached gingiva	6	255 ± 57‖	170	119 ± 27	35 ± 10

CTP, connective tissue papillae; N, number of specimens used for CTP- and surface counting; Np/mm², number of CTP per 1 mm² of mucosal surface; Height of CTP, comparative data were calculated from the difference of average epithelial thickness at interpapillary ridges and over connective tissue papillae.

* J. P. Bernimoulin, 1975, personal communication.

† Krzywicki & Rokicka, 1967.

‡ Landay & Schroeder, 1976.

§ Meyer & Schroeder, 1975.

‖ Schroeder, 1975, personal communication.

rows running partially or completely parallel to each other in sagittal direction (Figs. 18 and 22).

The papillae were shorter than those of the buccal mucosa (about 120 μm), and most of them stood erect. They were finger-shaped and implanted on a narrow base (about 30 μm). They terminated in a narrow tip (Fig. 23) or in a dome-shaped smooth surface (Fig. 21). Not infrequently the free endings seemed to be twisted along the axis of the papilla (Figs. 19 and 20). Bifurcations and tip angulations were also noted (Figs. 21 and 23).

The frequency of the various papillary features varied to some extent from case to case, but no differences could be established between the mucosa of the midline and that of the paramedian zone of the hard palate.

The epithelium was markedly thinner than that of the buccal mucosa, i.e. 248 ± 37 μm. The percentage of basal epithelial surface occupied by connective tissue papillae orifices was 23 ± 5. The basal surface of the epithelium showed rows of orifices

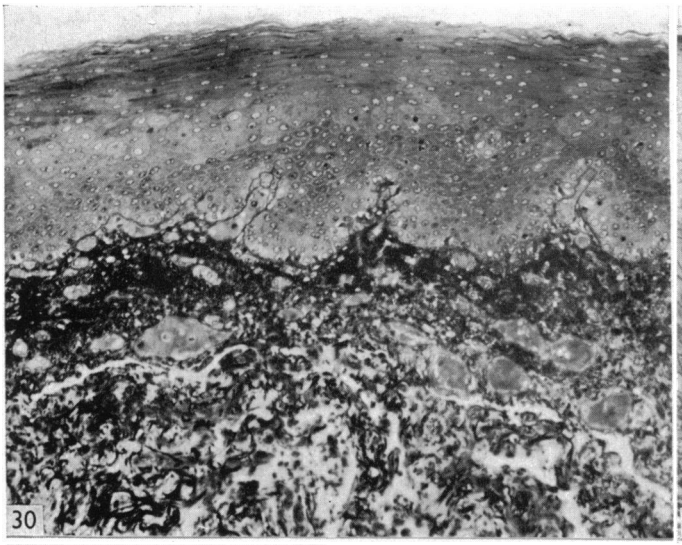
Fig. 24. Basal epithelial surface of lip mucosa. Note parallel rows of papillary orifices located in narrow grooves separated by epithelial ridges. × 50.

Fig. 25. Basal epithelial surface in lip mucosa characterized by rows of orifices without intervening epithelial ridges. × 190.

Fig. 26. Basal epithelial surface in lip mucosa showing narrow grooves separated by broader epithelial ridges. × 190.

Figs. 27 and 28. Fine, finger-shaped papillae in lip mucosa aligned either in rows and implanted on a flat connective tissue base (compare Figs. 27 and 25) or on a low connective tissue ridge (compare Figs. 28 and 26). × 310 and × 260.

Fig. 29. Papillary body in lip mucosa. Rows of markedly bent papillae are supported by narrow connective tissue ridges. Note correspondence between the papillary pattern and the basal epithelial surface as shown in Fig. 24. × 130.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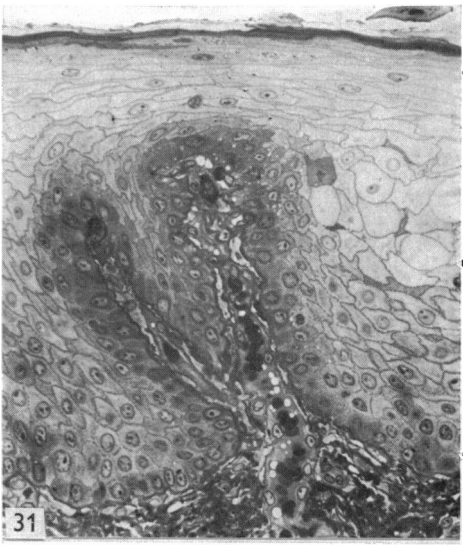
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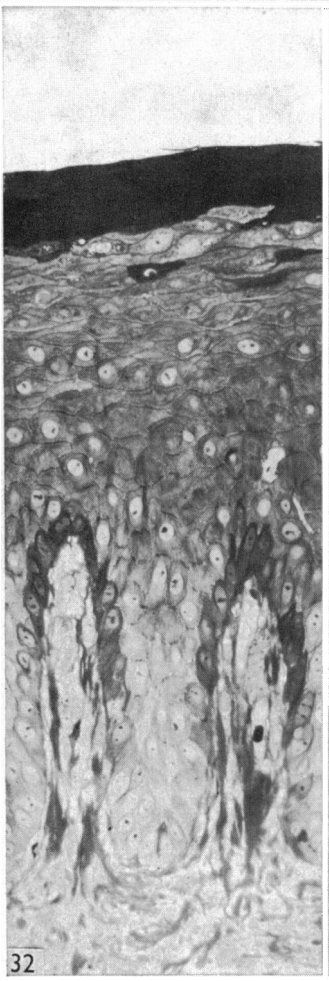
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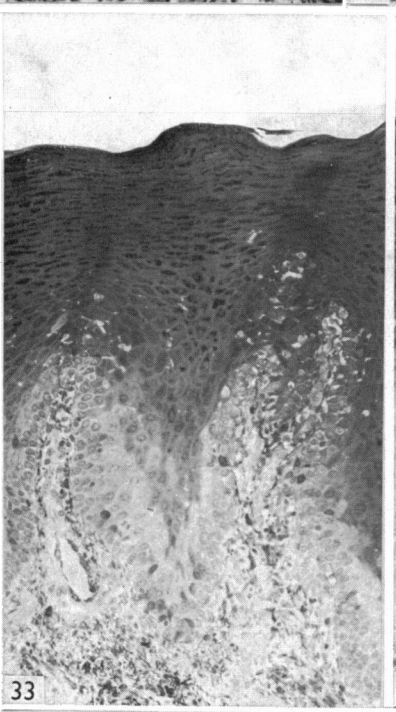
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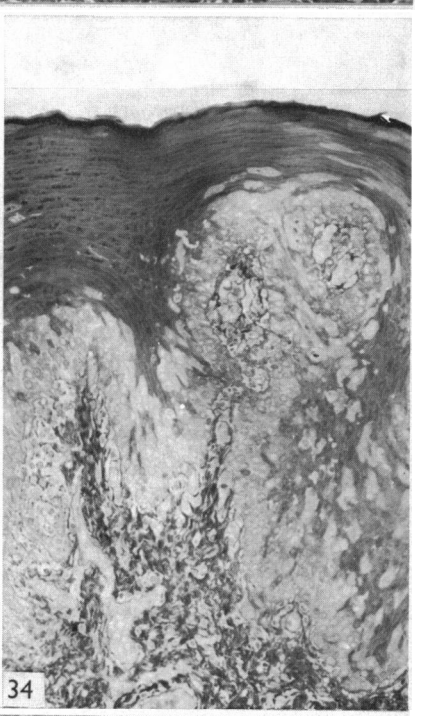
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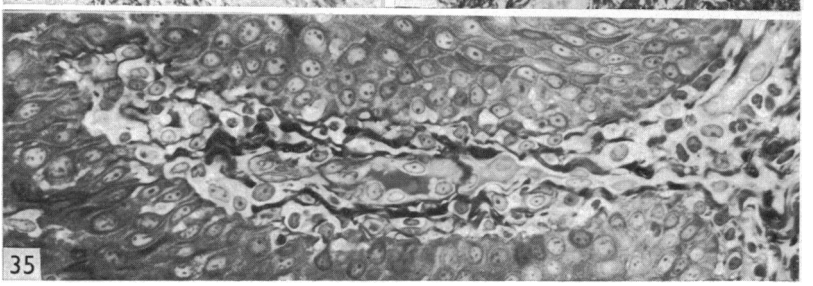
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separated in part by ridges (Figs. 16 and 17). These orifices were separated from each other by flat interpapillary areas (Fig. 17). The orifices were often grouped, and were observed to branch intraepithelially (Fig. 17). Semi-thin sections confirmed the regularity and erectness of the connective tissue papillae (Fig. 32).

Lip mucosa

The distribution and morphology of the connective tissue papillae in this region resembled those described for the buccal mucosa. The papillae were aligned in rows and either solitarily implanted or supported by a narrow connective tissue ridge (Figs. 27–29). There were 76 ± 10 papillae per 1 mm^2 connective tissue surface (Table 1). The papillae were tubular, finger-shaped, and often without a broader base (Figs. 27 and 28). The basal epithelial surface had similar characteristics to that of the buccal mucosa. The orifices of the papillae formed lines (Fig. 24) but occasionally solitary ones were seen (Fig. 25), surrounded by flat epithelium. In other areas, the orifices were seen at the fundus of a narrow, straight valley, corresponding to the narrow connective tissue ridges (Fig. 26). The percentage of the basal epithelial surface occupied by connective tissue papillae orifices was 15 ± 3 (Table 1).

Attached gingiva

The attached portion of the vestibular gingiva showed a very high density of connective tissue papillae (119 ± 27/mm^2; Table 1). Because of this, and because of the size of these structures (about 200 μm long, diameter of about 60 μm), it was very difficult to obtain adequately shadowed specimens which could be observed free from charging artifacts.

DISCUSSION

On the basis of the present morphological and morphometric data the oral mucous membrane can be subdivided into three regions with different characteristics of the epithelium–connective tissue interface, i.e. (1) floor of the mouth, (2) lip and cheek, and (3) gingiva and hard palate. The vestibular region displays characteristics between those of the floor of the mouth and the cheek.

In almost all sites, longitudinal plateaux or ridges, carrying a variable number of

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Fig. 30. Semi-thin cross section of the mucosa of the floor of the mouth. Note short papillae arising from an apparently flat connective tissue surface. Light micrograph. PAS, Azure II. × 40.

Fig. 31. Semi-thin cross section of the alveolar mucosa. A bifurcating papilla is seen to penetrate deeply into the epithelium. The irregular papillary contour corresponds with the undulating surface texture as shown in Figs. 4 and 6. Light micrograph. PAS, Azure II. × 75.

Fig. 32. Semi-thin cross section of the palate mucosa exhibiting straight and comparatively short solitary papillae. Light micrograph. PAS, Azure II. × 90.

Figs. 33 and 34. Semi-thin cross section of the buccal mucosa showing bifurcating of papillae. Note that the angulation of the papillae as shown in Fig. 9 corresponds with the tangential section seen in Fig. 33. The tip angulations as shown in Figs. 9 and 10 manifest themselves as papillary cross sections within higher strata of the epithelium as seen in Fig. 34. Light micrograph. PAS, Azure II. × 40.

Fig. 35. Bent papilla of the buccal mucosa. Note the irregular contour corresponding to the wrinkled surface texture shown in Fig. 10. Light micrograph. PAS, Azure II. × 90.

solitary or grouped papillae, were found to be the basic structural unit of the papillary body. The density of connective tissue papillae varied from site to site by a factor of 1–8. The percentage of the basal epithelial surface occupied by connective tissue papillae orifices was a function mainly of their density. Both their density and the percentage of the basal epithelial surface occupied by these orifices were not strictly related to epithelial thickness. The surface structure of the individual papillae was similar at all sites, although their shape varied both within a given region and between different regions. The length of the papillae increased with epithelial thickness. Bifurcation and angulation of connective tissue papillae were typical features of cheek mucosa, occurring more frequently than in lip.

With the exception of a recent study of the papillae filiformes of the human tongue in which trypsin separation of the epithelium was combined with scanning electron microscope observations of the connective tissue papillae (Schenk & Wersäll, 1975), all previous studies of the epithelium–connective tissue interface of the human oral mucosa have used light microscopy either in association with fairly gross separation procedures (Horstmann, 1954; Frenkel & Abraham, 1968; Bollinger & Riethe, 1973), or with three dimensional reconstructions based on serial paraffin sections (Kunze, 1969; Karring & Löe, 1970; Löe & Karring, 1971). Most authors attempting to separate epithelium from connective tissue have used maceration with acetic acid. The more precise EDTA incubation technique (Scaletta & McCallum, 1972) permitted a more uniform separation of the epithelium. In association with adequate fixation procedures and the critical point drying, it also made possible the observation of undistorted connective tissue papillae and well preserved epithelia. Except for the floor of the mouth mucosa in which separation was achieved by incubation in NaBr, all specimens of oral mucosa were successfully processed with EDTA. Confirming the results of Scaletta & McCallum (1972), cleavage took place along the lamina lucida. Using these methods, relatively large tissue fragments could be prepared and examined quickly. The estimation of connective tissue papillae height was based on measurements performed on scanning electron micrographs. Because of the tilted observation angle, most of these measurements are smaller than those calculated from the more precise measurements done on epithelial cross sections (Table 1).

The characteristic gross topographical features of connective tissue papillae arrangement, as described by Horstmann (1954) for the various sites of the oral mucosa, were confirmed in our material. The individual papillae when seen with the SEM revealed some structural details which have not been described previously in studies based on the light microscope and wax model reconstructions. Of special interest were the villus-like processes at the papillary tips, and the wrinkled appearance of the papillary surface, which have also been described for the filiform papillae of the human tongue (Schenk & Wersäll, 1975). This surface texture could be interpreted as being still another way of increasing the epithelium–connective tissue interface and providing an optimally large surface for anchoring and nourishing the epithelium. The same could be said of the bi- and trifurcations, as well as of the peripheral angulations of the connective tissue papillae.

Most papers dealing with this subject have offered a subjective estimation of the connective tissue papillae density in human oral mucosa (Horstmann, 1954; Fujisawa

& Watanabe, 1959). The general assertion that the connective tissue papillae in the cheek and alveolar mucosa are relatively short, slender and few in number as compared with hard palate and gingiva (Provenza, 1964; Karring, 1973) is in partial disagreement with our data and observations which show that cheek connective tissue papillae are long and extend rather close to the epithelial surface. The only previous quantitative appraisal of the human oral mucosa has been carried out on gingiva, demonstrating a range of connective tissue papillae density of 48–200/mm^2 and an average ($\pm$ standard deviation) of 96 ± 36/mm^2 (Karring & Löe, 1970). This range is confirmed by our data, although the observations of other authors (Horstmann, 1954; Shklar, 1966; Löe & Karring, 1971) regarding age and sex-dependence were not consistently seen by us.

The present data indicate that 'keratinizing' epithelia of hard palate and gingiva are associated with a high connective tissue papillary density, whereas the 'non-keratinizing' epithelia elsewhere have a much lower one. This relationship might be thought to argue in favour of functional adaptation to external mechanical stimuli (Horstmann, 1952). However, recent findings have shown that the configuration of these structures is essentially established before birth (Hale, 1952; Horstmann, 1954) and that these features are not changed when the entire tissues are transplanted to areas in which different mechanical conditions prevail (Smith, 1970; Karring, Østergaard & Löe, 1971). Furthermore, the typical papillary architecture, and the type of epithelium covering the papillary body, have been demonstrated to result from the action of unknown connective tissue inducers (Plagman, Lange, Bernimoulin & Howe, 1974; Karring *et al.* 1975). In consequence it may be argued that the architecture of the epithelium–connective tissue interface is genetically determined.

In our laboratory we have used this information about connective tissue papillae to sample different epithelia of the oral mucosa for stereologic estimation of epithelial strata construction (Meyer & Schroeder, 1975; Landay & Schroeder, 1976). The present findings show the importance and the technical feasibility of taking samples of the interpapillary epithelial ridges from sites such as cheek, vestibulum and floor of the mouth. Another application of the present observations is the exploration of diseased oral mucosa, which until now has been studied by very few authors (Frenkel & Abraham, 1968, 1969). The use of the techniques employed in this study, along with the possibility of comparing normal with pathologically altered epithelium–connective tissue interfaces, should certainly promote a better understanding of spontaneous and experimentally induced lesions of the oral mucosa.

SUMMARY

The papillary body of the human oral mucosa was studied at six different sites. Biopsy and autopsy material from 57 individuals, 11–81 years of age, was split chemically along the basal lamina and the epithelium–connective tissue interface examined by light and scanning electron microscopy. Morphometric techniques were employed in order to determine: epithelial thickness, height and density of connective tissue papillae and the percentage of basal epithelial surfaces occupied by them. In the majority of sites, connective tissue plateaux or ridges carrying a variable number

of single or grouped papillae were found to be the basic structural units of the papillary body.

Three regions with different characteristics of the epithelium–connective tissue interface could be identified: (1) floor of the mouth, (2) lip and cheek, (3) gingiva and hard palate. The floor of the mouth showed the lowest connective tissue papillae density, the smallest papillae, and connective tissue plateaux separated by narrow grooves. Lip and cheek mucosae revealed an intermediate density, the papillae were frequently bifurcated and angulated. Gingiva and hard palate were characterized by the highest papillary density and by papillae which were cylindrical, slender and erect. The alveolar mucosa exhibited intermediate features between those of the floor of the mouth and those of the cheek mucosa.

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