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THE SOFT TISSUE OF THE HUMAN PALATE

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A Thesis embodying a review of the literature and original work, submitted in support of candidature for the degree of Master of Dental Science, University of Sydney.

THE SOFT TISSUE OF THE HUMAN PALATE

TO MY MOTHER AND FATHER

PREFACE

The thesis comprises two parts. The first part is a review of the literature; a complete list of the references is to be found at the end. This survey reveals that although much knowledge of the subject has been gained, a great deal remains unknown.

The second part of the thesis is an original contribution by the author to the knowledge of the soft tissues of the palate. At the beginning of the project it was recognised that a major difficulty would be the shortage of specimens for examination. It was therefore not a workable proposition to attempt to investigate a few aspects of palatal mucosa in a large number of palates. Instead, a large number of aspects of palatal mucosa have been investigated with the light microscope in the small number of specimens available.

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Professor Mark Jolly, D.D.Sc., Professor of Oral Medicine and Oral Surgery, University of Sydney and supervisor of the project; Mr Geoffrey Stacy, B.D.S., F.D.S.R.C.S., D. Orth. R.C.S. (Eng.), Senior Lecturer in Oral Surgery, University of Sydney; Mr Neville Smith, M.D.S., Lecturer in Oral Surgery, University of Sydney; Miss C. Mattlener, A.A.I.M.L.T.,

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Sydney,

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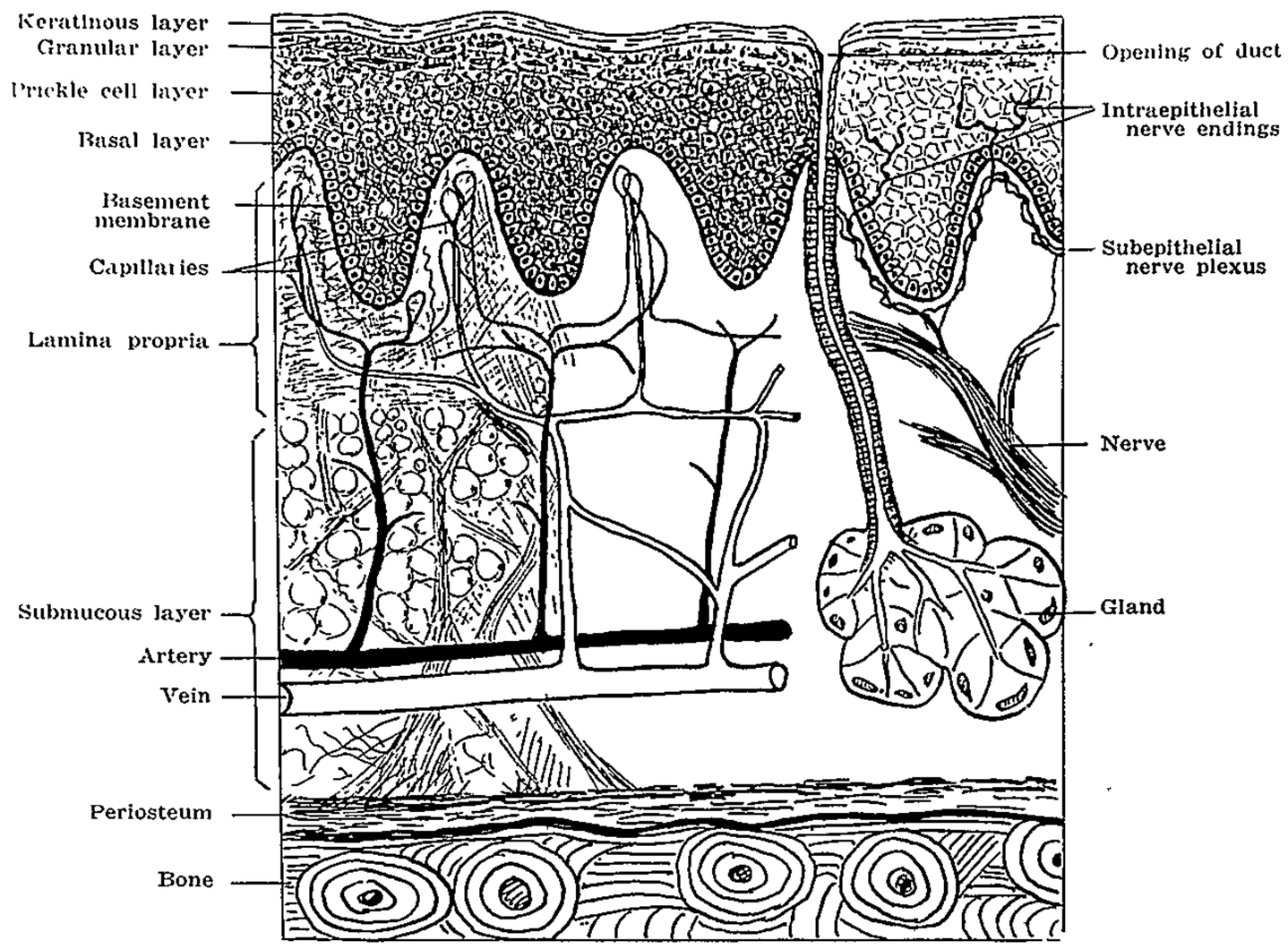


Fig. 167. Diagrammatic drawing of oral mucous membrane (epithelium, lamina propria, and submucosa).

Plate 1.

TERMS OF REFERENCE

The following are terms of reference which will be used when describing the palatal soft tissues.

1) Mucous membrane

The oral cavity is lined throughout by a mucous membrane. This term designates the lining of body cavities and passages that communicate with the exterior. The oral mucous membrane itself is composed of two layers, the lamina propria and the surface epithelium. A basement membrane separates the lamina propria from the stratified squamous epithelium, (Orban and Sicher, 1962). (Plate 1.)

2) Stratified squamous epithelium

Stratified squamous epithelium is the variety of epithelium prevalent as the covering of the oral mucous membrane and of dermal surfaces. It is composed of layers of cells which are given the following names in order of ascent from basement membrane to surface, basal layer, stratum spinosum, stratum granulosum, stratum lucidum (in dermal epithelium), and stratum corneum, (Boucher, 1963).

3) Lamina propria

The lamina propria is a layer of dense connective tissue of variable thickness. Its papillae, which indent the epithelium, carry both blood vessles and nerves. The inward epithelial projections between the connective tissue papillae are described as epithelial pegs or rete pegs because of their appearance

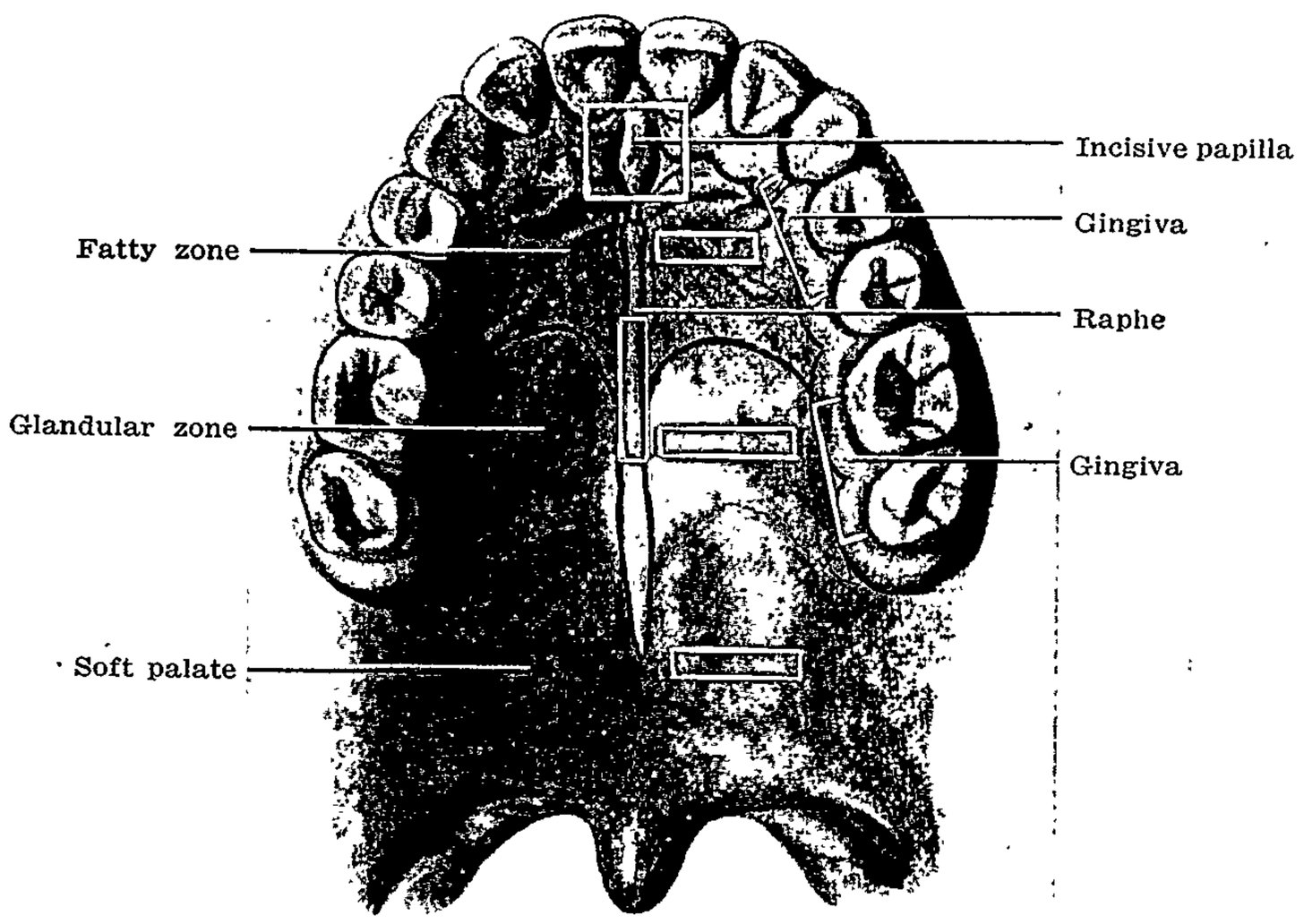


Plate 2.

The palatal zones, illustrating the sites from which specimens were taken.

in transverse sections. In reality, however, they form a continuous network of epithelial ridges. The presence of the papillae permits the subdivision of the lamina propria into the outer papillary and the deeper reticular layer, (Orban and Sicher, 1962).

4) Submucosa

The submucosa attaches the mucous membrane to the underlying structures. It consists of connective tissue of varying thickness and density. Glands, blood vessels, nerves and adipose tissue are present in this layer, (Orban and Sicher, 1962).

5) Fatty Zone of Hard Palate

The fatty zone is the anterolateral area of the hard palate between raphé and gingiva, (Orban and Sicher, 1962). (Plate 2.)

6) Glandular Zone of Hard Palate

The glandular zone is the posterolateral zone between raphé and gingiva, (Orban and Sicher, 1962).

7) Keratin

Keratin is not easily defined. Mercer (1961) states that "the keratins form a class of resistant, insoluble proteins found in the vertebrate epidermis and its appendages, and in small amounts in certain of the internal epithelia". He also states that, in the process of keratinization, cysteine residues in adjacent protein chains are covalently linked by disulphide bridges. Thus keratin is "a protein stabilized by disulphide cross-linkages".

8) Keratinization

Keratinization is the process whereby keratin is formed, (Hoerr and Osol, 1956).

a) In fully keratinized epithelium the surface layer consists of flat, tightly packed, horny scales,-the transformed surface cells. Nuclei are absent.

b) In parakeratosis the surface cells seem to be cornified but have retained pyknotic nuclei.

c) In incomplete parakeratosis, specific stains, e.g. Mallory's stain, show the surface layer divided into two layers. The deeper layer stains like keratin, but this stain is lost in the superficial layer, probably by the influence of oral fluids on the incompletely formed keratin of the nuclei-containing cells.

d) Where keratinization cannot be detected, the flat surface cells retain their nuclei, (Orban and Sicher, 1962).

9) Nerve endings

Definition of nerve endings is here restricted to two types, since the other types do not concern this investigation.

a) The Meissner corpuscle

The Meissner corpuscle is a circular to oval end organ usually found in the distal glabrous skin. Heavily myelinated fibres arise from the deeper dermal network, enter the ending, and upon doing so, lose their myelin sheath.

b) The Krause end bulb

The Krause end bulb is spherical or oval, resembles an

irregularly-wound ball of yarn, and is said to serve cold sensation, (Taylor et al, 1964).

10) Pigment Forming Cells

a) Melanoblast

A melanoblast is an immature melanin-forming cell at its origin in the neural crest or in its migration to the epidermal-dermal junction during the embryonal stage of development.

b) Melanocyte

A melanocyte is a dendritic-shaped mature pigment-forming cell. Melanocytes occur in the basal layer of the epidermis at the junction of the epidermis and dermis. They may occur in compact cellular masses or as groups of cells scattered through the dermal connective tissue or in malignant melanoma, (Dummett, 1959).

11) Rugae

The palatine rugae are ridges of mucous membrane extending laterally from the incisive papilla and the anterior part of the median palatal raphé. Their cores are composed of dense connective tissue with finely interwoven fibres, (Orban and Sicher, 1962).

CHAPTER 1.

EMBRYOLOGY OF THE PALATE

A logical starting point in a review of palatal soft tissue is a consideration of the prenatal development of this tissue. Wood, Pauline and Kraus (1962) have done this and selected findings from their work follow.

The palatal epithelium is already clearly defined at 8 weeks. Stratification of the cells has only begun, however, and in many areas where more than one layer of cells are present the outermost layer remains cuboidal. This is still true at 10 weeks, but by 12 weeks a stratified epithelium, having a thick basement membrane, is formed. Rapid changes in the succeeding days create a pattern by 12-14 weeks which persists. This pattern is described below.

Epithelium

The entire palate is lined on its oral surface by a stratified squamous epithelium. Anteriorly on the hard palate this epithelium becomes cornified, while that of the soft palate remains unkeratinized. In the rugal area the epithelium is thick. Just posterior to the rugal area the epithelium thins somewhat. Nearing the junction of hard and soft palate, where mucous glands occur in the submucosal region on either side of the midline, the epithelium across the median raphé becomes very thin. To the oral side of the glands many papillae project into the epithelium and the surface is penetrated by many glandular ducts. The soft palate also contains many mucous glands, and their ducts

interrupt the otherwise smooth epithelium. At the posterior end of the soft palate the epithelium is thicker and is formed into loose low folds about the midline region. Laterally it is not as thick. On its nasal surface the soft palate is covered by pseudo-stratified, ciliated epithelium containing numerous goblet cells and pierced by the openings of many ducts from palatal glands.

Anterior-posterior variations in epithelium thickness are actually only slight, except for the obvious thinning in the midline area of most of the hard and soft palate.

Lamina propria

The lamina propria of both hard and soft palate contains fine fibres, many of which, particularly in the papillae, lie perpendicular to the epithelium. The greater number of these fibres are collagen. An occasional elastic fibre is seen.

Submucosa

The midline of the hard palate lacks a true submucosa. By contrast, laterally, thick bands of collagen and a few elastic fibres form a network which contains the blood vessels and nerves. Anteriorly a few fat cells are found. Posteriorly, mucous glands are found just beneath the lamina propria. In the deeper layers are fibre-enclosed blood vessels, nerves and adipose tissue. In the soft palate large accumulations of glands are present beneath both oral and nasal surfaces, and these are surrounded by heavy collagen and elastic fibres. The many muscle bundles of the soft palate, surrounded by numerous elastic fibres, fill the interior spaces.

Fat

Wood, Pauline and Kraus (1962) produced interesting results from their investigation of fat in foetal palatal mucosa. Their findings suggest a greater deposition of adipose tissue among the mucous glands of the hard palate than in the zone known in adults as the fatty zone. Their sections contained increasing amounts of fat proceeding from the posterior part of the future fatty zone to the junction of hard and soft palates. This situation is the reverse of that in the adult where adipose tissue is more prevalent anteriorly in the hard palate, (Orban and Sicher, 1962). However they agree that the trend might readily become reversed in postnatal life, since only small amounts of fat are deposited prenatally. The findings of Lund (1924) are not in accord with those of Wood, Pauline and Kraus. He describes the rugae as best developed in foetal life, regressing later and sometimes being absent in the adult. He attributes their involution to a decrease of submucous fat.

CHAPTER 2.

THE STRUCTURE OF THE PALATAL SOFT TISSUE

It is impossible to discuss the structure of the palatal soft tissue without repeated reference to and comparison with the other oral soft tissues. There are two good reasons for this. Firstly, the palatal soft tissues are not a completely separate entity. They are a part of the oral soft tissues. As such they fall into general patterns or designs evident throughout the oral cavity. Comparison is essential for placing the palatal tissues in the correct perspective. Secondly, most of the research which has been carried out refers to the oral soft tissues in general. Not a great amount of literature has been published concerning the palatal soft tissues in particular.

This chapter firstly defines the constitution of the oral soft tissues. Three divisions of the oral mucosa are then explained. The first two divisions are discussed more fully since, into these categories fall the palatal gingiva, the hard palate and the soft palate. The gingiva is discussed in as much detail as is considered necessary to make a description of the palatal soft tissues complete. At the end of the chapter the subject of keratinization is given special attention.

Orban and Sicher (1962) point out that in studying any mucous membrane the following features should be considered: -

(1) type of covering epithelium,

(2) structure of lamina propria, especially as to its density, thickness, and presence or lack of elasticity,

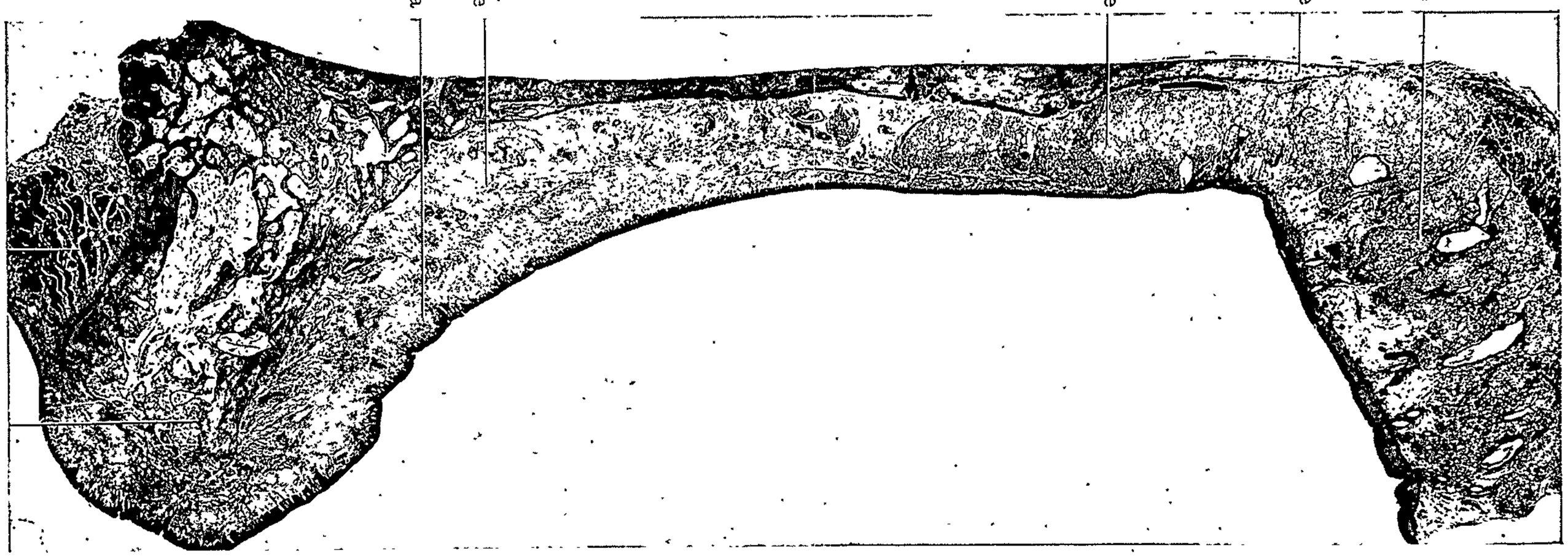


Fig. 201. Longitudinal section through hard and soft palate lateral to midline. Fatty and glandular zones of hard palate.

Plate 3.

(3) the type of junction between epithelium and lamina propria, and

(4) its fixation to the underlying structures, the submucous layer.

A submucosa may be present, as a separate and well-defined layer, or absent. Looseness or density of its texture determines whether the mucous membrane is movably or immovably attached to the deeper layers. Presence or absence and location of adipose tissue or glands should also be noted. (Plate 3.)

TYPES OF ORAL MUCOSA

The oral mucosa may be divided primarily into three different types. During mastication some parts are subjected to strong forces of pressure and friction. These parts, gingiva and covering of the hard palate, may be termed masticatory mucosa. The second type of oral mucosa is that which is merely the protective lining of the oral cavity. This may be termed lining mucosa. It comprises the mucosa of the lips and cheeks, the mucosa of the vestibular fornix, that of the upper and lower alveolar processes adjacent to the gingiva, the mucosa of the floor of the mouth extending to the inner surface of the lower alveolar process, the mucosa of the inferior surface of the tongue, and, finally, the mucous membrane of the soft palate. The third type of mucosa is represented by the covering of the dorsal surface of the tongue and is highly specialized; hence, the term specialized mucosa, (Orban and Sicher, 1962). The first two types of mucosa will be considered in more detail.

MASTICATORY MUCOSA

Gingiva and hard palate have in common a thick keratinized epithelium, a thick, dense, firm lamina propria, and a firm attachment to the deep structures. In the structure of the submucosa, the areas

of gingiva and hard palate differ markedly. In the gingiva, a well-differentiated submucous layer cannot be recognised; instead, the dense and nonelastic connective tissue of the lamina propria fuses with the periosteum of the alveolar process or is attached to the cervical region of the tooth.

1. Gingiva

It is not intended to digress far into the subject of gingiva; however, because the palatal mucosa merges into and becomes indistinguishable from gingiva, a brief description of gingiva is desirable.

(a) The zones of the gingiva

The gingiva can be divided into the free gingiva, the attached gingiva and the interdental papillae. Orban (1948) claims that there is a line between the free and the attached gingiva called the free gingival groove, which runs parallel to the margin of the gingiva at a distance of 0.5 to 1.5 mm. He describes it in histologic sections as a shallow, V-shaped notch corresponding to the heavy epithelial ridge that divides the free and the attached gingiva and states that the free gingival groove develops at the level of, or somewhat apical to, the bottom of the gingival sulcus. The free gingival groove and the epithelial ridge are probably caused by mechanical forces acting upon the free gingiva, folding the movable free part back upon the attached and immovable zone. However, Fehr and Mühlemann (1955) dispute the presence of such a groove after extensive studies of the free and attached gingiva. They point out that the free marginal gingiva is smooth whereas the attached gingiva is stippled. They feel that the microdepressions demarcating the free from the attached gingiva were

interpreted by Orban in histologic sections as being the free gingival groove. They state their observations to be in agreement with those of Vendrine and Frank, (1954). Levine, (1966), acknowledges the presence of a free gingival groove on the labial or buccal aspects but doubts its existence on the palatal side. He points out that in the posterior region of the palate where rugae are absent, no groove can be seen. In the rugal area a groove resembling a free gingival groove may be seen; this, however, is merely a groove at the base of a ruga and not a free gingival groove.

The interdental papilla is that part of the gingiva that fills the space between two adjacent teeth and is limited at its base by a line connecting the margin of the gingiva at the centre of one tooth and the centre of the next. The interdental papilla is shaped like a two-poled tent. Vestibular and oral peaks are elevated. The ridge of the papilla is concave. Vestibular and oral parts of the papilla occupy the embrasures between two adjacent teeth. The interdental part in the strict sense of the term seems to lack keratinization, (Orban and Sicher, 1962).

The gingiva surrounding the teeth is subjected to forces of friction and pressure in the process of mastication. The character of this tissue shows that it is adapted to these forces. The gingiva is limited sharply on the outer surface of both jaws by a scalloped line, the mucogingival junction, which separates it from the alveolar mucosa. On the palate, however, there is no sharp dividing line because of the dense structure and firm attachment of the entire palatal mucosa.

(b) <u>Gingival epithelium</u>

According to the histologic appearance of the superficial layer

of the epithelium, four types of epithelial maturation can be distinguished. The most common type is parakeratosis, occurring in about 50 per cent of mouths. Next in order of frequency is incomplete parakeratosis, 25 per cent. Then follows full keratinization, 15 per cent, and non-keratinization, 10 per cent, (Orban and Sicher, 1962).

The gingival epithelium covers the free margin of the gingiva and continues into the epithelial lining of the gingival sulcus to terminate on the surface of the tooth as the epithelial attachment.

The attached gingiva is characterised by high connective tissue papillae, so that the surface of the attached gingiva appears stippled. Orban, (1948), amplified this statement by explaining that high connective tissue ridges of the lamina propria, in sections appearing as papillae, elevate the epithelium into slightly rounded surface protrusions. The depressions on the oral surface between the papillae are in the centre of the epithelial rete pegs.

Orban and Sicher (1962) also point out that the cells of human oral epithelium show a sex difference. In females the nuclei contain a large chromatin particle adjacent to the nuclear membrane.

The cells of the basal layer of the oral epithelium may contain pigment granules (melanin). While pigmentation is a normal occurrence in Negroes, it is often found, too, in the Caucasian race, especially in people with a dark complexion. It is most abundant in the bases of the interdental papillae at the junction between the interdental papilla and the attached gingiva. The palatal gingiva may or may not be pigmented. Individuals with pigmented skin or pigmented labial and buccal gingiva may have palatal pigmentation; however in many

instances they do not(Levine, 1966). Oral pigmentation may increase considerably in persons suffering from Addison's disease. After being elaborated by melanoblasts (specific cells in the basal layer) melanin is taken up by basal epithelial cells. In histologic sections stained with haematoxylin and eosin, melanoblasts can be distinguished by their clear cytoplasm and are also known as "clear cells".

(c) The lamina propria of the gingiva

Orban and Sicher (1962) state that the lamina propria of the gingiva consists of dense connective tissue that is not highly vascular. Only a few elastic fibres are found in the lamina propria. These, for the most part, are confined to the walls of blood vessels. The connective tissue papillae are characteristically long, slender and numerous, in sharp contrast to those of the alveolar mucosa which are short and fewer in number. The gingiva again differs from the alveolar mucosa in the firrness of its attachment to the underlying structures. Whereas the lamina propria of the attached gingiva receives the gingival fibres of the periodontal ligament and the coarse collagenous bundles extending from the periosteum of the alveolar bone, the fibre bundles of the lamina propria of the alveolar mucosa are thin and regularly interwoven. Also the alveolar mucosa and submucosa contain numerous elastic fibres. Circular fibres in the attached gingiva are sometimes quite conspicuous (Arnim and Hagerman, 1953).

(d) The blood supply of the gingiva

The blood supply of the gingiva is derived chiefly from the branches of the alveolar arteries that penetrate the interdental septa. The interdental alveolar arteries perforate the alveolar crest in the

interdental spaces and end in the gingiva, supplying the interdental papillae and the adjacent areas of the buccal and lingual gingiva. In the gingiva these branches anastomose with superficial branches of arteries that supply the oral and vestibular mucosa and marginal gingiva, for instance, with branches of the palatine arteries. There is a rich network of lymph vessels in the gingiva along the blood vessels leading to submental and submaxillary lymph nodes.

(e) The nerve supply of the gingiva

The gingiva is well innervated. Different types of nerve endings can be observed, such as the Meissner or Krause corpuscles, end bulbs, loops, or fine fibres that enter the epithelium as "ultraterminal" fibres. These ultraterminal fibres were described by Gairns and Aitchison (1950) as long extensions into the epithelium from endings in the dermal papillae. They found that in the gingiva there are many endings which send one, two or three ultraterminal fibres to the outermost layers of epithelial cells. They point out that no similar fibres can be found anywhere on the skin surface. These ultraterminal fibres run out to the outermost layers of epithelial cells, sometimes to the very last layer. The end of the fibre usually consists of a small knob.

(f) Mitotic index of the gingival epithelium

The rate of cell renewal may be expressed as the mitotic index. This may be given as the number of cells in mitosis of 1,000 basal cells counted. This index increases with age (Meyer, Marwah and Weinmann, 1956). In individuals between 50 and 70 years of age it is higher by 50 per cent than in the goup between 25 and 35 years of age.

In the latter, the mitotic index of gingival epithelium was calculated as 1.37, which is higher than the mean index for the epidermis. Presence or lack of a granular layer also influences the mitotic index. It is twice as high in the absence of the granular layer (Meyer, Marwah and Weinmann, 1956). The same authors found no correlation of the mitotic index with the variations of keratinization.

2. Hard Palate

The mucous membrane of the hard palate is firmly fixed to the underlying periosteum and is therefore immobile. Its colour is pink like that of the gingiva. The lamina propria, a layer of dense connective tissue, is thicker in the anterior than in the posterior part of the palate. Various regions in the hard palate differ because of the varying structure of the submucous layer.

The marginal area adjacent to the teeth shows the same structure as the gingiva elsewhere in the mouth. In this zone, a submucous layer cannot be differentiated from the lamina propria or periosteum. Similarly, the layers of the lamina propria, submucosa and periosteum cannot be distinguished in the palatine raphé. The submucosa of both these regions, namely palatal gingiva and median raphé, contains neither fat nor glands, (Bhaskar, 1962).

In the lateral areas of the hard palate between the raphé and gingiva, in both fatty and glandular zones, the lamina propria is fixed to the periosteum by bands of dense, fibrous, connective tissue that are at right angles to the surface and divide the submucous

layer into irregularly-shaped spaces. The distance between lamina propria and periosteum is smaller in the anterior than in the posterior part. In the anterior zone the connective tissue spaces contain fat, whereas in the posterior part mucous glands occupy the spaces. The glandular layer of the hard palate continues posteriorly into that of the soft palate.

In the groove between alveolar process and hard palate, the anterior palatine vessels and nerves are surrounded by loose connective tissue. This region, wedge-shaped in cross-sections, is relatively large in the posterior part of the palate and gradually diminishes in size anteriorly.

(a) Incisive Papilla

The incisive papilla is formed substantially of dense connective tissue, (Orban and Sicher, 1962). It contains the oral parts of the vestigial nasopalatine ducts. These are blind epithelial ducts of various lengths. They are lined by a simple or pseudo-stratified, columnar epithelium, rich in goblet cells. Small mucous glands open into the lumen of the ducts. Frequently, around the ducts are seen small, irregular islands of hyaline cartilage, vestigial extensions of the paraseptal cartilages. The nasopalatine ducts are patent in most mammals and, together with Jacobson's organ, are considered as auxiliary, olfactory sense organs. (Jacobson's organ, also known as the vomeronasal organ, is a slender tubule ending in a blind sac situated in the anteroinferior part of the nasal septum, (Hoerr and Osol, 1956). Although it is

vestigial in man, in lower mammals a special part of the olfactory nerve is distributed to Jacobson's organ as the vomeronasal nerve, (Hamilton, Boyd and Mossman, 1964).) The cartilage is sometimes found in the anterior part of the papilla. It then shows no apparent relation to nasopalatine ducts.

(b) Palatine Rugae (transverse palatine ridges)

The palatine rugae, irregular and often asymmetric in man, are ridges of dense connective tissue covered by mucous membrane and extending laterally from the incisive papilla and the anterior part of the palatine raphe, (Orban and Sicher, 1962). The rugae are examined in greater detail in a later chapter.

(c) Epithelial pearls

In the midline, especially in the region of the incisive papilla, epithelial pearls may be found in the lamina propria. They are concentrically arranged and are frequently keratinized. They are remnants of epithelium in the line of fusion between the palatine processes, (Orban and Sicher, 1962).

LINING MUCOSA

All the zones of the lining mucosa of the oral cavity are characterised by a relatively thin, non-keratinized epithelium and by the thinness of the lamina propria. They differ from one another in the structure of their submucosa. In regions where the lining mucosa covers muscles, as on the lips, cheeks and underside of the tongue, it is immovably fixed to the epimysium or fascia of the respective muscle. In these regions the mucosa is also highly elastic.

The mucosa of the soft palate is a transitional form between this type of lining mucosa and that which is found in the fornix vestibuli and in the sublingual sulcus at the floor of the oral cavity. In the latter zones, the submucosa is loose and of considerable volume and the mucous membrane is novably attached to the deep structures, which allows the free movement of lips, cheeks and tongue, (Orban and Sicher, 1962).

Soft palate

The mucous membrane on the oral surface of the soft palate is highly vascular and of reddish-pink colour, noticeably differing from the pale colour of the hard palate. Bhaskar (1962) points out that this colour difference is due to the presence of a keratin layer on the mucosa of the hard palate and its absence in the soft palate. The papillae of the connective tissue are sparse and short. The stratified squamous epitholium is not keratinized. The lamina propria shows a distinct layer of elastic fibres separating it from the submucosa. The latter is relatively loose-textured and contains an almost continuous layer of mucous glands. Typical oral mucosa continues around the free border of the soft palate for a variable distance and is then replaced by nasal mucosa with its pseudostratified, ciliated, columnar epithelium, (Orban and Sicher, 1962).

KERATINIZATION

At least three studies have been reported on the keratinization of the human oral mucosa, Weinmann (1940), Miller

(1952) and Onisi (1963). Their findings are similar and indicate that the degree of keratinization found in the various parts of the oral cavity decreases in the following order: hard palate, lower gingiva, upper gingiva, tongue (dorsal surface), cheek and ventral surface of the tongue. The mucosa of the hard palate, then, has the greatest degree of keratinization of all regions of the oral mucosa.

Sognnaes and Albright (1958) examined the squamous epithelium of the cheeks of adult males with the electron microscope. They investigated the maturation process associated with the partial keratinization characteristic of this tissue. The keratohyaline granules appear to possess an inherent electron density demonstrable not only in osmium-fixed material but also in formalin-fixed material. These keratohyaline granules are widely scattered through the cytoplasm of normal epithelial cells from the "intermediary and superficial" layers of human oral epithelium. This is true even though the epithelium may not be classified as keratinized when viewed with a conventional optical microscope. Under the optical microscope these granules may be too small to be detectable.

The keratohyaline granules appear to arise in association with (1) certain foldings of the nuclear membrane,(2) nucleolar fragmentations and formation of nucleolar satellites migrating to the nucleolar surface, and (3) the formation of cytoplasmic complexes

in near proximity to the nuclei. These cytoplasmic complexes contain granules of various dimensions together with mitochondrial fragments as well as the high-density keratohyaline granules.

In addition to these changes in the internal machinery of the keratinizing epithelium, certain ultra-structural changes in the peripheral cell membranes have been described. These are characterised by a great increase in total cell surface and by the development of deep foldings of the cell membrane which interdigitate with grooves in adjacent cells. Finally, it has been noted that, while the deeper cells appear to be held together by a relatively dense cementing substance, the superficial cells separate more readily and have little or no intercellular cementing substance between them.

Wright (1936) investigated the mucous membrane of the oral cavity pointing out variations which may be considered to lie within the category of normal. This is interesting because so few mouths present the classical thirty-two natural teeth in optinal occlusion that constant variations of the mucosa associated with tooth loss may need to be classified as normal rather than pathologic. Wright points out that the mucosa found in a small edentulous space will exhibit, microscopically, irregular down-growths of the epithelium into the connective tissue. Also the surface will be covered with a thick layer of cornified squamous cells. These findings, he states, are the result of the friction from foods. Within physiologic limits, increased stimulation

results in increased cornification. Mucosa removed from the anterior maxillary ridge of an edentulous patient who has masticated on the gums shows an enormously thick layer of cornified squamous epithelium. The associated epithelial rete pegs are well-rounded. When the stimulation exceeds physiologic limits, however, as when teeth bite directly onto opposing gum, the epithelium is crushed into a narrow band of flattened cells. Cornification is not present, having been lost because of the excessive wear and tear. The associated epithelial rete pegs are enlarged, blunt and club-shaped. Numerous round cells, indicative of an inflammatory reaction, may be present.

The absence of normal stimulation may result in the absence of cornification in a normally cornified site. Wright examined mucosa removed from under a fixed bridge. Here no stimulation was applied and no cornification was present. Of great interest are Wright's findings concerning denture-supporting mucous membrane. Beneath a full upper denture opposed for twenty years by a full complement of natural mandibular teeth in reasonably good occlusion, the mucosa lacked cornification.

CHAPTER 3.

PIGMENTATION

Very little research has been carried out on the pigmentation of palatal mucosa; most of the research on pigmentation has been concerned with skin and oral mucosa in general. Because the palatal mucosa is part of this, a review of the current knowledge of pigmentation is not out of place.

Firstly, factors contributing to oral pigmentation will be considered. Secondly, the pigment melanin will be discussed more fully.

FACTORS CONTRIBUTING TO ORAL PIGMENTATION

1. Pigments

The early workers in the field of pigmentation were hampered by the lack of instruments suitable for measuring pigmentation. However this difficulty has now been surmounted by adapting spectrophotometric techniques to this field. With this apparatus it is possible to record, for example, the reflectance of the intact living skin over the range of two hundred and twenty to seven hundred millimicrons. Collectively, the research to date indicates there are six primary pigments in the skin. They are: (1) melanin which has a marked absorption at the violet end of the visible spectrum but no clearly defined absorption band; (2) oxyhemoglobin which has definite absorption bands at 542 and 576 millimicrons; (3) reduced hemoglobin which has a single broad

absorption band at 556 millimicrons; (4) carotene which has a well defined absorption band at 482 millimicrons; (5) melanoid which, like melanin, has general absorption at the violet end of the spectrum but unlike melanin has a distinctive absorption band at 400 millimicrons; (6) soft keratin which has a characteristic absorption band at 290 millimicrons, (Volker and Kenney, 1960).

Spectrophotometric analysis of the oral mucosa probably would indicate the presence of the same primary pigment components as found in the skin though perhaps in different proportions. Melanin may play the largest role just as it does in skin pigmentation, (Bolden, 1960).

2. Other factors

Bolden (1960) states that the factors other than pigments, which contribute to skin colour, are the thickness of the skin, the light-scattering phenomenon and the vascular bed. Probably the same factors influence the colour of oral mucosa.

(a) Thickness

Structural differences probably cause the difference in colour between the pale pink masticatory mucosa of the gingiva, and the darker lining mucosa, which shows numerous vessels close to the surface. Differences in the thickness of the stratum corneum probably play an important role in producing this effect, (Bolden, 1960).

(b) The Tyndall effect

It is quite probable that the Tyndall effect also influences skin colour. This is a light-scattering phenomenon that results from the rearrangement of light passing through a turbid medium. Light transmitted through such a medium contains an increased number of the long red wave lengths since the light scattered to the side and back to the source has a greater content of the shorter blue wave lengths. Because the stratum corneum of the skin is relatively transparent, it is responsible for only minimal scattering of the light. The deeper layers of the skin which are more turbid, however, scatter light to a considerable degree. As a consequence, if a pigmented area is in the deeper layers of the skin, it appears bluer. This phenomenon is responsible for the so-called blue nevi. (Volker and Kenney, 1960).

(c) The vascular bed

Cheraskin (1960) explains that the colour of the oral mucosa is modified by the subjacent circulating blood in the vascular system. To a large degree it is a function of the amount of reduced or oxygenated haemoglobin circulating in the subepithelial blood vessels. A grey or purple tinge to the gingiva may be attributed to stagnation and poor oxygenation of the blood and therefore the gingiva, (Bolden, 1960).

MELANIN

Melanin will be considered under seven headings: cells associated with melanin, formation, chemistry, melanoid, identification, distribution and function.

1. Cells associated with melanin

Melanocytes, also known as melanoblasts in their primitive stage, are the normal, mammalian melanin-forming cells. They are of neuro-ectodermal origin, appear first in the dermis and then migrate to the basal layer of the epithelium, (Kanof, 1955). In human mucosa and skin (Lorinez, 1954), they are found in the basal layer of epithelium as "clear cells" and as dendritic cells, (Lever, 1949). They have no intercellular bridges, (Becker, 1958). Dendritic cells form a syncytium around contiguous epithelial cells. Some melanocytes have been shown to move into the prickle cell layer, granular layer and finally the keratinized layer, losing almost all of their dendrites but retaining much of their enzymatic activity, (Lever, 1949).

Melanophages, melanophores or chromatophores are melanin-containing cells in the lamina propria which, as far as is known, do not produce the pigment they carry.

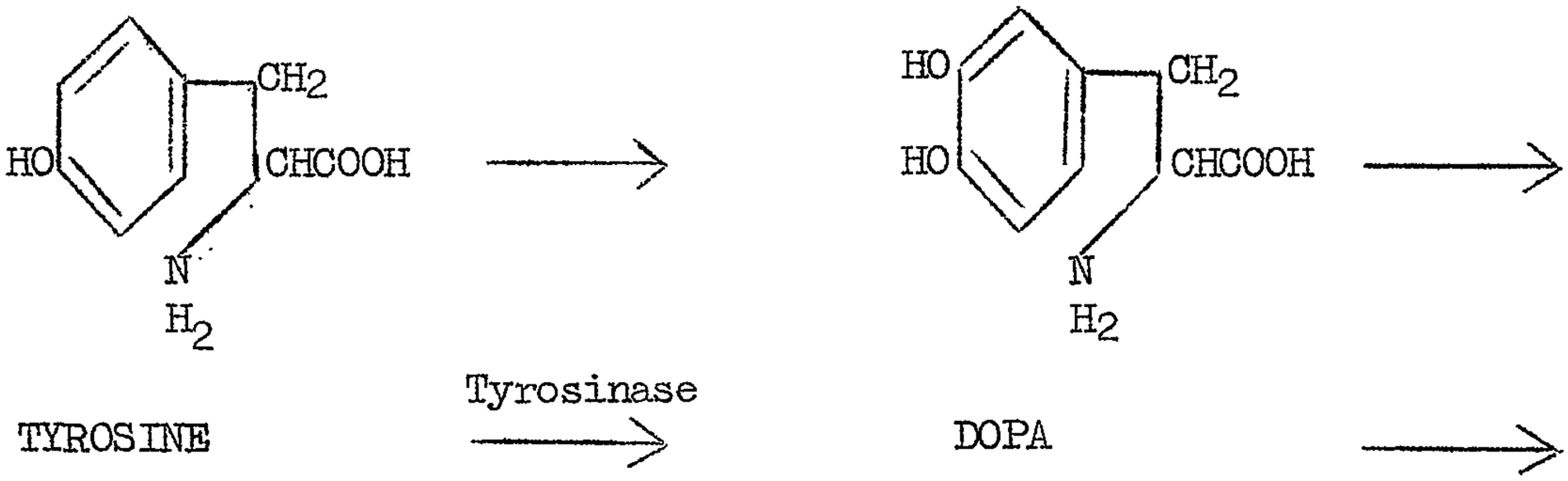
It is believed by Masson (1948) that melanocytes are able to transfer melanin granules into neighbouring epidermal cells, a process which he terms "cytocrine" action. This view is not unanimously held since it seems possible that as melanocytes migrate, melanin granules are picked up by the other cells of the epidermis.

However, the cytocrine theory has found some support in recent electron-microscopic investigations. Birbeck and his associates (1959) found in studying the fine structure of hair melanocytes and cortical cells with the electron microscope that melanocytes had a type of cell polarity characteristic of a secretory cell. Saggital sections of the hair follicle at different levels revealed that a portion of the cytoplasmic process of the hair melanocyte appeared to be phagocytozed by the cortical cell. Then the cell wall of the process disappeared and the melanin granules were seen to be dispersed throughout the cytoplasm of the cortical cells.

2. Formation

Around the turn of the century, Bourquelot and Bertrand demonstrated the presence of an enzyme in mushrooms that could oxidize the amino acid tyrosine to a black pigment. They named the enzyme tyrosinase. Shortly thereafter, von Furth expressed the opinion that this oxidative enzyme was responsible for skin melanin formation. It was not, however, until 1950 that it was possible to demonstrate the presence of tyrosinase in the skin by histo-chemical methods, (Fitzpatrick et. al., 1950). The key material in melanin formation is 1-3, 4-dihydroxy-phenylalanine which has the common name "dopa". This substance is the first compound formed by the action of tyrosinase and oxygen on tyrosine. The early fundamental studies of Bloch clearly showed that if frozen sections of pigmented skin are incubated with dopa at pH7.3, brown granules appear in the cytoplasm

of scattered cells in the basal layer. The enzymatic nature of the reaction is easily established. It does not take place if the skin is boiled, if it is made acid or if an enzyme poison such as hydrogen sulfide is present. Whereas the conversion of tyrosine to dopa by oxygen and tyrosinase is relatively slow, the subsequent action of these materials on dopa initiates a series of rapid changes that result in ring closure and ultimately formation of Indole 5, 6-quinone which furnishes the basic unit for melanin formation by polymerization, (Lerner and Fitzpatrick, 1950). The essentials of these reactions are outlined below.



3. Chemistry

Chemically, melanin is a pigment of high molecular weight that is insoluble in water and most organic solvents. However, it is soluble in hot, aqueous sodium hydroxide, (White, 1958). On analysis it yields approximately 57% carbon, 30% oxygen, 9% nitrogen and 4% hydrogen. It reduces silver and gold salts and is susceptible to oxidation by hydrogen peroxide and potassium permanganate, (Volker and Kenney, 1960).

Melanin granules from pigment cells of human skin have been shown to have uniform size and shape, within a given locus, (Mason et al, 1947). They are round and approximately 0.3 microns in diameter. The molecular weight is approximately 20,000, (Kanof, 1955).

Melanin granules have been shown to vary according to the size of the dendritic cell which carries them. Dendritic cells of the mucous membrane of the mouth are larger than dendritic cells from the epidermis of the nipple, axilla and abdomen, and contain larger melanin granules. The granules are seen within the processes as well as within the cell body, (Becker, 1927).

4. Melanoid

Initially it was assumed that melanoid was a degradation product of melanin. This belief was supported by the observation that the two pigments were found usually in the same areas of the skin and that melanoid appeared after considerable quantities of melanin had been formed in response to prolonged exposure to sunlight. More recently, however, it has been shown that testosterone injections in eunuchs

increase greatly the melanoid content of their skin with very little effect on melanin content. Also, the amount of melanoid in the skin of eunuchs is greatly increased by ultraviolet radiation without any unusual melanin production, (Volker and Kenney, 1960). Thus the nature of melanoid is uncertain at present. It is known, however, that whereas melanin shows no clear cut spectrum absorption band, melanoid has a distinct absorption band at 400 millimicrons, (Bolden, 1960).

5. Identification of melanin and melanocytes under the microscope

Sections of oral mucosa stained with hematoxylin and eosin may show the distribution of both "clear cells" and dendritic cells within the basal layer of the epithelium, and of chromatophores within the papilla of the lamina propria, (Bolden, 1960). A few granules may be seen within the cytoplasm of some clear cells and fine yellow granules or golden granules appear to be distributed around the contiguous epithelial cells like a cuff. These granules are actually within the cytoplasm of dendritic cells and in many instances obscure their nuclei.

A similar distribution of melanin is seen in thionin-treated sections. The granules stain black or yellow. An occasional dendritic cell may be seen. Silver impregnation (Masson-Fontana) identifies melanin as a black precipitate which stands out sharply against the red colour of the connective tissue. Melanin also becomes visible with dopa due to the oxidation of tyrosine. Tyrosinase activity is

demonstrated by the black staining of melanin granules.

The mast cell which may be confused with melanocytes is present in clinically normal and pathologic gingival tissue and may lead to some difficulty of identification in some histologic preparations. Mast cells are found principally in the corium, but also in the epithelium. These cells contain PAS positive granules and exhibit strong pleomorphism.

With thionin, the granules of mast cells stain metachromatically, while melanin granules stain orthochromatically. A new technique recently developed selectively stains mast cells to the exclusion of other cells, (Smith and Atkinson, 1956).

Some melanocytes are characterised by two or more dendritic processes. Melanocytes contain, in their pigmented form, numerous light or dark brown cytoplasmic granules. Recent electron microscopic studies of melanocytes in the human epidermis have shown melanocytes to contain many more mitochondria and a more complex endoplasmic reticulum than the adjacent basal cells. The intercellular bridges, so characteristic of ordinary basal cells, are absent from melanocytes, (Volker and Kenney, 1960).

6. Distribution of melanin

(a) General distribution

Since melanin is the most important of the skin pigments, it has been the most intensively studied. It is present as colouration in many biologic species including fishes, reptiles and mammals. Some idea of its intense effect upon skin colour

can be gained from the knowledge that the total amount of melanin in an adult Negro man has been estimated to be only one gram, (Volker and Kenney, 1960). In Caucasians, regional variations in skin pigmentation over the body have been classified as occurring normally from greatest to least as follows: nipple and areola, navel, genitalia, dorsal surface of forearm, hypogastrium, axilla, epigastrium, flexor surfaces of the extremities and the palms and soles. The same pattern of regional body variations has been demonstrated in Negroes, Indians, Chinese, Koreans, Italians, Hebrews and practically all of the ethnic and religious groups and nationalities comprising the human race, (Dunnett, 1959).

Szabo (1954) has contributed much to the understanding of the number and distribution of melanocytes. In general there are more melanocytes per square millimeter on exposed skin than on covered areas. However, there is a high density of melanocytes about the genitalia and the nasal mucous membranes.

Melanocytes are symmetrically distributed and do not differ significantly in size, shape and population density for any given area in various races. There are approximately two to three times as many melanocytes present in facial skin as elsewhere. The total epidermal melanocyte population is estimated at 2×10^9 with an average of 1560 per square millimeter $\pm$ 110.

Variations in skin colour between racial groups and possibly between different individuals of the same race are a function of the rate and amount of melanin production by melanocytes rather than of the number of melanocytes present. It has been pointed out that the cheek of a Caucasian with white skin colour contains more melanocytes per square millimeter than the thigh of a dark-skinned individual with brown or black skin colour, (Fitzpatrick and Szabo, 1959).

(b) Oral Distribution

The evidence for the presence of melanin pigmentation in human oral tissues is sparse.

Laidlaw and Cahn (1932) demonstrated melanin or melanoblasts or both in sections of clinically non-pigmented gums from Negroes and Caucasians. They reported that a high percentage of Negroes showed no oral pigmented areas, and that an equally high percentage of whites did shown oral pigmentation. Contrary to general opinion, oral pigmentation, and particularly gingival pigmentation, is by no means confined to members of the Negro race. It has been reported in the French, Filipino, Algerian, Arabian, Chinese, East Indian, German, Roumanian, Italian, Jewish, Greek, Puerto Rican, Syrian, Peruvian and Ceylonese, (Dunnett, 1959).

Orban and Wentz (1955) demonstrated clear cells, melanoblasts, dendritic cells and melanophores in sections of oral mucosa.

If pigmentation of the intra-oral tissues is present, there is a distribution in the amount of pigmentation from greatest to least as follows: gingivae, buccal mucosa, hard palate, tongue, soft palate and the floor of the mouth, (Dummett, 1959).

7. Function

Melanin has a role in the protection of the skin against ultraviolet light. As epidermal cells move outward to become the stratum corneum, the melanin granules contained within them are carried along and appear in the stratum corneum not as coarse granules any longer but as fine irregular pigmented particles. In dark-skinned individuals the stratum corneum is regularly flecked with these melanin particles. By contrast, they are absent from the stratum corneum of Caucasians due to lack of melanin production by the melanocytes except during a short period after exposure to ionizing and ultraviolet radiation, (Fitzpatrick and Szabo, 1959). Thomson (1955) has been able to show the protective function of melanin against ultraviolet light. Using some of the African hospital aides and white South Africans as subjects, he obtained layers of stratum corneum from unexposed skin of both sets of individuals. The Negro stratum corneum contained distinctly more melanin, even though the thickness of the stratum corneum in both the white and coloured skin was of the same thickness. When these sheets of stratum corneum were

placed on photographic plates and exposed to ultraviolet light, the markedly greater filtering ability of the darker skin was clearly shown.

CHAPTER 4.

PALATINE GLANDS

The palatine glands can arbitrarily be divided into glands of the hard palate and glands of the soft palate and uvula. The glands of the hard palate which are found in the post-rugal region, lie between the mucous membrane and the periosteum, supported by a dense framework of connective tissue. Posteriorly these glands merge with those of the soft palate and form a thick layer between the mucous membrane and palatal musculature.

The palatine glands are mucus-secreting with short intercalated ducts; these ducts may undergo mucous transformation and function as part of the mucous terminal portion.

According to Krikos (1962), there are approximately two hundred and fifty independent glandular aggregates in the hard palate, approximately one hundred in the soft palate and approxinately twelve in the uvula. Schlack and Edwards (1943) atterpted to gain some information concerning the relative mucous gland population densities of three areas of the hard palate adjacent to the first molar tooth. This was done by counting the mucus droplets which appeared in marked areas after a short period of time and equating the number of droplets with the number of glands in the area. They found that few glands were close to the

median line or close to the tooth itself. In most cases, they were clustered about the junction of the median and middle thirds of the area between the tooth and raphé.

The only other information on this subject which was found in the literature dealing with palatal tissue was presented by Baum (1926-27). He warns ear, nose and throat surgeons that the mucous glands of the soft palate encroach upon the superior portion of the tonsillar fossa and can be mistaken for lymphoid tissue during tonsilectomy.

CHAPTER 5.

RUGAE

The palatine rugae will be discussed under the headings anatomy, histology, physiology, heredity and comparative anatomy.

1. Anatomy

Burchard (1895) presented a brief but commendable exposition on the anatomy of the palatine rugae. He attributed the first description of them to Dr. Harrison Allen in 1889. Burchard described the rugae as a series of ridges running in a transverse direction and usually having a curved outline. Those with the smallest radius of curvature are most anterior and those of increasing radius of curvature are farther posterior until the most posterior rugae are nearly straight. The rugae are progressively longer from the anterior part of the palate to the posterior. However the highest rugae are those immediately behind the incisor teeth; the height decreases the farther posteriorly they are situated. The rugae occupy approximately the anterior half of the hard palate. Burchard reported that Dr. Allen named the ovoid elevation overlying the incisive foramen, the "incisive pad".

Lysell (1955) stated that observations of the rugal pattern in various age groups and serial observations of a single subject show that, in general, the rugae are unchanged throughout life. Nevertheless the relation between the rugae and the teeth does tend to alter during growth, the teeth moving forwards in relation to the rugae. Furthermore, Lysell stated that in older subjects there is a reduction in the number of the rugae. Lund (1924) believed that this age change is due to a decrease in the amount of fat in the submucosa deep to the rugae.

2. Histology

According to Lund (1924) the palatine rugae are not simple elevations of mucous membrane but contain as their base a connective tissue core called "ruga nucleus" which consists of a tissue of immature character, rich in cells and interwoven with very delicate connective tissue fibres. Orban and Sicher (1962) state that the connective tissue core is dense; however they agree that it consists of fine, interwoven fibres.

3. Physiology

According to Burchard (1895) the primary function of the rugae is the provision of a non-slip surface on which the

tongue can be steadied while it manoeuvres a bolus of food. While it is possible that the rugae do play such a role, the tongue, nevertheless, can manage in the absence of the rugae. This is proven by the masticating and swallowing efficiency of countless patients who use full upper dentures with a shiny, smooth, palatal surface. The same writer pointed out that no rugae are needed, nor are they found, on the posterior part of the palate since here the muscles of the soft palate assist the tongue to propel the bolus toward the pharynx.

Burchard relegated the part played by the rugae in speech to a function of secondary importance. He supported his contention by reminding us that even the lower animals possess rugae.

Wright (1936) claimed that the size and form of the anterior rugae are modified by the form of the lingual surfaces of the maxillary incisors. He implied that increased pressure from foods causes rugal hypertrophy. Therefore small cingula and/or a narrow arch are associated with prominent rugae.

Lysell (1955) emphasized the importance of the rugae as an aid in grasping the maternal nipple. However he quotes

Retzius, who lived in the time of Burchard, and who considered that the rugae in man have no function in the uptake of nourishment after suckling is finished. Finally he suggests that the rugae may facilitate the orientation of the tongue in the oral cavity and thus aid enunciation.

Sicher (1965) states that the rugae in man are a vestige of the far higher and regular folds which, in many animals, play an important auxiliary role in the process of mastication.

4. Heredity

Similarities of rugal pattern due to heredity were studied by Lysell (1955). Findings were disappointing and of little practical value. No evidence was found that the rugal pattern alone is a reliable guide to the determination of paternity.

5. Comparative Anatomy

An article of interest from the comparative standpoint was presented by Linton (1905). Writing on the morphology of the mammalian palatine rugae he pointed out that members of entirely different sub-orders have rugae of remarkably similar form if their foods are similar, e.g. the armadillo and the hedgehog. By contrast great dissimilarity may exist among the members of the

same sub-order if their foods are dissimilar. Always the best developed and most prominent rugae are those anteriorly situated. In the majority of cases, these well developed rugae become blended with the rugae from the opposite side, or else are so placed that they alternate and cross the mid-line, (e.g. the pig). By contrast, the posterior rugae are less well developed and usually fail to reach the median raphé. If they do reach it they do not blend with opposite rugae. Linton concluded that in all animals there is a correlation between the type of food eaten and the form of the rugae.

CHAPTER 6.

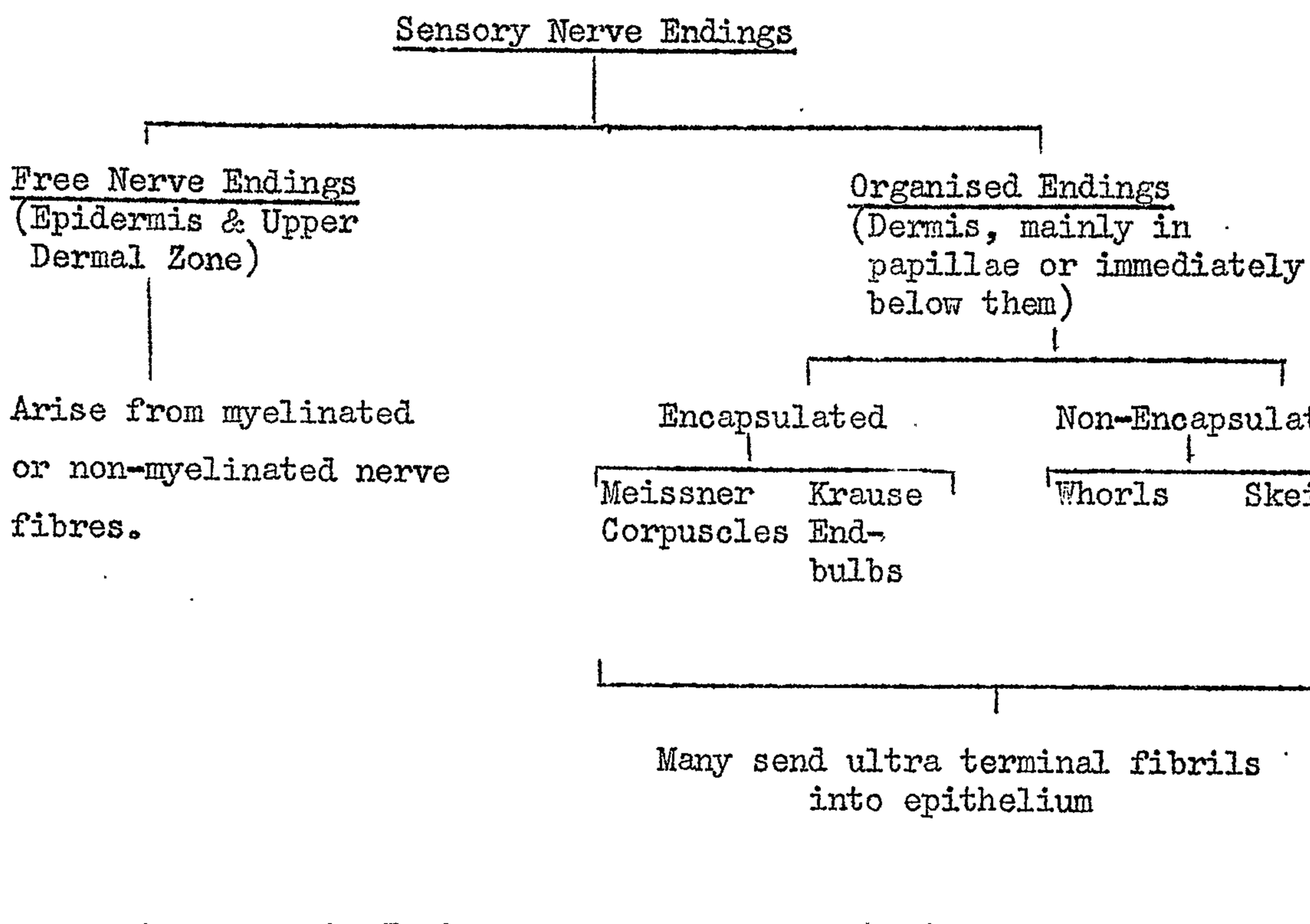
NERVE ENDINGS OF PALATAL MUCOSA

The nerve endings of palatal mucosa will be disoussed under five main headings. These will be (1) types of nerve endings (2) nerve endings of the hard palate (3) nerve endings of the soft palate (4) nerve endings of the uvula (5) clinical significance. The nerve endings in each of the above regions of the palate will be described under four sub-headings. These will be (a) endings in the epithelium (b) endings in the dermal papillae (c) endings in the dermal papillae with extensions into the epithelium (d) endings in the dermis deep to the papillae.

1. TYPES OF NERVE ENDINGS

Gairns (1956) stated that the endings in the gingiva, palate and tongue are similar. In all three sites the endings are of 2 main types: (1) free nerve endings in the epidermis and upper dermal zone, and (2) organised endings in the dermis lying mainly in the dermal papillae or immediately below them. The free nerve endings are extremely profuse and may arise from either myelinated or non-myelinated nerve fibres. The organised endings are either encapsulated or non-encapsulated. The encapsulated endings are typical Meissner corpuscles or Krause end-bulbs such as are found in the glabrous skin. Winklemann (1960) disagrees over this point and asserts that the nerve endings

described by Gairns as Meissner corpuscles differ from true Meissner corpuscles in that they are formed of non-myelinated nerve fibres, do not possess terminal expansions and are not lobulated. He suggests that the term "Meissner-form endings" be used to describe them. The unencapsulated types are usually whorls or skeins of varying size and shape. Several may be found in a single papilla. Many of the organised endings have a special feature: they exhibit fine fibrils (ultra-terminal) which pass from the ending in the papilla into the epithelium and run there in a straight unbranched course to the outermost layers. It is suggested that these "ultra-terminal" fibrils are probably present only in moist mucous membranes since there is no evidence for their occurrence on other surfaces of the body.



Some of the nerve endings are formed from fibres that are thickly myelinated until the final node which lies very close to the ending; others are formed from fibres which are non-myelinated as far back from the ending as they can be traced. The thick myelinated fibre can be recognised when the myelin is stained, as well as the axon, as it is in many of the staining methods. In these instances the nodes can be seen and the Schwann cell nuclei do not bulge out from the side of the myelin sheath. The thinner myelinated fibre may, with light stains, not reveal its myelin or its nodes, but with a deeper stain these become obvious. Non-myelinated fibres are of smaller diameter, show no nodes even with deep stains, and the Schwann cell nuclei bulge out from the side of the fibre. A thick myelinated fibre near its termination changes its diameter abruptly and is continued on in one or more fibres, which are without nodes and decrease in diameter on branching; all these latter are regarded as non-myelinated branches, (Radden, 1945). Dixon (1961) cast grave doubts on the likelihood of "a one to one relationship between sensory endings and a tetrad of modalities". He points out that the mucous membrane over the nasal conchae is sensitive to ill-defined pain, cold, warmth and touch, although only free nerve endings can be demonstrated. In the skin of the human external ear there are no organised nerve endings, only free nerve terminals or basket-like networks around the roots of hairs. Nevertheless cutaneous sensibility is

adequately represented in all its modalities. Dixon states that although nerve endings in oral tissues can be classified simply, they differ sufficiently in histological detail to prevent their correlation with specific sensations. It is possible that many of the nerve endings may subserve more than a single sensory function. Until the physiological behaviour of the various endings is better understood, no definite conclusions can be drawn.

Winkelmann (1960) considers that the intra-epithelial nerve fibres must subserve the function of the dermal nerve network by increasing acuity.

In silver-impregnated sections, throughout all regions of the palate, there is clear evidence of an autonomic ground plexus similar in pattern to that in the human nipple and in the human gum. In many cases the ground plexus is closely associated with the smaller blood vessels and capillaries, (Gairns, 1955).

2. HARD PALATE

(a) Endings in the epithelium

One of the first authors to describe nerve endings in palatal epithelium was Kadanoff (1927). The present author had his writings translated into English. It is interesting to note that his findings stand up well in comparison with more recent investigations despite the subsequent refinement of histologic techniques. Kadanoff's main point was that the intraepithelial nerves of the human palate have completely

different forms and pathways from intraepithelial nerves in human skin. The intraepithelial nerves in skin are described as branching and independent branches of the subpapillary nerve plexus. In palatal epithelium they go through the apex of the papillae into the epithelium and then without branching, zig-zag through the epithelium, ending under the keratin layer. They develop mostly from the nerve-end plexus and the end bodies which are situated in the papillae. Very few of them come directly from branches of the subpapillary plexus.

Radden (1945) added to Kadanoff's findings. He called the epithelial endings "free nerve endings" and stated that, most commonly, they arise from myelinated fibres which pass through the dermis almost to the epithelium before they divide into two or more non-myelinated lateral branches. These branches may run closely related to the basal edge of the epithelium for some distance and send fine short twigs into the epithelium. Here they become extremely delicate and finally ramify freely among the epithelial cells. On other occasions fine branches from non-myelinated fibres, which give rise to the dermal free endings, pass into the epithelium to form free endings there. These are probably the nerve endings described by Kadanoff.

(b) <u>Endings in the dermal papillae</u>

The types of nerve endings are those described by

Gairns (1956) earlier in this chapter. This is confirmed by Taylor et al, (1964). He states that usually the endings lie in approximately the middle of a dermal papilla. He prefers the term "mucocutaneous" end organs for the endings described by Gairns as Meissner corpuscles and by Winklemann (1960) as "Meissner-form" endings. Radden (1945) pointed out that in some papillae no organised endings are present at all, but instead, numbers of nerve fibres of different calibre turn and twist in a complex pattern. Still other papillae have fibres which run to their apices and loop back on themselves to re-enter the dermis below, without any break in their continuity.

(c) Endings in the dermal papillae with extensions into the epithelium

Some endings in the dermal papillae are characterised by one or several unbranched extensions, "ultra-terminal" fibrils, which pass into the epithelium. All the types of organised endings in the dermal papillae excepting the Meissner-form endings, show these extensions. Radden (1945) confirmed Kadanoff's findings (1927) that these "ultra-terminal" fibrils do not branch, and that some terminate just short of the free surface of the epithelium.

(d) Endings in the dermis deep to the papillae

In this region fewer nerve endings are found. They are all Krause end-bulbs, (Radden, 1945). Often several fine

accessory fibres accompany the main myelinated nerve fibre to the bulb. One or two of these fibres may enter the bulb while some travel around the outside of the capsule close to it; others run towards the epithelium or run up into the nearest papillae superficial to the bulb.

3. SOFT PALATE

The nerve endings of the soft palate resemble those of the hard palate except that none of them show "ultra-terminal" fibrils, (Radden, 1945). The significance of this difference is not known. It is possible that the lack of keratinisation on the soft palate mucosa eliminates the necessity for such superficial nerve endings. A further difference between the nerve endings of the hard and soft palates is that there are fewer organised endings in the soft than in the hard palate. This is associated with the smaller number of connective tissue papillae in the soft palate. A relative increase in the number of Krause end-bulbs also is noted.

Dixon and Williams (1963) reported on the soft palates of young adult monkeys, cats, rabbits and white rats. They stated that, in these animals, the soft palate receives contributions to its nerve supply from the glossopharyngeal nerve, as well as from the lesser palatine nerve. The submucous plexus is largely confined to the anterior part of the soft palate and the uvula region. It gives origin to a fine sub-epithelial plexus and provides fibres for the ducts and secretory units of mucous glands and palatal blood vessels. The fine submucous plexus in the uvula region may

be concerned with the retching reflex.

4. UVULA

According to Radden (1945) the striking characteristics in the uvula are the very large numbers of small nerve bundles present in the dermis, the presence of beading of the component fibrils in the nerve endings and the large number of autonomic fibres. Many of the nerve bundles in the dermis are motor fibres supplying the subjacent skeletal muscle. The autonomic fibres are required for the supply of the vascular network which is more prominent here than in any other region of the palate.

(a) Endings in the epithelium

The epithelium of the uvula contains many free nerve endings. They arise from non-myelinated fibres which either run along parallel to the dermal-epidermal junction or arrive more directly from the deeper tissues. The branches of these nerves enter the epithelium and inter-twine, but do not extend far towards the surface of the epithelium. From the point of their first branching they are beaded throughout.

(b) Endings in the dermal papillae

Radden (1945) stated that practically all the organised endings in the uvula are of the end-bulb type. They often occur in clusters of two, three or more. Inside the end-bulbs the fibres are numerous and fine. They show in their most delicate branches a typical beaded appearance. The end-bulbs

are situated very close to the basal surface of the epithelium, some even lying in indentations in the dermal-epidermal junction.

(c) Endings in the dermal papillae with extensions into the epithelium

As in the soft palate, the nerve endings in the dermal papillae of the uvula do not send "ultra-terminal" fibrils through the epithelium. This feature, then, is found in the hard palate only.

(d) Endings in the dermis deep to the papillae

No sensory nerve endings were found in the deep part of the dermis corresponding to those found in this region of the hard palate. Large numbers of skeletal muscle bundles are present at this depth in the uvula.

5. CLINICAL SIGNIFICANCE

Dixon (1962) pointed out that sensory nerve receptors are found more commonly in the anterior part of the palate than in the posterior part. This finding is in accord with the fact that the greatest accummulation of sensory spots, especially cold spots, lies towards the anterior part of the oral cavity. (Cold spots are defined by Hoerr and Osol (1956) as areas overlying the nerve endings that are stimulated by cold i.e. they are spots specially sensitive to cold.) These findings are also applicable to the tongue and gingivae. He made a further interesting observation, namely, that a greater proportion of intra-epithelial fibres appear

to be located in the epithelium of the rugae than in the epithelial floor between adjacent rugae. This fact may have some importance clinically with regard to administering local anaesthetics in the least painful manner.

Taylor et al (1964) have shown that the number of nerve endings in the rugae region of the hard palate decreases slightly with age.

The significance of the confinement of most of the intra-epithelial fibres to the deeper layers of the stratified epithelium is explained by Dixon, (1962). If the majority of such fibres reached the surface layers we might expect a much higher sensitivity of the normal mucous membrane than is known to exist. However the high incidence of more deeply placed endings could account for the hypersensitivity which results from conditions which denude the superficial zone of the epithelium.

Dixon observed further that sensory discrimination in the oral mucosa may depend, not only on the position and incidence of nerve endings, but also on their mode of origin from the underlying nerve plexus. The frequent finding that nerve fibres converge towards groups of sensory terminations from more than one direction is in agreemont with the topography of the peripheral nerves in the skin and is considered to be an arrangement conducive to accurate tactile localisation.

SUMMARY

1. The sensory nerve endings of the adult human hard

and soft palates and of the uvula have been described. They consist of free nerve endings within the epithelium, of numerous organised endings mainly in the dermal papillae, and of a few organised endings in the subpapillary region of the dermis.

2. The organised endings of the hard and soft palates show a general similarity in morphological character, but are more numerous in the former, where they also show "ultra-terminal" fibril's penetrating the epithelium. Those in the uvula are of one type, show no "ultra-terminal" fibrils and exhibit fine beading in their component fibrils.

3. Most of the organised endings are of unnamed form. Typical Meissner corpuscles are infrequent, while Krause end-bulbs are relatively uncommon. Accessory fibres are found associated with all these types.

4. An autonomic ground plexus is present in the dermis of palate and uvula.

CHAPTER 7.

BLOOD VESSELS

The most thorough investigation of the submucosal blood vessels of the palate has been made by Maher and Swindle (1962). The following information is from their findings.

At the time of commencing their investigation, the principal arterial and venous highways of the palate had already been charted, but the task of establishing the patterns of the by-roads of these vessels remained to be accomplished.

Gross Arterial Anatomy

The principal arteries are the right and left greater palatine arteries, which arise from the internal maxillary arteries. The greater palatine arteries have mucosal, periosteal, osteal, gingival and terminal branches. The terminal branch of the greater palatine artery, the naso-palatine artery, reaches the incisive foramen and ascends through the incisive canal to reach the nasal cavity where it anastomoses with septal branches of the spheno-palatine artery. The lesser palatine arteries supply the soft palate and uvula and the upper portion of the tonsil. The palate is also supplied by the ascending palatine branch of the facial artery, and the palatine branch of the ascending phargyngeal artery.

Method of Investigation

Maher and Swindle investigated the palatal submucosal

blood vessels of man, monkey, baboon, dog, bear, cat, pig, ox, sheep, antelope and deer. Their method was to inject the vessels with dyes. Two dyes were used - ink and red cinnabar. For arteries aqueous cinnabar only was injected; as its particles were too large to cross the capillary bed only the arterial tree was defined. To show both veins and arteries ink was first injected into an artery followed by an injection of cinnabar which forced some of the ink into the veins via the capillaries which the cinnabar could not enter. The veins, filled with ink, could then be distinguished from the arteries which contained cinnabar. Even slender arteries and veins could be differentiated. It should be recognised that this study makes reference only to large arteries and veins, small arteries, veins and capillaries. There was no attempt made to distinguish histologically arteries from arterioles or veins from venules.

The palatal area reported on is bordered laterally and anteriorly by the attached gingiva, posteriorly by the soft palate, superficially by the lamina propria and deeply by the periosteum.

Arterial patterns

Maher and Swindle reported that in many important respects the arrangement of the submucosal arteries is the same in all the mammals studied.

The basic arterial pattern is in the form of an arcade system comprised of arterial anastomoses. The primary arcade

consists of the right and left greater palatine arteries. Secondary arcades are more or less symmetrically arched anastomoses, interconnecting parts of the primary arcade. Tertiary arcades interconnect the secondary arcades. Sometimes arcades are seen which consist of anastomoses passing from one part of the main vessel to another part of the same vessel or from a portion of one arcade to another.

Ink (or blood) may flow from a primary to a secondary to a tertiary arcade. Many arcades also have arteries of small lumen through which the blood may escape to enter the lumina of nearby or distant capillaries. The nearby capillaries are in the submucosa and include those supplying nervous tissue, fat islands of the connective tissue and tunics of the principal artery. The remote capillaries are in the mucosal and periosteal layers and extend as far as the soft palate, bone, gingiva, periodontal ligament and tooth pulp.

An important point emerging from this investigation by Maher and Swindle is that the nutrition of the greater palatine nerve is a primary function of the greater palatine artery. The two structures are enveloped within a common sheath of connective tissue called the epineurium. The artery's position is often somewhat coaxial with the nerve. At other times the artery follows a more tortuous course. Sometimes the artery lies at the outermost portion of the epineurium. However, the artery was never observed by these investigators to be extra-epineural.

The greater palatine artery supplies its nerve by means of slender branches which connect with capillary-to-capillary anastomoses in and about the nerve bundles. Some of the arterial ramuscules are anastomosed with one another and with the greater palatine artery to form minor arcades. These are considered to be part of the general arcade system.

The findings of Maher and Swindle are in accordance with the postulation of Quinn and Lejars (1892) that every subcutaneous nerve has a satellite artery. In the entire palatal submucosa they were unable to find an extra-epineural artery. They note, however, that the finest terminal nerve filaments, which were not considered in their study, have no vasa nervorum.

Venous patterns

To observe the palatal venous patterns ink was injected into the ascending thoracic aorta, (Maher and Swindle, 1962). It coursed through the arterial arcade then via the escape arteries into the capillaries. Then, via the small collecting venules, it reached the vein-to-vein anastomoses of the venous arcade system at the submucosal level. In the posterior part of the hard palate the venous network is superficial to the greater palatine arteries. By contrast, in the anterior part the relation is reversed with the arterial trunks superifical to the venous anastomoses. Finally, the ink flowed within and from this arcade through valved venous anastomoses back to two main collecting veins

that lead to a venous network in the soft palate. This network is located posterior to the point of entrance of the greater palatine arteries through the greater palatine foramen.

It is known that this network drains eventually into the pterygoid venous plexus. The exact route followed by the blood from palate to plexus is, however, a mystery even in the most recent text-books. The findings of Maher and Swindle do not support the classical anatomical diagrams of a greater palatine artery juxtaposed with a large companion vein, but indicate that the most likely route to the plexus is via the large external palatine vein which descends from the soft palate immediately lateral to the tonsil before piercing the superior constrictor muscle to join the pharyngeal venous plexus. This plexus drains into the pterygoid plexus of veins above, and into the internal jugular or facial vein below.

Many arterial and venous arcades are closely related, particularly in the anterior portion of the palate. Consequently, nervous tissues accompanying the arteries sometimes envelope parts of the veins. It should be realised, however, that there is no tendency for nerves to accompany palatal veins as they do palatal arteries. If a portion of a vein is in the vicinity of an artery it may become surrounded by nerve tissue associated with the artery. However there is no tendency of nerve tissue to follow the venous pattern of growth. The extra-epineural vein is a lone vein

in the sense that it is not a constant companion to any of the other neurovascular structures.

Once a vein enters the epineurium, it is no longer termed a lone vein as it accompanies other vessles, nerves and fat. Veins in this situation either emerge as lone veins to join capillaries in other areas or pass within the nerve sheath to capillaries in the outer tunics of the principal nutrient artery of the arterioneural structure, or pass to capillaries of the epineural fat islands.

When a lone vein emerges from an arterioneural arcade it sometimes adopts a meandering course. Such configurations may be serpentine or helicine or simply a "swerving" of the vein.

So far the submucosal arrangement of the blood vessels has been presented. However little has been said of the final distribution forms of these vessels. As the afferent vessels ascend into the reticular and papillary layers they pursue a straight path. The terminal arteriole (identified by a continuous muscular tunica media) may give rise to two types of precapillary vessels before forming a plexus of true capillaries. They are metarterioles and precapillaries. The metarteriole has intermittently-located muscle fibres. The precapillary has single or multiple muscle fibres located at the attachment area of the parent vessel. The true capillary has no muscular elements. Although the constituents of capillary plexuses in the reticular

layer are of a true capillary variety, those in the connective tissue papillae are sinusoidal capillaries, consisting only of a thin, delicate, epithelial wall composed of three to six cells circumferentially arranged. The diameter of the sinusoidal capillaries varies from 25 to 50 $/^{u}$ compared with 7 to 15 $/^{u}$ for true capillaries. The efferent vessels of the papillary plexus are similar to the terminals of the capillaries which they drain. The constituents of the papillary plexus, therefore, are considered to be venous sinusoids, (Duda and Provenza, 1963).

An interesting investigation was done by Maher (1964) concerning the variation in the network of submucosal arteries of the palate of the human foetus with a view to determining whether cleft palate is associated with deficient blood supply. No deficiency could be found.

Lymph Drainage

The vessels of the hard palate run posteriorly and medially to join those of the soft palate which pass backwards and laterally in front of the anterior pillar of the fauces, pierce the superior constrictor of the pharynx, and end partly in the retropharyngeal and partly in the upper deep cervical lymph nodes, (Davies and Davies, 1962).

CHAPTER 8.

THE UVULA

The uvula is a conical process projecting from the free, posterior margin of the soft palate. It comprises a mass of racemose glands and connective tissue as well as slender prolongations of the musculus uvulae in its upper, contractile part, (Richardson and Pullen, 1948). It is covered by mucous membrane. The musculus uvulae consists of a pair of slender slips that arise from the posterior nasal spine, pass posteriorly through the soft palate, unite and enter the uvula to be inserted into its mucous membrane. Their action is to shorten the uvula and they are supplied by the accessory nerve through the pharyngeal plexus. Sensory nerve fibres from the spheno-palatine ganglion reach the uvula through the middle or external palatine nerve. Blood supply is by arterial branches from the soft palate, (Richardson and Pullen, 1948).

A valuable contribution to the understanding of the spread of nerves in the uvula was made by Hamilton (1957). The present author had the article translated into English and the main points are now summarised. The uvulae from men and women of different age groups were examined. The mucosa on the oral side is, on the average, thicker than the mucosa on the pharyngeal side in all age groups. In the older age groups the mucosa is thicker in

men than in women.

On the oral side of the uvula, nerve endings in the form of reticulated and twisted corpuscles are found beneath the epithelium. They increase in number from the apex to the root of the uvula. They are connected with a thin, flat, network of nerves which runs parallel with the epithelial border. Fibrils emerging from the corpuscles can sometimes be observed running into the epithelium.

It is interesting that neither the corpuscles nor the flat network of nerves could be found on the pharyngeal side. Instead nerves were seen closely related to the blood vessels; these nerves form spiral figures with endings extending into the epithelium. These spirals, which belong to the autonomic nervous system, are found only beneath the epithelium of the pharyngeal side. Clinical investigation shows that both oral and pharyngeal sides are sensitive to touch. Therefore the sensation of touch is not dependent on the corpuscles which are situated only on the oral side. Hamilton proposed that the function of the corpuscles could be to intensify any kind of stimulus. Certainly minimal physical touch at the base of the uvula leads to stimulation of the vomiting reflex. The thicker coil-shaped fibrils of the posterior side convey the sensation of swallowing and thereby contribute to the co-ordination of this act.

Richardson and Pullen (1948) list the following functions of the uvula.

1. It massages and moistens the posterior pharygeal wall, thereby aiding the passage of material from this site downward to the hypopharynx and base of the tongue.

2. It serves as a bridge for secretion moving posteriorly from the velum to the posterior pharyngeal wall.

3. The uvula helps prevent pharyngitis sicca with subsequent drying of the eustachian orifices and middle ear disease, especially in children.

4. It is a valuable adjunct to voice control, possibly as a midline buttress, particularly in singers. This function is of little value in the speaking range apart from preventing unpleasant qualities.

Richardson and Pullen stated that the uvula is the warning flag of the pharynx in many instances, being a visible means of ascertaining possible inflammatory changes occurring below the base of the tongue. They also mentioned that deviation of the uvula to one side is a valuable diagnostic aid as it may indicate a weakness of the accessory nerve on the opposite side.

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P A R T 2

ORIGINAL INVESTIGATION

CHAPTER 9

INTRODUCTION

The oral mucous membrane is composed of two layers, the lamina propria and the surface epithelium. This investigation, using the light microscope, is confined in the main to the mucous membrane of the human hard and soft palates. In a few chapters, however, features of the submucosa also are considered.

The specimens were taken as follows: (Plate 2.)

1. FATTY ZONE

   A rectangular piece of tissue from the centre of the fatty zone for sectioning in a coronal plane.

2. GLANDULAR ZONE

   A rectangular piece of tissue from the centre of the glandular zone for sectioning in a coronal plane.

3. SOFT PALATE

   A rectangular piece of tissue from the soft palate for sectioning in a coronal plane.

4. GINGIVA ADJACENT FATTY ZONE

   A rectangular piece of tissue for sectioning in a sagittal plane. N.B. In edentulous regions a similar sample was taken, confined to the medial side of the centre of the alveolar ridge.

5. GINGIVA ADJACENT GLANDULAR ZONE

A rectangular piece of tissue for sectioning in a sagittal plane. N.B. In edentulous regions a similar sample was taken, confined to the medial side of the centre of the alveolar ridge.

6. INCISIVE PAPILLA

A square piece of tissue including the entire papilla when available, or otherwise one half, for sectioning in a coronal plane.

7. MEDIAN RAPHÉ

A rectangular piece of tissue from the midline adjacent to both fatty and glandular zones for sectioning in the median sagittal plane.

The investigation was concentrated on less familiar characteristics of palatal mucosa. These are listed in Fig. 1, with the fixatives and stains used. Where necessary, control slides were made using bandicoot-snout and liver.

Fig.1.

STAIN	FIXATIVE	TO DEMONSTRATE
Ammoniacal Silver Nitrate	Bouin's	Reticular fibres
Best's Carmine	Bouin's	Glycogen
Congo Red	Formalin	Keratohyalin Granules
Haematoxylin and Eosin	Formalin	Basophil intensity of nuclei Binucleate epithelial cells Capillary loops Intercellular spaces and intercellular bridges Rete pegs Clear cells Taste buds
Heidenhain's haematoxylin	Zenker	Tonofibrils
Modified Mallory	Formalin	Parakeratosis, incomplete keratosis, full keratinization, non-keratinization
Methenamine Silver	Formalin	Melanin
Orcein	Any fixative	Elastic fibres
P.A.S.	Bouin's	Feulgen reactivity of nuclei. Ground substance
Toluidine Blue	Formalin	Mast cells
Van Gieson's	Zenker	Collagen fibres

This permitted investigation of eighteen different features in each site. One hundred and twenty six reports were compiled for each feature of each zone.

However, this was done in three different specimens so that in all three hundred and seventy eight reports were made. These are recorded in the following pages. Groups of slides which gave similar findings are recorded collectively. An eyepiece carrying a graduated scale was used for making the various measurements reported. A magnification of 1000X with oil immersion was used for examining tonofibrils.

Three codes known as codes 1, 2 and 3 (pages 77, 81 and 85) were used for recording data. Each space in each code was numbered to correspond with the appropriate slide. The relevant details concerning the specimens on the slide were recorded under seven headings. Both the headings and the details were abbreviated for practical reasons. The headings in order were: Donor (D), Sex (S), Age in years (A), Ethnic Origin (E), Fixative (F), Stain (S) and Origin (O). The origin of the specimen was recorded as being one of the following:

Fresh (F) (i.e. from a living donor), Post-Mortem specimen (P.M.) or Dissecting Room Material (D.R.M.). Other symbols used were as follows:

Ammoniacal Silver Nitrate ($AgNO_3$), Best's

Carmine (B.Car.), Bouin's (B), Congo Red (C.R.), European (Eur.), Female (F), Formalin (F), Haematoxylin and Eosin (H&E), Heidenhain's (H), Male (M), Modified Mallory (M.M.), Methenamine Silver (Ag), Mongoloid (Mon), Orcein (O), Periodic Acid-Schiff (P.A.S.), Toluidine Blue (T.B.), van Gieson's (v.Gies.) and Zenker (Z).

Because of the difficulty in obtaining specimens it was necessary to limit the investigation of each feature to three specimens from each zone.

Fig. 2.

RESEARCH PROJECT ON PALATAL MUCOSA. - CODE 1.

		Reticular Fibres	Glycogen	Keratohyalin Granules	Basophil Intensity of Nuclei	Binucleate epithelial cells	Capillary Loops	Intercellular spaces and intercellular bridges	Rete Pegs	Clear Cells (Melanocytes)
		1	2	3	4	5	6	7	8	9
	D	C	C	A	A	A	A	A	A	A
	S	M	M	F	F	F	F	F	F	F
	A	13	13	13	13	13	13	13	13	13
Fatty Zone	E	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.
	F	B	B	F	F	F	F	F	F	F
	S	$AgNO_3$	B.Car	C.R.	H&E	H&E	H&E	H&E	H&E	H&E
	O	F	F	F	F	F	F	F	F	F
		19	20	21	22	23	24	25	26	27
	D	H	H	B	B	B	B	B	B	B
	S	M	M	F	F	F	F	F	F	F
Gland-	A	39	31	32	32	32	32	32	32	32
ular	E	Eur.	Eur.	Mon.	Mon.	Mon.	Mon.	Mon.	Mon.	Mon.
Zone	F	B	B	F	F	F	F	F	F	F
	S	$AgNO_3$	B.Car	C.R.	H&E	H&E	H&E	H&E	H&E	H&E
	O	P.M.	P.M.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.
		37	38	39	40	41	42	43	44	45
	D	H	H	B	B	B	B	B	B	B
	S	M	M	F	F	F	F	F	F	F
	A	39	31	32	32	32	32	32	32	32
Soft	E	Eur.	Eur.	Mon.	Mon.	Mon.	Mon.	Mon.	Mon.	Mon.
Palate	F	B	B	F	F	F	F	F	F	F
	S	$AgNO_3$	B.Car	C.R.	H&E	H&E	H&E	H&E	H&E	H&E
	O	P.M.	P.M.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.
		55	56	57	58	59	60	61	62	63
Gingiva	D	C	C	B	B	B	B	B	B	B
Adjacent	S	M	M	F	F	F	F	F	F	F
Fatty	A	13	13	32	32	32	32	32	32	32
Zone (or	E	Eur.	Eur.	Mon.	Mon.	Mon.	Mon.	Mon.	Mon.	Mon.
mucosa	F	B	B	F	F	F	F	F	F	F
to centre	S	$AgNO_3$	B.Car	C.R.	H&E	H&E	H&E	H&E	H&E	H&E
edentu-	O	F	F	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.
lous ri-										
dge)		73	74	75	76	77	78	79	80	81
Gingiva	D	H.	H	B	B	B	B	B	B	B
Adjacent	S	M	M	F	F	F	F	F	F	F
Gland-	A	39	31	32	32	32	32	32	32	32
ular	E	Eur.	Eur.	Mon.	Mon.	Mon.	Mon.	Mon.	Mon.	Mon.
Zone	F	B	B	F	F	F	F	F	F	F
	S	$AgNO_3$	B.Car	C.R.	H&E	H&E	H&E	H&E	H&E	H&E
	O	P.M.	P.M.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.

Fig. 2 (Cont'd)

	Taste Buds	Tono-fibrils	Parakeratosis, incomplete keratosis, full keratinization, non keratinization	Melanin	Elastic fibres	Feulgen reactivity of nuclei	Ground substance	Mast Cells	Collagen Fibres
	10	11	12	13	14	15	16	17	18
	D A	C	A	A	A	C	C	A	C
	S F	F	F	F	F	F	F	F	F
Fatty	A 13	13	13	13	13	13	13	13	13
Zone	E Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.
	F F	Z	F	F	F	B	B	F	Z
	S H&E	H	M.M.	Ag	O	PAS.	PAS.	T.B.	v.Gies
	O F	F	F	F	F	F	F	F	F
	28	29	30	31	32	33	34	35	36
	D B	H	B	B	B	H	H	B	H
Gland-	S F	M	F	F	F	M	M	F	M
ular	A 32	39	32	32	32	39	39	32	39
Zone	E Mon.	Eur.	Mon.	Mon.	Mon.	Eur.	Eur.	Mon.	Eur.
	F F	Z	F	F	F	B	B	F	Z
	S H&E	H	M.M.	Ag	O	PAS.	PAS.	T.B.	v.Gies
	O DRM.	P.M.	DRM.	DRM.	DRM.	P.M.	P.M.	DRM.	P.M.
	46	47	48	49	50	51	52	53	54
	D B	H	B	B	B	H	H	B	H
Soft	S F	M	F	F	F	M	M	F	M
Palate	A 32	39	32	32	32	39	39	32	39
	E Mon.	Eur.	Mon.	Mon.	Mon.	Eur.	Eur.	Mon.	Eur.
	F F	Z	F	F	F	B	B	F	Z
	S H&E	H	M.M.	Ag	O	PAS.	PAS.	T.B.	v.Gies
	O DRM.	P.M.	DRM.	DRM.	DRM.	P.M.	P.M.	DRM.	P.M.
Gingiva	64	65	66	67	68	69	70	71	72
Adjacent	D B	C	B	B	B	C	C	B	C
Fatty Zone	S F	F	F	F	F	F	F	F	F
(or mucosa	A 32	13	32	32	32	13	13	32	13
to centre	E Mon.	Eur.	Mon.	Mon.	Mon.	Eur.	Eur.	Mon.	Eur.
of edentu-	F F	Z	F	F	F	B	B	F	Z
lous ridge)	S H&E	H	M.M.	Ag.	O	PAS.	PAS.	T.B.	v.Gies
	O DRM.	F	DRM.	DRM.	DRM.	F	F	DRM.	F
Gingiva	82	83	84	85	86	87	88	89	90
Adjacent	D B	H	B	B	B	H	H	B	H
Glandular	S F	M	F	F	F	M	M	F	M
Zone (or	A 32	39	32	32	32	39	39	32	39
mucosa to	E Mon.	Eur.	Mon.	Mon.	Mon.	Eur.	Eur.	Mon.	Eur.
centre of	F F	Z	F	F	F	B	B	F	Z
edentulous	S H&E	H	M.M.	Ag	O	PAS.	PAS.	T.B.	v.Gies
ridge)	O DRM.	P.M.	DRM.	DRM.	DRM.	P.M.	P.M.	DRM.	P.M.

Fig. 2. (Cont'd)

		Reticular Fibres	Glycogen	Keratohyalin Granules	Basophil Intensity of Nuclei	Binucleate epithelial cells	Cap-illary Loops	Intercellular Spaces and intercellular bridges	Rete Pegs	Clear Cells (Melanocytes)
		91	92	93	94	95	96	97	98	99
Incis-	D	H	H	B	B	B	B	B	B	B
ive	S	M	M	F	F	F	F	F	F	F
Pap-	A	39	31	32	32	32	32	32	32	32
illa	E	Eur.	Eur.	Mon.	Mon.	Mon.	Mon.	Mon.	Mon.	Mon.
	F	B	B	F	F	F	F	F	F	F
	S	$AgNO_3$	B.Car	C.R.	H&E	H&E	H&E	H&E	H&E	H&E
	O	P.M.	P.M.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.
		109	110	111	112	113	114	115	116	117
	D	H	H	B	B	B	B	B	B	B
Median	S	M	M	F	F	F	F	F	F	F
Raphe	A	39	31	32	32	32	32	32	32	32
	E	Eur.	Eur.	Mon.	Mon.	Mon.	Mon.	Mon.	Mon.	Mon.
	F	B	B	F	F	F	F	F	F	F
	S	$AgNO_3$	B.Car	C.R.	H&E	H&E	H&E	H&E	H&E	H&E
	O	P.M.	P.M.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.

Fig. 2. (Cont'd.)

	Taste Buds	Tono-fibrils	Parakeratosis, incomplete keratosis, full keratinization, non keratinization	Melanin	Elastic fibres	Feulgen reactivity of nuclei	Ground substance	Mast Cells	Collagen Fibres
	100	101	102	103	104	105	106	107	108
Incisive Papilla	D B S F A 32 E Mon. F F S H&E O DRM.	H M 39 Eur. Z H P.M.	B F 32 Mon. F M.M. DRM.	B F 32 Mon. F Ag DRM.	B F 32 Mon. F O DRM.	H M 39 Eur. B PAS. P.M.	H M 39 Eur. B PAS. P.M.	B F 32 Mon. F T.B. DRM.	H M 39 Eur. Z v.Gie P.M.
	118	119	120	121	122	123	124	125	126
Median Raphé	D B S F A 32 E Mon. F F S H&E O DRM.	H M 39 Eur. Z H P.M.	B F 32 Mon. F M.M. DRM.	B F 32 Mon. F Ag DRM.	B F 32 Mon. F O DRM.	H M 39 Eur. B PAS. P.M.	H M 39 Eur. B PAS. P.M.	B F 32 Mon. F T.B. DRM.	H M 39 Eur. Z v.Gie P.M.

Fig. 3.

RESEARCH PROJECT ON PALATAL MUCOSA - CODE 2.

		Reticular Fibres	Glycogen	Keratohyalin Granules	Basophil Intensity of Nuclei	Binucleate epithelial cells	Capillary Loops	Intercellular spaces and intercellular bridges	Rete Pegs	Clear Cells (Melanocytes)
		1	2	3	4	5	6	7	8	9
	D	F	F	D	D	D	D	D	D	D
	S	M	M	M	M	M	M	M	M	M
	A	48	48	73	73	73	73	73	73	73
Fatty	E	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.
Zone	F	B	B	F	F	F	F	F	F	F
	S	$AgNO_3$	B.Car	C.R.	H&E	H&E	H&E	H&E	H&E	H&E
	O	P.M.	P.M.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.
		19	20	21	22	23	24	25	26	27
	D	F	F	D	D	D	D	D	D	D
Gland-	S	M	M	M	M	M	M	M	M	M
ular	A	48	48	73	73	73	73	73	73	73
Zone	E	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.
	F	B	B	F	F	F	F	F	F	F
	S	$AgNO_3$	B.Car.	C.R.	H&E	H&E	H&E	H&E	H&E	H&E
	O	P.M.	P.M.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.
		37	38	39	40	41	42	43	44	45
	D	F	F	D	D	D	D	D	D	D
	S	M	M	M	M	M	M	M	M	M
Soft	A	48	48	73	73	73	73	73	73	73
Pal-	E	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.
ate	F	B	B	F	F	F	F	F	F	F
	S	$AgNO_3$	B.Car.	C.R.	H&E	H&E	H&E	H&E	H&E	H&E
	O	P.M.	P.M.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.
Gingiva		55	56	57	58	59	60	61	62	63
Adjacent	D	F	F	D	D	D	D	D	D	D
Fatty	S	M	M	M	M	M	M	M	M	M
Zone(	A	48	48	73	73	73	73	73	73	73
or ruc-	E	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.
osa to	F	B	B	F	F	F	F	F	F	F
centre	S	$AgNO_3$	B.Car.	C.R.	H&E	H&E	H&E	H&E	H&E	H&E
of edent-	O	P.M.	P.M.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.
ulous ridge)										

Fig. 3 (Cont'd).

		Taste Buds	Tono-fibrils	Parakeratosis, incomplete keratosis, full keratinization, non keratinization	Melanin	Elastic fibres	Feulgen reactivity of nuclei	Ground substance	Mast Cells	Collagen Fibres
		10	11	12	13	14	15	16	17	18
	D	D	F	D	D	D	F	D	D	F
Fatty	S	M	M	M	M	M	M	M	M	M
Zone	A	73	48	73	73	73	48	73	73	48
	E	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.
	F	F	Z	F	F	F	B	F	F	Z
	S	H&E	H	M.M.	Ag	O	PAS.	PAS.	T.B.	v.Gies
	O	DRM.	P.M.	DRM.	DRM.	DRM.	P.M.	DRM.	DRM.	P.M.
		28	29	30	31	32	33	34	35	36
	D	D	F	D	D	D	F	D	D	F
Gland-	S	M	M	M	M	M	M	M	M	M
ular	A	73	48	73	73	73	48	73	73	48
Zone	E	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.
	F	F	Z	F	F	F	B	F	F	Z
	S	H&E	H	M.M.	Ag	O	PAS.	PAS.	T.B.	v.Gies
	O	DRM.	P.M.	DRM.	DRM.	DRM.	P.M.	DRM.	DRM.	P.M.
		46	47	48	49	50	51	52	53	54
	D	D	F	D	D	D	F	D	D	F
	S	M	M	M	M	M	M	M	M	M
Soft	A	73	48	73	73	73	48	73	73	48
Palate	E	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.
	F	F	Z	F	F	F	B	F	F	Z
	S	H&E	H	M.M.	Ag	O	PAS.	PAS.	T.B.	v.Gies
	O	DRM.	P.M.	DRM.	DRM.	DRM.	P.M.	DRM.	DRM.	P.M.
Gingiva		64	65	66	67	68	69	70	71	72
Adjacent	D	D	F	D	D	D	F	D	D	F
Fatty	S	M	M	M	M	M	M	M	M	M
Zone(or	A	73	48	73	73	73	48	73	73	48
mucosa	E	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.
to cen-	F	F	Z	F	F	F	B	F	F	Z
tre of	S	H&E	H	M.M.	Ag	O	PAS.	PAS.	T.B.	v.Gies
edentu-	O	DRM.	P.M.	DRM.	DRM.	DRM.	P.M.	DRM.	DRM.	P.M.
lous ridge)										

Fig. 3 (Cont'd).

	Reticular Fibres	Glycogen	Keratohyalin Granules	Basophil Intensity of Nuclei	Binucleate epithelial cells	Capillary Loops	Intercellular spaces and intercellular bridges	Rete Pegs	Clear Cells (Melanocytes)
	73	74	75	76	77	78	79	80	81
Gingiva	D F	F	D	D	D	D	D	D	D
	S M	M	M	M	M	M	M	M	M
Adjacent Gland-ular zone	A 48	48	73	73	73	73	73	73	73
	E Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.
	F B	B	F	F	F	F	F	F	F
	S $AgNO_3$	B.Car.	C.R.	H&E	H&E	H&E	H&E	H&E	H&E
	O P.M.	P.M.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.
	91	92	93	94	95	96	97	98	99
Incisive Papilla	D F	F	D	D	D	D	D	D	D
	S M	M	M	M	M	M	M	M	M
	A 48	48	73	73	73	73	73	73	73
	E Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.
	F B	B	F	F	F	F	F	F	F
	S $AgNO_3$	B.Car.	C.R.	H&E	H&E	H&E	H&E	H&E	H&E
	O P.M.	P.M.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.
	109	110	111	112	113	114	115	116	117
Median Raphé	D F	F	D	D	D	D	D	D	D
	S M	M	M	M	M	M	M	M	M
	A 48	48	73	73	73	73	73	73	73
	E Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.
	F B	B	F	F	F	F	F	F	F
	S $AgNO_3$	B.Car.	C.R.	H&E	H&E	H&E	H&E	H&E	H&E
	O P.M.	P.M.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.

Fig. 3 (Cont'd).

		Taste Buds	Tono-fibrils	Parakeratosis, incomplete keratosis, full keratinization, non keratinization	Melanin	Elastic fibres	Feulgen reactivity of nuclei	Ground substance	Mast Cells	Collagen Fibres
		82	83	84	85	86	87	88	89	90
Gingiva	D	D	F	D	D	D	F	D	D	F
Adjacent	S	M	M	M	M	M	M	M	M	M
Gland-	A	73	48	73	73	73	48	73	73	48
ular	E	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.
Zone	F	F	Z	F	F	F	B	F	F	Z
	S	H&E	H	M.M.	Ag	O	PAS.	PAS.	T.B.	v.Gies
	O	DRM.	P.M.	DRM.	DRM.	DRM.	P.M.	DRM.	DRM.	P.M.
		100	101	102	103	104	105	106	107	108
	D	D	F	D	D	D	F	D	D	F
Incis-	S	M	M	M	M	M	M	M	M	M
ive	A	73	48	73	73	73	48	73	73	48
Papilla	E	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.
	F	F	Z	F	F	F	B	F	F	Z
	S	H&E	H	M.M.	Ag	O	PAS.	PAS.	T.B.	v.Gies
	O	DRM.	P.M.	DRM.	DRM.	DRM.	P.M.	DRM.	DRM.	P.M.
		118	119	120	121	122	123	124	125	126
	D	D	F	D	D	D	F	D	D	F
	S	M	M	M	M	M	M	M	M	M
Median	A	73	48	73	73	73	48	73	73	48
Raphé	E	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.
	F	F	Z	F	F	F	B	F	F	Z
	S	H&E	H	M.M.	Ag	O	PAS.	PAS.	T.B.	v.Gies
	O	DRM.	P.M.	DRM.	DRM.	DRM.	P.M.	DRM.	DRM.	P.M.

Fig. 4.

RESEARCH PROJECT ON PALATAL MUCOSA - CODE 3.

		Reticular Fibres	Glycogen	Keratohyalin Granules	Basophil Intensity of Nuclei	Binucleate epithelial cells	Capillary Loops	Intercellular spaces and intercellular bridges	Rete Pegs	Clear Cells (Melanocytes)
		1	2	3	4	5	6	7	8	9
Fatty Zone	D	G	G	E	E	E	E	E	E	E
	S	M	M	M	M	M	M	M	M	M
	A	84	84	81	81	81	81	81	81	81
	E	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.
	F	B	B	F	F	F	F	F	F	F
	S	$AgNO_3$	B.Car.	C.R.	H&E	H&E	H&E	H&E	H&E	H&E
	O	P.M.	P.M.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.
		19	20	21	22	23	24	25	26	27
Glandular Zone	D	G	G	E	E	E	E	E	E	E
	S	M	M	M	M	M	M	M	M	M
	A	84	84	81	81	81	81	81	81	81
	E	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.
	F	B	B	F	F	F	F	F	F	F
	S	$AgNO_3$	B.Car.	C.R.	H&E	H&E	H&E	H&E	H&E	H&E
	O	P.M.	P.M.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.
		37	38	39	40	41	42	43	44	45
Soft Palate	D	G	G	E	E	E	E	E	E	E
	S	M	M	M	M	M	M	M	M	M
	A	84	84	81	81	81	81	81	81	81
	E	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.
	F	B	B	F	F	F	F	F	F	F
	S	$AgNO_3$	B.Car.	C.R.	H&E	H&E	H&E	H&E	H&E	H&E
	O	P.M.	P.M.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.
		55	56	57	58	59	60	61	62	63
Gingiva Adjacent Fatty Zone (or mucca to centre of edentulcus ridge)	D	G	G	E	E	E	E	E	E	E
	S	M	M	M	M	M	M	M	M	M
	A	84	84	81	81	81	81	81	81	81
	E	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.
	F	B	B	F	F	F	F	F	F	F
	S	$AgNO_3$	B.Car.	C.R.	H&E	H&E	H&E	H&E	H&E	H&E
	O	P.M.	P.M.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.

Fig. 4 (Cont'd).

	Taste Buds	Tono-fibrils	Parakeratosis, incomplete keratosis, full keratinization, non keratinization	Melanin	Elastic Fibres	Feulgen reactivity of nuclei	Ground substance	Mast Cells	Collagen Fibres
Fatty Zone	10 D E S M A 81 E Eur. F F S H&E O DRM.	11 G M 84 Eur. Z H P.M.	12 E M 81 Eur. F M.M. DRM.	13 E M 81 Eur. F Ag DRM.	14 E M 81 Eur. F O DRM.	15 G M 84 Eur. B PAS. P.M.	16 E M 81 Eur. F PAS. DRM.	17 E M 81 Eur. F T.B. DRM.	18 G M 84 Eur. Z v.Gies P.M.
Glandular Zone	28 D E S M A 81 E Eur. F F S H&E O DRM.	29 G M 84 Eur. Z H P.M.	30 E M 81 Eur. F M.M. DRM.	31 E M 81 Eur. F Ag DRM.	32 E M 81 Eur. F O DRM.	33 G M 84 Eur. B PAS. P.M.	34 E M 81 Eur. F PAS. DRM.	35 E M 81 Eur. F T.B. DRM.	36 G M 84 Eur. Z v.Gies P.M.
Soft Palate	46 D E S M A 81 E Eur. F F S H&E O DRM.	47 G M 84 Eur. Z H P.M.	48 E M 81 Eur. F M.M. DRM.	49 E M 81 Eur. F Ag DRM.	50 E M 81 Eur. F O DRM.	51 G M 84 Eur. B PAS. P.M.	52 E M 81 Eur. F PAS. DRM.	53 E M 81 Eur. F T.B. DRM.	54 G M 84 Eur. Z v.Gies P.M.
Gingiva Adjacent Fatty Zone (or mucosa to centre of edentulous ridge)	64 D E S M A 81 E Eur. F F S H&E O DRM.	65 G M 84 Eur. Z H P.M.	66 E M 81 Eur. F M.M. DRM.	67 E M 81 Eur. F Ag DRM.	68 E M 81 Eur. F O DRM.	69 G M 84 Eur. B PAS. P.M.	70 E M 81 Eur. F PAS. DRM.	71 E M 81 Eur. F T.B. DRM.	72 G M 84 Eur. Z v.Gies P.M.

Fig. 4 (Cont'd).

		Reticular Fibres	Glycogen	Keratohyalin Granules	Basophil Intensity of Nuclei	Binucleate epithelial cells	Capillary Loops	Intercellular spaces and intercellular bridges	Rete Pegs	Clear Cells (Melanocytes)
		73	74	75	76	77	78	79	80	81
Gingiva	D	G	G	E	E	E	E	E	E	E
	S	M	M	M	M	M	M	M	M	M
Adjacent Glandular Zone	A	84	84	81	81	81	81	81	81	81
	E	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.
	F	B	B	F	F	F	F	F	F	F
	S	$AgNO_3$	B.Car.	C.R.	H&E	H&E	H&E	H&E	H&E	H&E
	O	P.M.	P.M.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.
		91	92	93	94	95	96	97	98	99
	D	G	G	E	E	E	E	E	E	E
Incisive Papilla	S	M	M	M	M	M	M	M	M	M
	A	84	84	81	81	81	81	81	81	81
	E	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.
	F	B	B	F	F	F	F	F	F	F
	S	$AgNO_3$	B.Car.	C.R.	H&E	H&E	H&E	H&E	H&E	H&E
	O	P.M.	P.M.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.
		109	110	111	112	113	114	115	116	117
	D	G	G	E	E	E	E	E	E	E
Median Raphé	S	M	M	M	M	M	M	M	M	M
	A	84	84	81	81	81	81	81	81	81
	E	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.
	F	B	B	F	F	F	F	F	F	F
	S	$AgNO_3$	B.Car.	C.R.	H&E	H&E	H&E	H&E	H&E	H&E
	O	P.M.	P.M.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.	DRM.

Fig. 4 (Cont'd).

	Taste Buds	Tono-fibrils	Parakeratosis, incomplete keratosis, full keratinization, non keratinization	Melanin	Elastic Fibres	Feulgen reactivity of nuclei	Ground substance	Mast Cells	Collagen Fibres
	82	83	84	85	86	87	88	89	90
D	E	G	E	E	E	G	E	E	G
S	M	M	M	M	M	M	M	M	M
Gingiva A	81	84	81	81	81	84	81	81	84
Adjacent E	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.
Gland- F	F	Z	F	F	F	B	F	F	Z
ular S	H&E	H	M.M.	Ag	O	PAS.	PAS.	T.B.	v.Gies
Zone O	DRM.	P.M.	DRM.	DRM.	DRM.	P.M.	DRM.	DRM.	P.M.
	100	101	102	103	104	105	106	107	108
D	E	G	E	E	E	G	E	E	G
S	M	M	M	M	M	M	M	M	M
Incis- A	81	84	81	81	81	84	81	81	84
ive E	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.
Papilla F	F	Z	F	F	F	B	F	F	Z
S	H&E	H	M.M.	Ag	O	PAS.	PAS.	T.B.	v.Gies
O	DRM.	P.M.	DRM.	DRM.	DRM.	P.M.	DRM.	DRM.	P.M.
	118	119	120	121	122	123	124	125	126
D	E	G	E	E	E	G	E	E	G
S	M	M	M	M	M	M	M	M	M
A	81	84	81	81	81	84	81	81	84
Median E	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.	Eur.
Raphé F	F	Z	F	F	F	B	F	F	Z
S	H&E	H	M.M.	Ag	O	PAS.	PAS.	T.B.	v.Gies
O	DRM.	P.M.	DRM.	DRM.	DRM.	P.M.	DRM.	DRM.	P.M.

CHAPTER 10

RETICULAR FIBRES

Describing reticular fibres in human dermis, Montagna (1962) says:

"So-called because they branch and form a network, reticular fibres are found throughout the connective tissue. A dense bed of them found in the upper part of the papillary layer, underneath the epidermis, either forms the basement membrane or is a component part of it. The greatest preponderance of reticular fibres is in the papillary layer and in its extensions around the cutaneous appendages. In the reticular layer, reticular fibres are numerous only around blood vessels. In the fatty layer, reticular fibres are well developed around blood vessels and they form basketlike capsules around each fat cell. The fibres are of different thicknesses and at least the larger ones seem to consist of bundles of finer fibrils.

Reticular fibres are argyrophil, reducing ammoniacal silver nitrate.

Reticulin is probably a precursor of collagen and its presence seems to denote a primitive condition in the tissue."

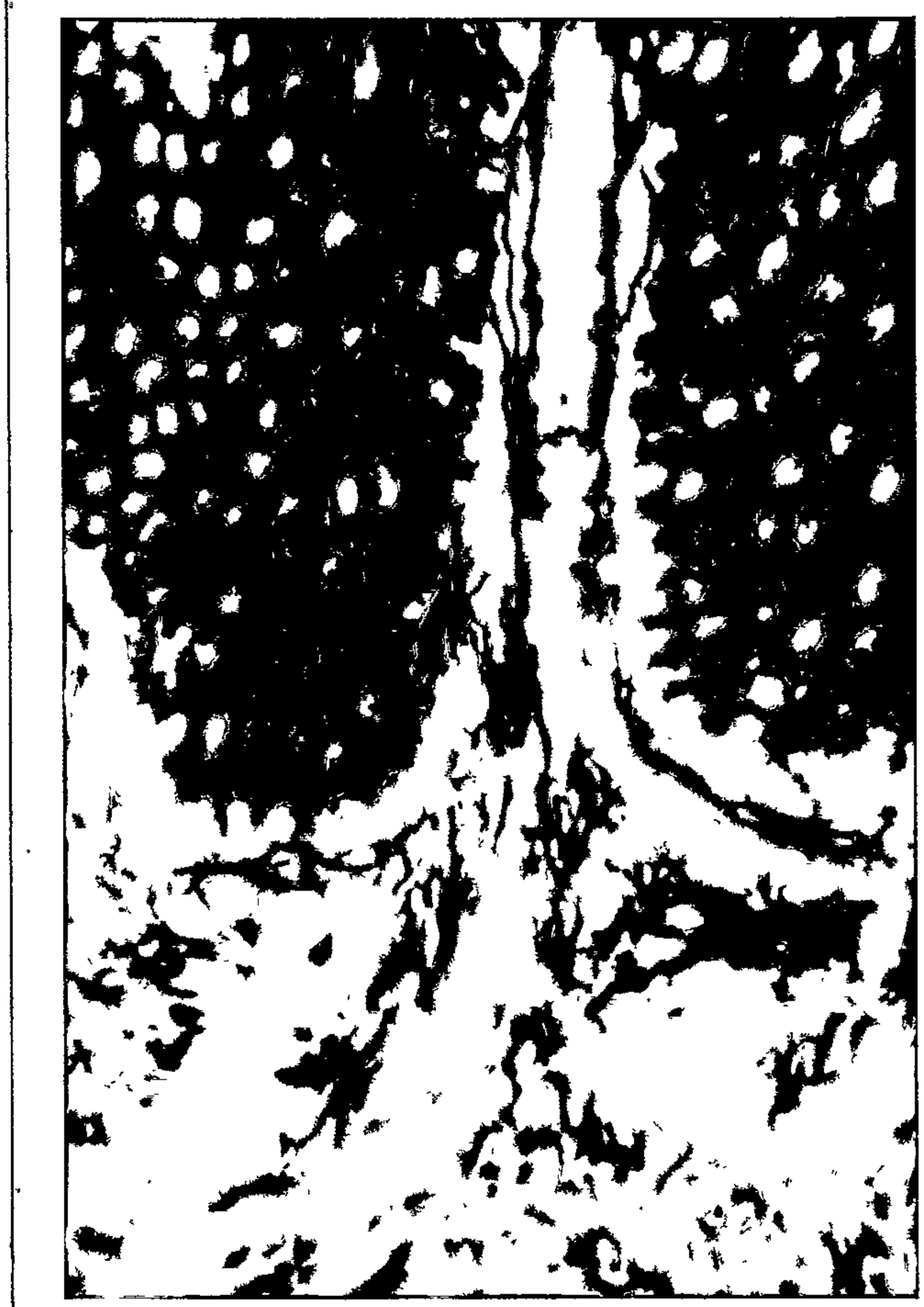

Fig. 5.

Fatty zone specimen demonstrating basal membrane clearly demarcated by reticulin. (Ammoniacal Silver Nitrate x400.)

How are reticular fibres distributed in palatal mucosa? To determine this, specimens which had been fixed in Bouin's solution were stained with ammoniacal silver nitrate. This stained the reticular fibres black. They were fine and usually wavy. Collagen fibres were contrasted a pale pink.

FATTY ZONE - RETICULAR FIBRES

1C
1F
1G The basal membrane was clearly demarcated by reticulin, a slight space separating it from the epithelium, (Fig. 5). The lamina propria was very dense with wavy reticular fibres, those between the rete pegs running parallel to them. The submucosa also contained numerous reticular fibres although in this case they appeared less concentrated than in the lamina propria. Some fat cell outlines could be seen in the submucosa. Some blood vessels were present also, with reticulin prominent in the walls.

GLANDULAR ZONE - RETICULAR FIBRES

19F
19G The basal membrane was demarcated by reticulin
19H with a very narrow space between it and the epithelium. The lamina propria contained many wavy reticular fibres with those between the rete pegs orientated normal to the surface. Some fat cells were visible in the submucosa, only the reticular outline being visible. More

Fig. 6.

Soft palate specimen demonstrating salivary glands, fat cells and striated muscle bundles, outlined by reticulin.
(Ammoniacal Silver Nitrate x400.)

prevalent however, were salivary glands distinguishable from the fat cells by the very pale grey staining material within the honeycomb outline. A good deal of reticular tissue was seen in the blood vessels. There were also other reticular fibres to be seen in the submucosa unrelated to these structures and perhaps more sparsely arranged than in the lamina propria.

SOFT PALATE - RETICULAR FIBRES

37F
37G
37H

The basal membrane was clearly demarcated by reticulin separated slightly from the basal layer of cells. The lamina propria contained many wavy reticular fibres which became parallel with the rete pegs as they ran into the papillae. In the submucosa (Fig. 6) a network of salivary glands was outlined by reticulin and contained the pale grey staining salivary tissue. A few fat cells also were observed. Of great interest were the striated muscle bundles. These were outlined whether in cross-section or longitudinal section by reticulin. That these structures were, in fact, muscle was confirmed by the presence of striations which could be clearly seen. These structures were observed in soft palate sections only. The remainder of the submucosa contained sparsely arranged reticular fibres.

GINGIVA ADJACENT FATTY ZONE - RETICULAR FIBRES

55C
55F
55G
The basal membrane was outlined by reticulin and stood free of the epithelial cells by about 5/u. The reticular tissue seemed in this case to provide a means of differentiating the lamina propria from the submucosa. Numerous dark stained fibres were visible immediately deep to the epithelium whereas pale-pink stained collagen predominated more deeply.

GINGIVA ADJACENT GLANDULAR ZONE - RETICULAR FIBRES

73F
73G
73H
The lamina propria, especially the papillae between the rete pegs, contained many reticular fibres. There was also much reticulin in the deeper submucosa although it was definitely less prominent than in the tissue immediately deep to the epithelium. The basal membrane was clearly demarcated by reticulin.

INCISIVE PAPILLA - RETICULAR FIBRES

91F
91G
91H
The reticular component of the basal membrane was stained black and could be traced around the base of the epithelium. The density of reticular fibres was greater in the deeper submucosa than in the zone immediately beneath the epithelium. There were reticular fibres in the papillae between the rete pegs but in this

case they seemed less prominent than the collagen. The reticular outlines of a few scattered fat cells were seen also.

MEDIAN RAPHÉ - RETICULAR FIBRES

109F
109G Reticular fibres were very conspicuous in
109H these sections. The basal membrane was clearly defined. Immediately deep to it were wavy silver stained fibres. Deeper these gave way to fat cells whose outlines were also silver stained. Finally, collagen almost free of reticulin was present in the deepest layer. Some blood vessels, with silver-stained endothelium and walls containing fragmented reticular fibres, were noted.

CONCLUSIONS

The distribution of reticular fibres in palatal mucosa can now be recorded. The various zones are listed in decreasing order of density of reticular fibres. The densities in the lamina propria and submucosa are also compared.

1
- FATTY ZONE
- Lamina propria - heavy
- Submucosa - moderate
- INCISIVE PAPILLA
- Lamina propria - moderate
- Submucosa - heavy

2
- GLANDULAR ZONE
- Lamina propria - moderate
- Submucosa - moderate
- SOFT PALATE
- Lamina propria - moderate
- Submucosa - moderate

3 GINGIVA ADJACENT
GLANDULAR ZONE

Lamina propria - heavy

Submucosa - slight

4 GINGIVA ADJACENT
FATTY ZONE

Lamina propria - moderate

Submucosa - slight

MEDIAN RAPHE

Lamina propria - moderate

Submucosa - slight

The sections confirm the belief of Montagna (1962) that reticular fibres either form the basement membrane or are a component part of it.