Digestive System:

Oral Cavity and Related Structures

The abdominal part of the alimentary canal (consisting of the stomach and intestines) is often referred to as the ***gastrointestinal tract***. Closely related to the alimentary canal there are several accessory organs that form part of the alimentary system. These include the structures of the oral cavity (lips, teeth, tongue, and salivary glands) and the liver and pancreas.

Oral Cavity

The wall of the oral cavity is made up partly of bone (jaws and hard palate), and partly of muscle and connective tissue (lips, cheeks, soft palate, and floor of mouth). These structures are lined by mucous membrane which is lined by stratified squamous epithelium that rests on connective tissue, similar to that of the dermis.

The epithelium differs from that on the skin in that it is not keratinized. Papillae of connective tissue (similar to dermal papillae) extend into the epithelium. The size of these papillae varies considerably from region to region. Over the alveolar processes (where the mucosa forms the gums), and over the hard palate, the mucous membrane is closely adherent to the underlying Periosteum. Elsewhere it is connected to underlying structures by loose connective tissue.

In the cheeks, this connective tissue contains many elastic fibers and much fat (specially in children).

The Lips

Lips are fleshy folds which on the 'external' surface are lined by skin, and on 'internal' surface are lined by mucous membrane.

The substance of each lip (upper or lower) is predominantly muscular (skeletal muscle) (Fig. 15.1).

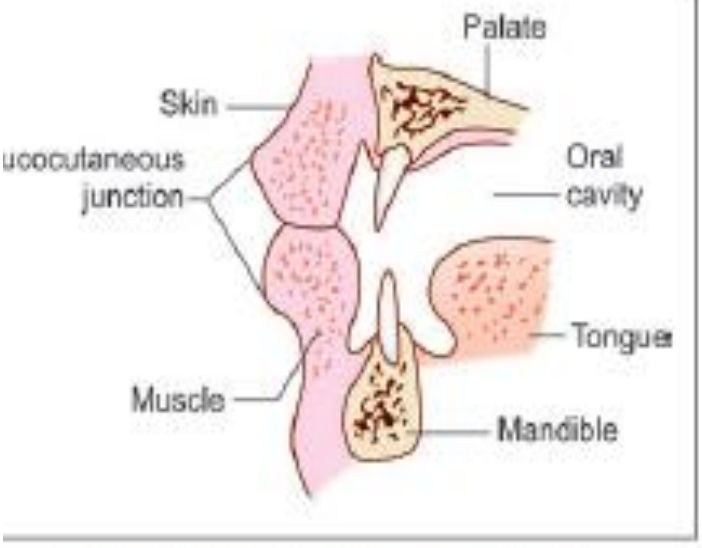


Fig. 15.1: Some relationships of the lips (Schematic representation)

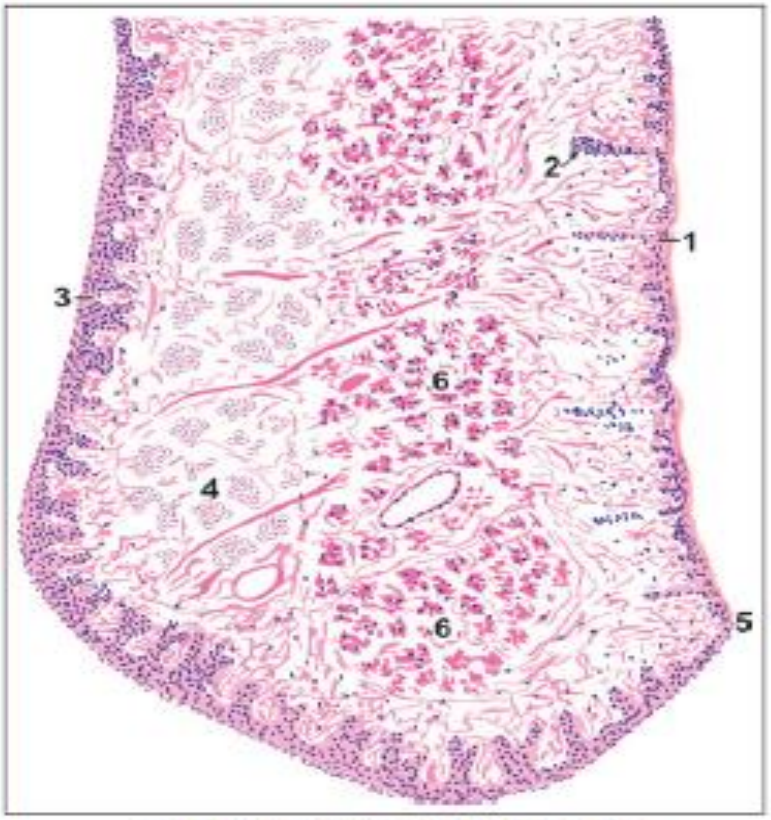
The upper and lower lips close along the red margin which represents the ***Muco-cutaneous junction***. There is a transitional zone between the skin and mucous membrane which is sometimes referred to as the ***vermilion***, because of its pink colour in fair-skinned individuals. This part meets the skin along a distinct edge.

The ‘external’ surface of the lip is lined by true skin in which hair follicles and sebaceous glands can be seen.

The mucous membrane is lined by stratified squamous non-keratinized epithelium (Plate 15.1). This epithelium is much thicker than that lining the skin (specially in infants). The epithelium has a well-marked ***rete ridge system***. The term rete ridges is applied to fingerlike projections of epithelium that extend into underlying connective tissue, just like the epidermal papillae. This arrangement anchors the epithelium to underlying connective tissue, and enables it to withstand friction. A similar arrangement is seen in the mucosa over the palate.

Subjacent to the epithelium the mucosa has a layer of connective tissue (corresponding to the dermis), and a deeper layer of loose connective tissue. The latter contains numerous mucous glands. Sebaceous glands, not associated with hair follicles, may be present. Their secretions prevent dryness and cracking of the exposed part of the mucosa.

PLATE 15.1: Longitudinal Section through the Lip



Longitudinal Section through the Lip as seen in drawing

- The substance of the lip is formed by a mass of muscle.
- Each lip has an 'external' surface covered by skin and an 'internal' surface lined by mucous membrane.
- There is a transitional zone between the skin and mucous membrane known as vermilion border.

Key

1. Outer surface covered by skin (keratinised epithelium)
2. Hair follicle
3. Inner surface (mucosa) covered by stratified squamous non-keratinised epithelium
4. Glands
5. Junction of skin and mucosa
6. Bundles of skeletal muscle

Clinical Correlation

--**Fordyce’s granules:** Fordyce’s granules are symmetric, small, light yellow macular spots on the lips and buccal mucosa and represent collections of sebaceous glands. Fordyce spots are benign (not cancerous).

--**Pyogenic granuloma:** This is an elevated, bright red swelling of variable size occurring on the lips, tongue, buccal mucosa and gingiva. It is a vasoproliferative inflammatory lesion. ***Pregnancy tumour*** is a variant of pyogenic granuloma. It is a benign (noncancerous)

The Tongue

The tongue lies in the floor of the oral cavity. It has a dorsal surface that is free; and a ventral surface that is free anteriorly, but is attached to the floor of the oral cavity posteriorly. The dorsal and ventral surfaces become continuous at the lateral margins, and at the tip (or apex) of the tongue.

Near its posterior end the dorsum of the tongue is marked by a V-shaped groove called the ***Sulcus Terminalis*** (Fig. 15.5).

The apex of the 'V' points backwards and is marked by a depression called the ***foramen caecum***.

The limbs of the sulcus terminalis run forwards and laterally. The sulcus terminalis divides the tongue into a larger (2/3) anterior, or oral part; and a smaller (1/3) posterior, or pharyngeal part. The substance of the tongue is made up chiefly of skeletal muscle supported by connective tissue (Plate 15.2). The muscle is arranged in bundles that run in vertical, transverse and longitudinal directions. This arrangement of muscle permits intricate movements of the tongue associated with the chewing and swallowing of food, and those necessary for speech. The substance of the tongue is divided into right and left halves by a connective tissue septum.

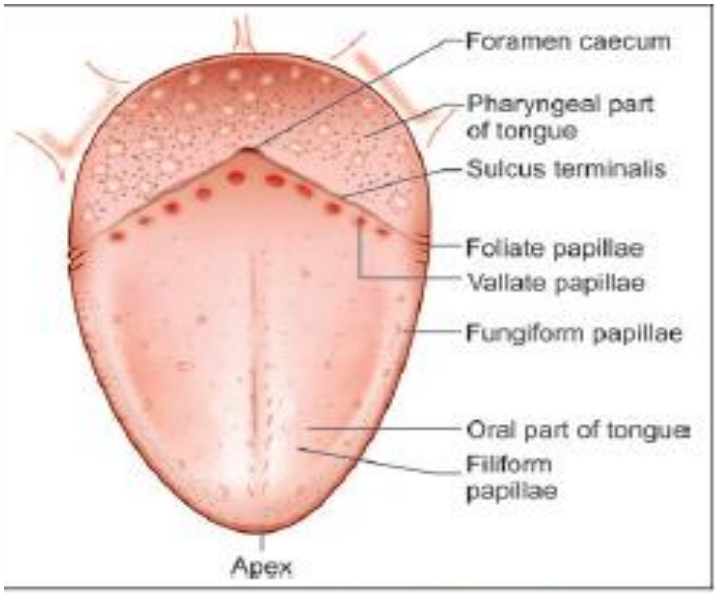


Fig. 15.5: Dorsal surface of the tongue (Schematic representation)

The surface of the tongue is covered by mucous membrane lined by stratified squamous epithelium. The epithelium is supported by a layer of connective tissue. On the undersurface (ventral surface) of the tongue the mucous membrane resembles that lining the rest of the oral cavity, and the epithelium is not keratinized.

The mucous membrane covering the dorsum of the tongue is different over the anterior and posterior parts. Over the part lying in front of the sulcus terminalis the mucosa bears numerous projections or ***papillae***.

Papillae

Each papilla consists of a lining of epithelium and a core of connective tissue. The epithelium over the papillae is partially keratinised (parakeratinised).

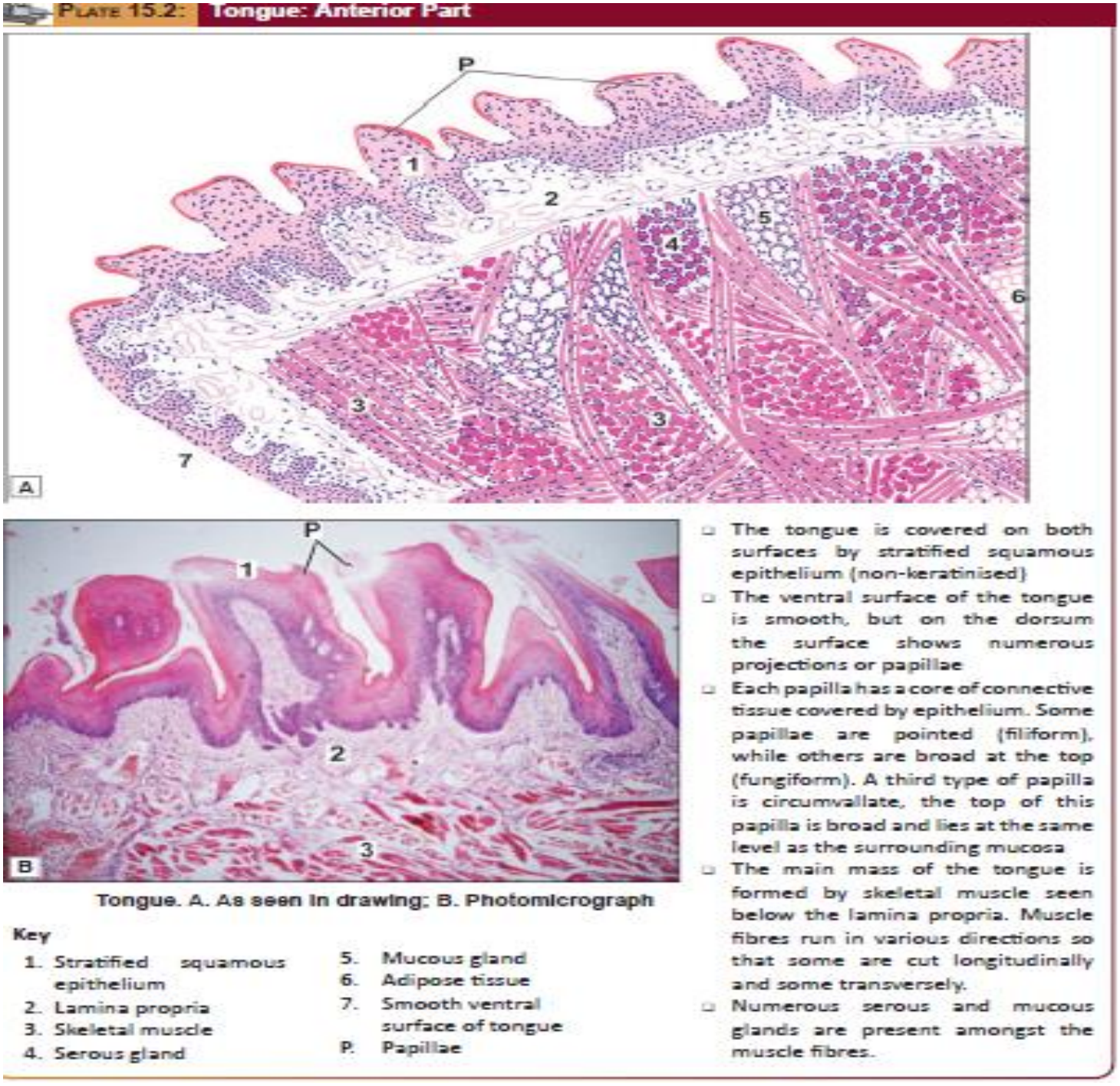
The papillae are of various types (Fig. 15.6):

1. **Filiform papillae:** They are the most numerous papillae. They are small and conical in shape. The epithelium at the tips of these papillae is keratinized. It may project in the form of threads.

2. **Fungiform papillae:** At the apex of the tongue and along its lateral margins there are larger fungiform papillae with rounded summits and narrower bases. Fungiform papillae bear taste buds. In contrast to the filiform papillae the epithelium on fungiform papillae is not keratinized.
3. **Circumvallate papillae*:*** These are the largest papillae of the tongue. They are arranged in a row just anterior to the sulcus terminalis. When viewed from the surface each papilla is seen to have a circular top demarcated from the rest of the mucosa by a groove.

   In sections through the papilla it is seen that the papilla has a circumferential 'lateral wall' that lies in the depth of the groove (Fig. 15.6 and Plate 15.3). Taste buds are present on this wall, and also on the 'outer' wall of the groove.

4. **Foliate papillae**: These are rudimentary in man. They can be seen along the posterior part of lateral margin of tongue.



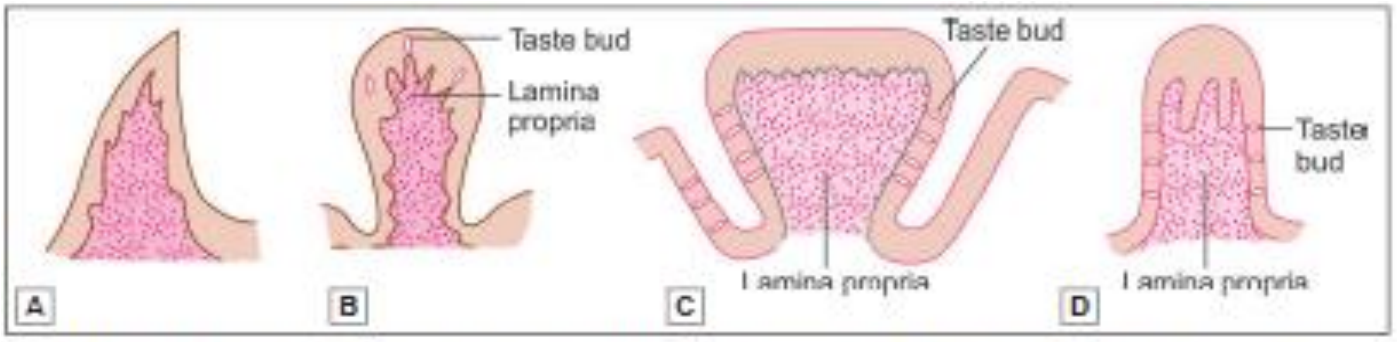
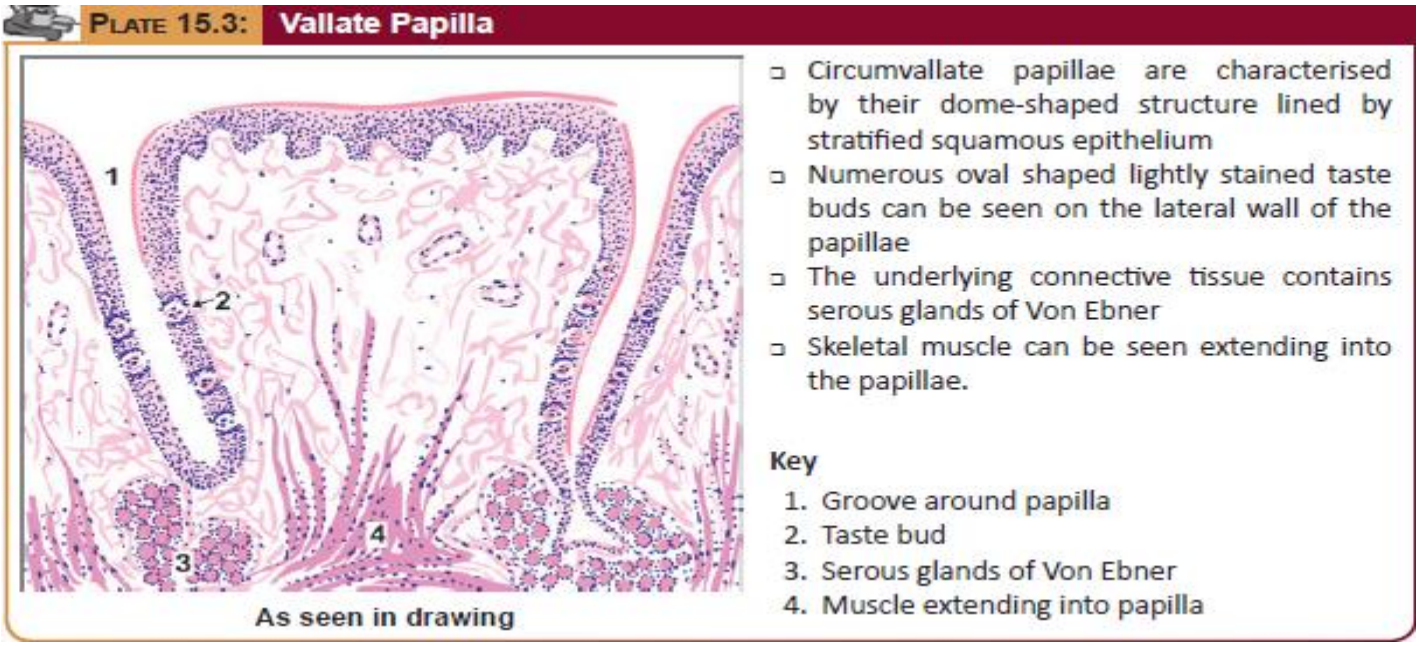


Fig. 15.6: Papillae, A. Filiform; B. Fungiform; C. Circumvallate; D. Foliate (Schematic representation)

Note: Another variety of papilla sometimes mentioned in relation to the tongue is the ***papilla simplex***. Unlike the other papillae which can be seen by naked eye, the papillae simplex are microscopic and are quite distinct from other papillae. They are not surface projections at all, but are projections of subjacent connective tissue into the epithelium. In other words these papillae are equivalent to dermal papillae of the skin.

Note: The mucous membrane of the posterior (pharyngeal) part of the dorsum of the tongue bears numerous rounded elevations that are quite different from the papillae described above. These elevations are produced by collections of lymphoid tissue present deep to the epithelium which are collectively called the **Lingual Tonsil**.



Mucous and serous glands: Numerous mucous and serous glands are present in the connective tissue deep to the epithelium of the tongue. Mucous glands are most numerous in the pharyngeal part, in relation to the masses of lymphoid tissue. They open into recesses of mucosa that dip into the masses of lymphoid tissue. The serous glands are present mainly in relation to circumvallate papillae, and open into the furrows surrounding the papillae.

Serous glands also open in the vicinity of other taste buds. It is believed that the secretions of these glands dissolve the substance to be tasted and spread it over the taste bud; and wash it away after it has been tasted.

The largest glands in the tongue are present on the ventral aspect of the apex. They contain both mucous and serous acini and are referred to as the ***anterior lingual glands***.

Taste Buds

Taste buds are present in relation to Circumvallate papillae, to fungiform papillae, and to leaf-like folds of mucosa (***folia linguae***) present on the posterolateral part of the tongue. Taste buds are also present on the soft palate, the epiglottis, the palatoglossal arches, and the posterior wall of the oropharynx.

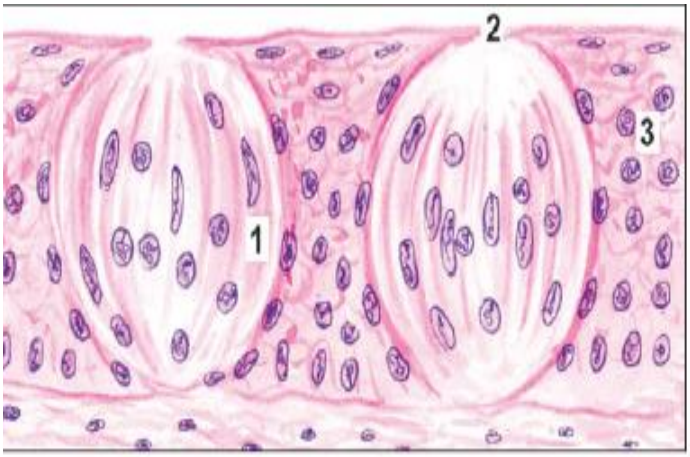


Fig. 15.7: Taste buds. 1–elongated cells; 2–pore; 3–stratified squamous epithelium; (Schematic representation)

Each taste bud is a piriform structure made up of modified epithelial cells (Fig. 15.7). It extends through the entire thickness of the epithelium. Each bud has a small cavity that opens to the surface through a ***gustatory pore***. The cavity is filled by a material rich in polysaccharides.

The cells present in taste buds are elongated and are vertically orientated, those towards the periphery being curved like crescents (Fig. 15.8). Each cell has a central broader part containing the nucleus, and tapering ends. The cells are of two basic types. Some of them are ***receptor cells*** or ***gustatory cells***. Endings of afferent nerves end in relation to them. Other cells perform a supporting function and are called ***supporting cells***.

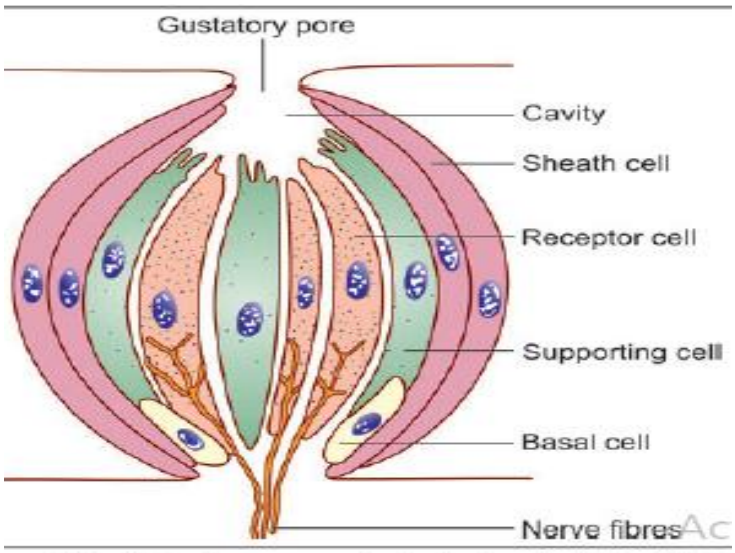


Fig. 15.8: Arrangement of cells in a taste bud (Schematic representation)

Note: Supporting cells are probably of three types. Some of them that lie at the periphery of the taste bud form a sheath for it. Those near the center of the bud are truly supporting. They probably secrete a material that fills the cavity at the apex of the taste bud. Microvilli are often present at the tips of these cells. A third variety of supporting cell is seen in the basal part of the bud. These basal cells multiply and produce new supporting and receptor cells to replace those that are worn out. This may be correlated with the fact that cells of taste buds have a short life and are continuously being replaced.

Recognition of Various Tastes by Tongue

It has been held that taste buds in different parts of the tongue may respond best to particular modalities of taste. However, it is now known that the same taste bud can respond to different types of taste (sweet, sour, salt and bitter) and that taste is a complicated sensation depending upon the overall pattern of responses from taste buds all over the tongue. With this reservation in mind, we may note that sweet taste is best appreciated at the tip of the tongue, salt by the area just behind the tip and along the lateral border, and bitter taste by circumvallate papillae.

Clinical Correlation

Fissured Tongue

It is a genetically-determined condition characterised by numerous small furrows or grooves on the dorsum of the tongue.

Hairy Tongue

In this condition, the filiform papillae are hypertrophied and elongated. These 'hairs' (papillae) are stained black, brown or yellowish-white by food, tobacco, oxidising agents or by oral flora.

Salivary Glands

There are two main groups of salivary glands—major and minor. The major salivary glands are the three paired glands: parotid, submandibular and sublingual. The parotid glands are located laterally to the mandibular ramus and its main duct drains into the oral cavity opposite the second maxillary molar. The submandibular glands are present in the floor of the mouth, superior to digastric muscles. The sublingual gland lie anterior to submandibular glands. The ducts of submandibular and sublingual glands empty in the floor of the mouth.

The minor salivary glands are numerous and are widely distributed in the mucosa of oral cavity. Some of the minor salivary glands are the Von Ebner's gland in tongue, buccal glands in cheeks and labial glands in lips.

The secretions of these glands help to keep the mouth moist, and provide a protective and lubricant coat of mucous. Some enzymes (amylase, lysozyme), and immunoglobulin IgA are also present in the secretions.

Structural organisation

Basically, a salivary gland consists of stroma, parenchyma and a duct system which carries the secretions into the oral cavity.

Stroma

I. -The stroma consists of connective tissue capsule and septa.
II. -Numerous septa arise from the capsule and enter the parenchyma of the gland, dividing the gland into numerous lobules.
III. -These septa bring the blood vessels and nerves into the gland. Large ducts of the glands are also present in it.

Parenchyma

Parenchyma has two components: the secretory part and conducting part.

Secretory Part

Salivary glands are compound tubuloalveolar glands (racemose glands). Their secretory elements (also referred to as **End pieces** or as the **Portio terminalis**) may be rounded (acini), pear shaped (alveoli), tubular, or a mixture of these (tubuloacinar, tubuloalveolar).

The secretory elements lead into a series of ducts through which their secretions are poured into the oral cavity.

In sections through salivary glands we see a large number of closely packed acini with ducts scattered between them (Plates 15.3, 15.4 and 15.6). These elements are supported by connective tissue that also divides the glands into lobules, and forms capsules around them.

Blood vessels, lymphatics and nerves run in the connective tissue that may at places contain some adipose tissue.

The acini are made up of either ***serous*** or ***mucous*** cells.

A salivary gland may have only one type of acini or there may be a mix of both serous and mucous acini, these are called mixed acini. A secretory unit, or gland, with only one type of cell (serous or mucous) is said to be **Homocrine**. If it contains more than one variety of cells it is said to be **Heterocrine**.

Myoepithelial Cells

Myoepithelial cells are present in relation to acini and Intercalated ducts of salivary glands. They may also be seen in relation to larger ducts (intralobular and extralobular). These cells lie between the epithelial cells and their basement membrane. The myoepithelial cells located on acini are often branched (stellate) and may form 'baskets' around the acini. Those located on the ducts are fusiform and run longitudinally along them.

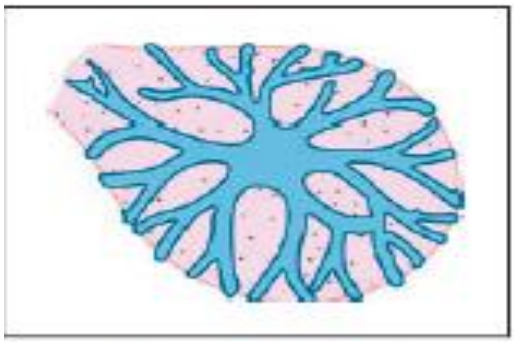


Fig. 15.9: Surface view of an acinus showing myoepithelial cell. Its processes form a basket around the acinus (Schematic representation)

Conducting Part:

Duct System

Secretions produced in acini pass along a system of ducts, different parts of which have differing structure. The smallest ducts are called **Intercalated ducts**. These are lined by cuboidal or flattened cells. Intercalated ducts open into **Striated ducts** lined by columnar cells.

They are so called because the basal parts of the cells show vertical striations. Both intercalated and striated ducts are intra-lobular ducts. Striated ducts open into ***excretory ducts*** (interlobular) that are lined by simple columnar epithelium.

Clinical Correlation

Sialorrhoea (Ptyalism) : Increased flow of saliva is termed sialorrhoea or ptyalism.

Xerostomia : Decreased salivary flow is termed xerostomia.

Sialadenitis : Inflammation of salivary glands is called as sialadenitis.

Tumours of Salivary Glands

Pleomorphic adenoma (mixed salivary tumour): It is the most common tumour of major and minor salivary gland. It is characterised by pleomorphic or mixed appearance in which there are epithelial elements present in a matrix of mucoid, myxoid and chondroid tissue. It is benign salivary gland tumor.

Mucoepidermoid carcinoma: It is the most common malignant salivary gland tumour. The tumour is composed of combination of 4 types of cells: mucin-producing, squamous, intermediate and clear cells.
Well-differentiated tumours have predominance of mucinous cells, while poorly differentiated have more solid and infiltrative pattern.

Cells of Salivary Glands

Serous Cells

Serous cells are usually arranged in the form of rounded acini. As a result each cell is roughly pyramidal having a broad base (towards the basement membrane) and a narrow apex (towards the lumen) (Fig. 15.10). Some microvilli and pinocytotic vesicles are seen at the apex of the cell. The lumen of the acinus often extends for some distance between adjacent cells: these extensions are called ***Intercellular Secretory Canaliculi***. Deep to these canaliculi the cell membranes of adjoining cells are united by tight junctions. Deep to these junctions, the lateral cell margins show folds that **interdigitate** with those of adjoining cells. The apical cytoplasm contains secretory granules that are small, homogeneous, and electron dense. The cytoplasm also contains a prominent Golgi complex and abundant rough endoplasmic reticulum, both features indicating considerable synthetic activity.
Mitochondria, lysosomes, and microfilaments are also present.

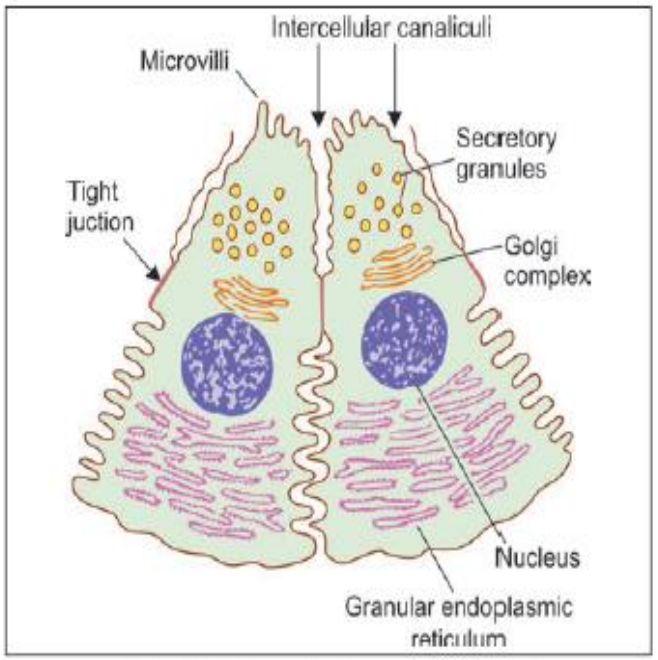


Fig. 15.10: Some features of serous cell in a salivary gland (Schematic representation)

Mucous Cells

Mucous cells are usually arranged in the form of tubular secretory elements (Fig. 15.11). Crescents present in relation to them are located at the ends of the tubules. The cells lining mucous cells tend to be columnar rather than pyramidal. Their secretory granules are large and ill defined. Rough endoplasmic reticulum and Golgi complex are similar to those in serous cells, but microvilli, foldings of plasma membrane, and intercellular canaliculi are not usually seen.

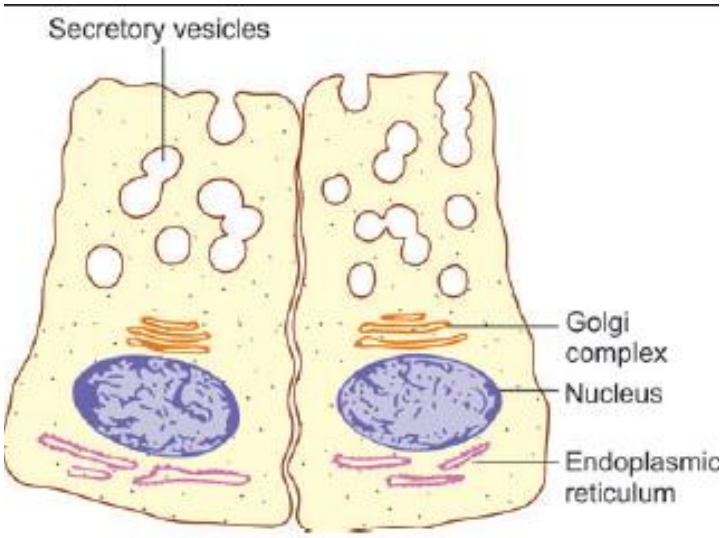


Fig. 15.11: Some features of mucous cells in salivary glands (Schematic representation)

Seromucous Cells

From the point of view of ultrastructure many cells of salivary glands are intermediate between serous and mucous cells. They are referred to as ***seromucous cells***. Most of the cells identified as serous with light microscopy in the parotid and submandibular glands are really seromucous.

The secretions of all types of salivary secretory cells contain protein carbohydrate complexes.

Their concentration is lowest in cases of serous cells, very high in mucous cells, and with widely differing concentrations in seromucous cells.

In the submandibular glands mucous acini are often capped by serous demilunes. The serous cells of a demilune drain into the lumen of the acinus through fine canaliculi passing through the intervals between mucous cells.

With the EM myoepithelial cells are seen to contain the usual organelles. In addition they have conspicuous filaments that resemble myofilaments of smooth muscle cells. These filaments are numerous in processes arising from the cell. Cilia are present on some myoepithelial cells. It has been suggested that the cilia may subserve a sensory or chemoreceptor function.

Myoepithelial cells are contractile, their contraction helping to squeeze out secretion from acini.

The cells lining the striated ducts show an interesting ultrastructure (Fig. 15.12). Their basal striations are seen to be due to the presence of numerous deep infoldings of the basal parts of the cell membranes. Numerous elongated mitochondria are present in the intervals between the folds. Similar cells are also present scattered in the epithelium of the excretory ducts. These cells are believed to play a role in regulating the water and electrolyte content of saliva to make it hypotonic.

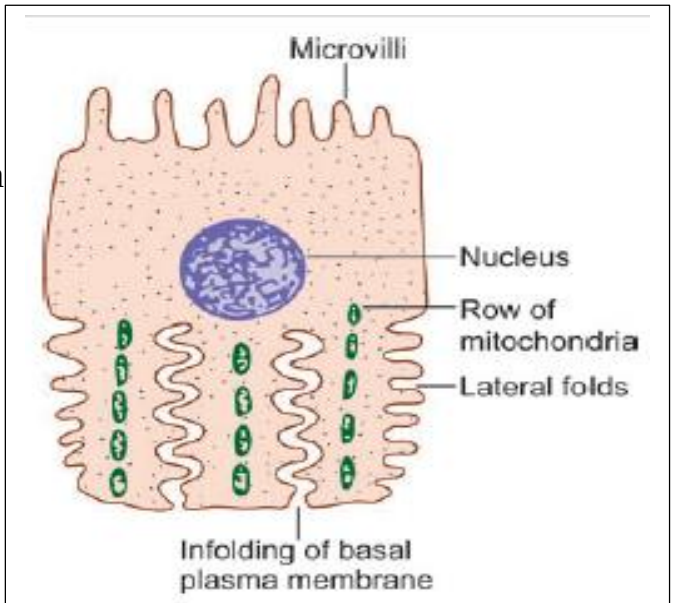


Fig. 15.12: Electron microscopic structure of a cell from striated duct (Schematic representation)

Immunoglobulin A, produced by plasma cells lying subjacent to the epithelium, passes into saliva through the cells lining the striated ducts.

Innervation of Salivary Glands

Secretion by salivary glands is under hormonal as well as neural control. A local hormone **Plasma-kinin** formed by secretory cells influences vasodilation. Salivary glands are innervated by autonomic nerves, both parasympathetic (cholinergic) and sympathetic (adrenergic).

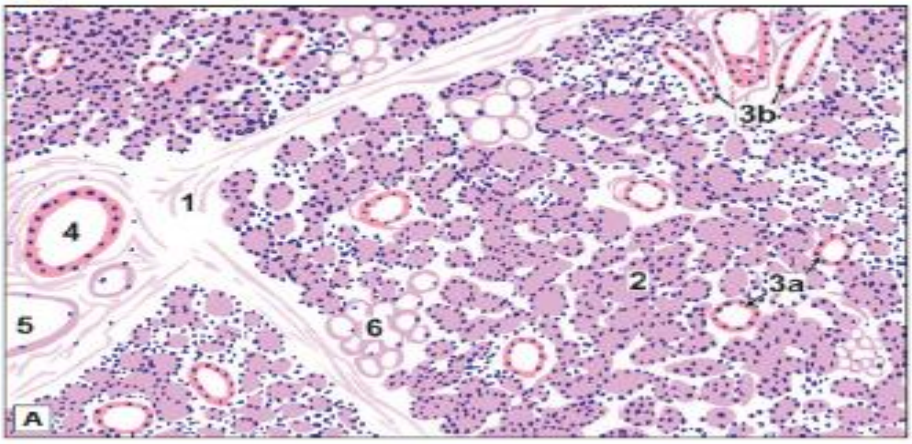
Parasympathetic nerves travel to secretory elements along ducts, while sympathetic nerves travel along arteries. Synaptic contacts between nerve terminals and effector cells form **Neuro-effector junctions**.

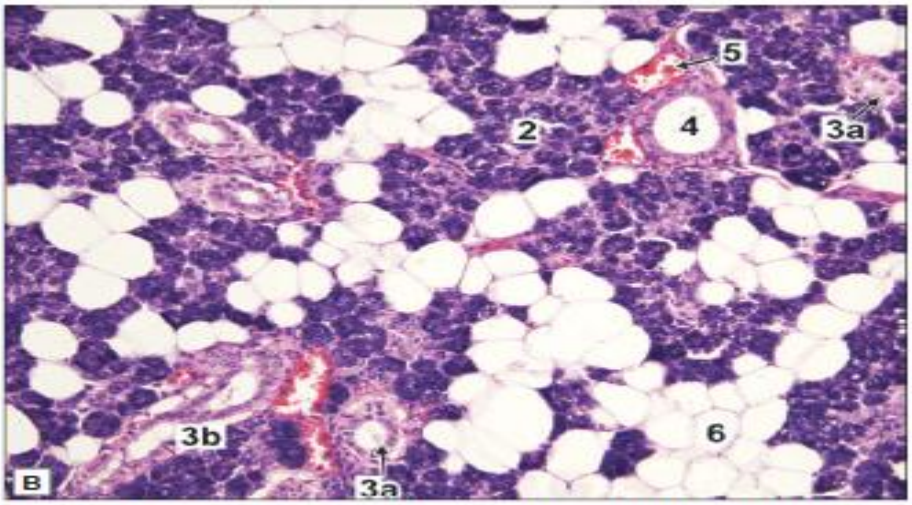
Two types of junction, **Epilemmal** and **Hypolemmal**, are present. At epilemmal junctions the nerve terminal is separated from the secretory or effector cell by the basal lamina. At hypolemmal junctions the nerve terminal pierces the basal lamina and comes into direct contact with the effector cell.

Nerve impulses reaching one effector cell spread to others through intercellular contacts. Classically, salivary secretion has been attributed to parasympathetic stimulation. While this is true, it is believed that sympathetic nerves can also excite secretion either directly, or by vasodilation.

Autonomic nerves not only stimulate secretion, but also appear to determine its viscosity and other characteristics. Autonomic nerve terminals are also seen on myoepithelial cells and on cells lining the ducts of salivary glands. The latter probably influence reabsorption of sodium by cells lining the ducts. Salivary glands are sensitive to pain, and must therefore have a sensory innervation as well.

Plate 15.4: Parotid Gland





Parotid gland. A. As seen in drawing; B. Photomicrograph

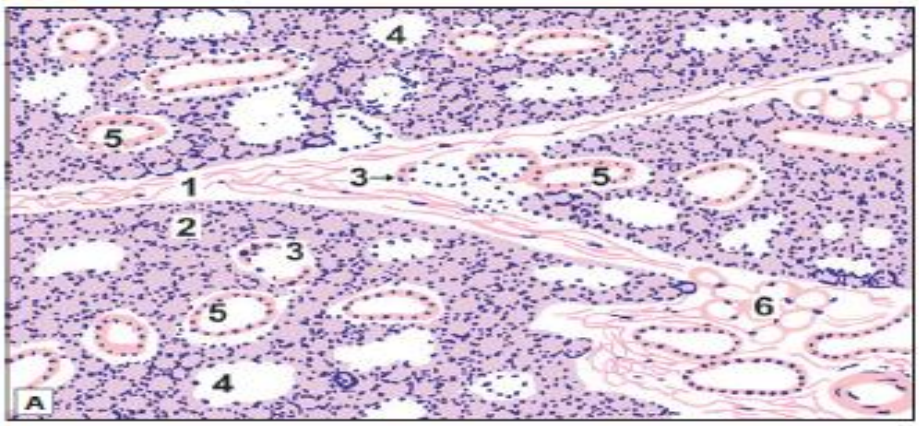
The parotid gland is a serous salivary gland. The characteristic features are:

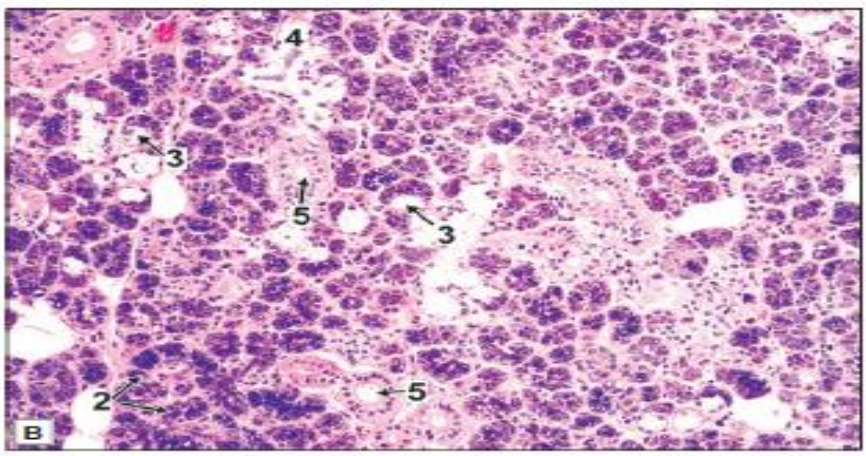
- Only serous acini are present which contain basophilic zymogen granules and are darkly stained
- Intercalated and striated (Intralobular) ducts are seen
- Interlobular duct can be seen
- It also contains adipocytes.

Key

1. Interlobular connective tissue septum
2. Serous acini
3. Intralobular duct
   a. Intercalated duct
   b. Striated duct
4. Interlobular duct
5. Blood vessel
6. Adipose tissue

Plate 15.5: Submandibular Gland





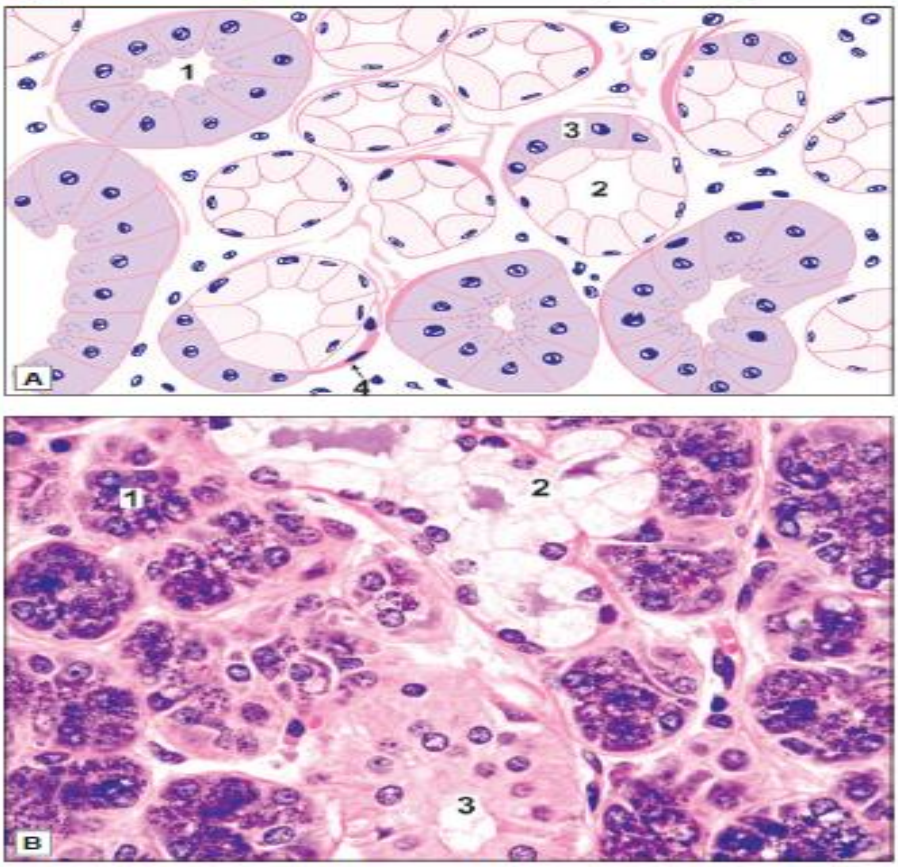
Submandibular gland (low magnification). A. As seen in drawing; B. Photomicrograph

- The submandibular gland is a mixed salivary gland, predominantly serous with a few mucous acini
- Serous cells are frequently located at the periphery of mucous acini in the form of a crescent and called as demilunes
- Striated ducts are more prominent than those in parotid gland.

Key

1. Interlobular connective tissue septum
2. Serous acini
3. Mucous acini with serous demilune
4. Mucous acini
5. Intralobular duct
6. Adipose tissue

Plate 15.6: Submandibular Gland (High Magnification)



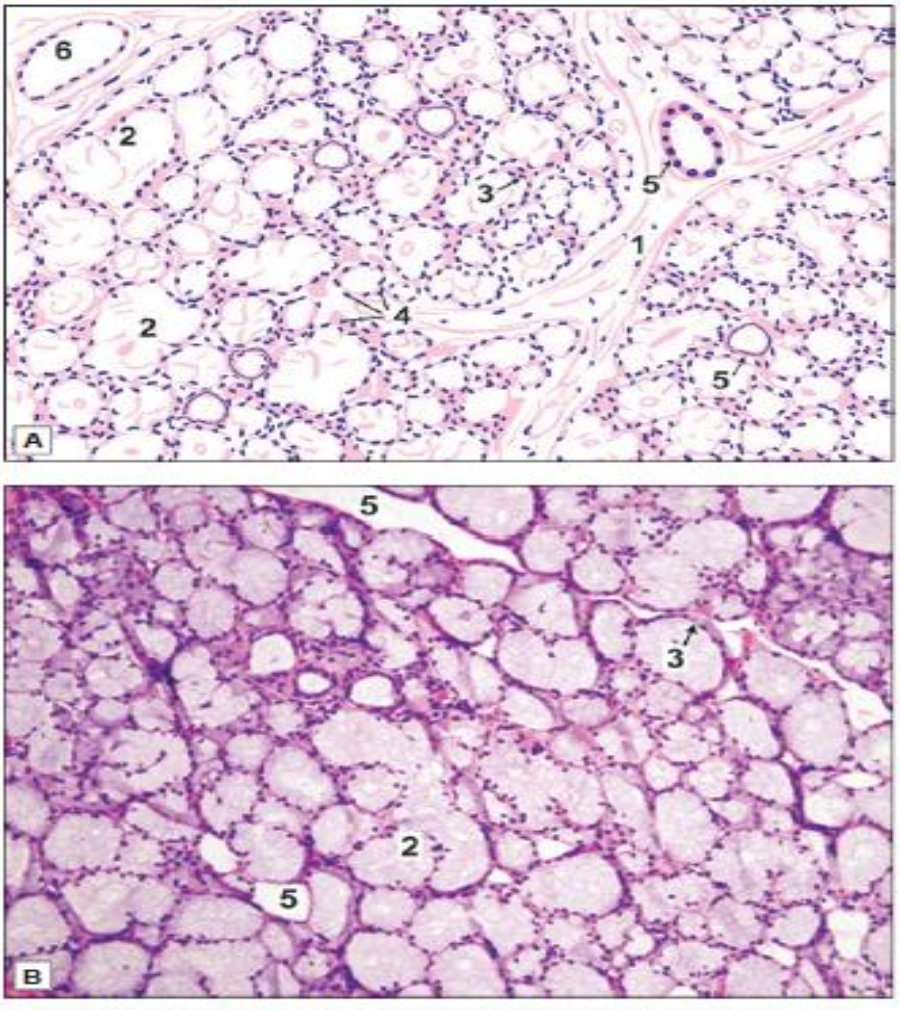
Submandibular gland (high magnification). A. As seen in drawing; B. Photomicrograph

- In the high power view the serous and mucous acini can be identified by their staining reaction, and shape and position of nucleus
- The serous acini are darkly stained and have rounded nucleus placed near the centre of the cell
- The mucous acini are lightly stained with flat nucleus placed towards the basement membrane
- The mucous acini are often associated with darkly stained crescentic patch of serous cells called serous demilune.

Key

1. Serous acini
2. Mucous acini
3. Serous demilune
4. Myoepithelial cells

Plate 15.7: Sublingual Gland



Sublingual gland. A. As seen in drawing; B. Photomicrograph

- The sublingual gland is predominantly a mucous gland but few serous acini may also be seen
- Serous demilunes may be present

Key

1. Interlobular septum
2. Mucous acini
3. Serous demilune
4. Serous acini
5. Duct
6. Capillary