

# Digestive System

University of Jordan  
Faculty of Medicine  
Batch of 2013-2019



Slide  Sheet  Handout  Other

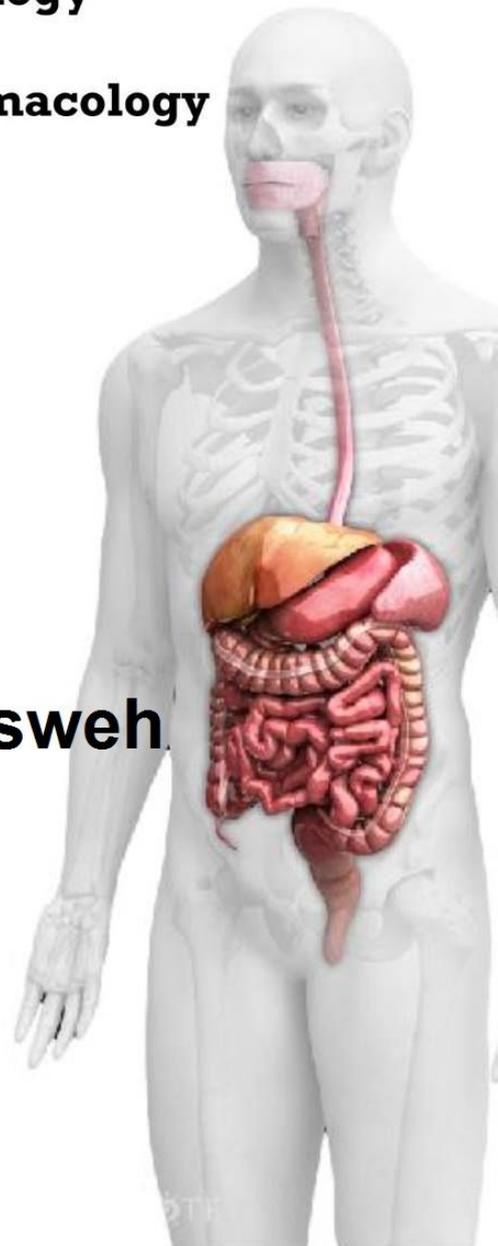
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**Sheet #: 1**

**Done by: Yara N. Anasweh**

**Date:**

**Price:**



# Histology of the G.I.

## (Histology of the oral cavity)

In this lecture we will start with a brief introduction to the GI system then we'll continue with the histology part. This lecture and all the upcoming lectures in this system will be longer and they will be more condensed than the MSS lectures.

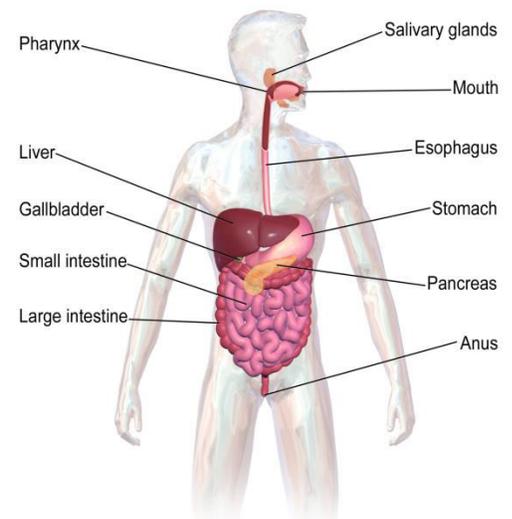
The doctor didn't mention some of the information in this sheet but they were mentioned in the slides.

I tried my best to make this lecture easy for memorization but you have to be patient since the sheet is really really realllllly مليانة ☹️ and always remember nothing lasts forever (اخرتها تخلص) :P

بسم الله نبداً ...

### An introduction to the digestive system:

- #What is the digestive system?!
- 1- The GI tract (The alimentary canal): This is the organ system that includes all structures between the mouth (oral cavity) and the anus → {oral cavity, pharynx, esophagus, stomach, small and large intestines, rectum, and anus}.
- 2- The association organs (accessory organs) which are: The liver, the gallbladder, the



The Components of the Digestive System

pancreas, the salivary glands; small and large (the submandibular gland, the parotid gland and the sublingual gland).

# **functions of the digestive system:**

1- **Digestion** → conversion of complicated materials (Carbohydrates, fats and proteins) into absorbable simple materials (glucose, fatty acids and amino acids).

2- **absorption** of these small molecules as well as water, minerals and vitamins. Then they will reach the liver in order to be metabolized and produce the energy needed for growth and other body functions (maintenance).

- Why the liver!!!! Because it's the site of metabolism and storage of energy producing materials (ex: glycogen), also it produces some hormones, enzymes and coagulative materials (we will discuss that later when we study the liver).

3- **Getting rid of the waste products:**

A- Waste products gather in **the colon** which removes water, salt, and some nutrients forming stool/feces.

B- **The rectum** will act as a reservoir for the stool.

C- The stool reaches **the anal canal** for defecation.

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**The objectives of studying the histology of the digestive tract:**

- 1- **Describe the cells of the GI tract and their function:** you will notice that the cellular composition of each organ or part of the gastrointestinal tract differs from the other parts. Let's take the liver as an example, the liver cells are called **hepatocytes** and as we all know most of the

metabolic activities occur in the liver as well as the formation of bile and detoxification of toxic materials, so these cells have characteristics in order to accomplish all the functions related to the liver.

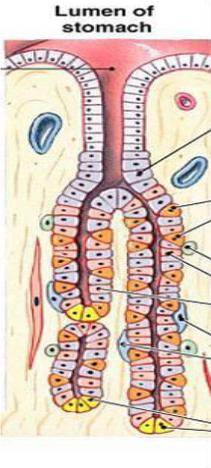
-Now if you look at the cellular composition of the stomach you will find four major types of cells:

A- Parietal cells which secretes the HCL.

B- Pepsinogen (chief) cells which secretes the pepsinogen.

C- Mucous cells which secretes mucous :P

D-Gastrin cells (G-cells) endocrine cells that secretes gastrin hormone.



Cell Types	Substance Secreted
Mucous neck cell	Mucus (protects lining)
	Bicarbonate
Parietal cells	Gastric acid (HCl)
	Intrinsic factor (Ca++ absorption)
Enterochromaffin-like cell	Histamine (stimulates acid)
Chief cells	Pepsin(ogen)
	Gastric lipase
D cells	Somatostatin (inhibits acid)
G cells	Gastrin (stimulates acid)

➤ What you need to know for now is that each part has its own cellular components; which means a specific function {Type-function relationship}.

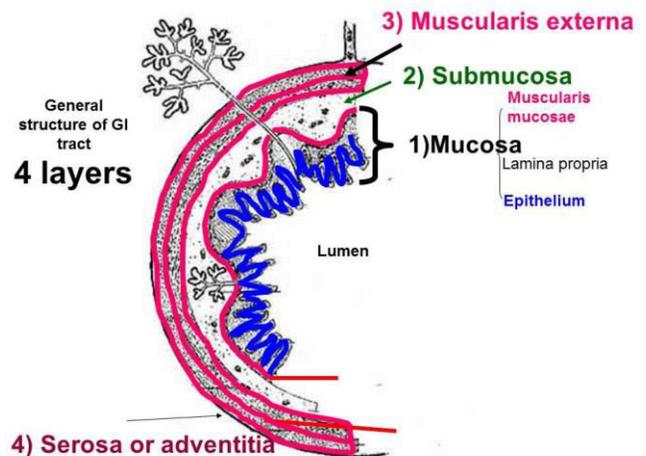
2- Describe the histological features of each part of the GI tract: you will notice that in general the GI tract is composed of four types of layers: (details will be mentioned later on):

A-Mucosa.

B- Submucosa.

C- Muscularis externa.

D- Adventitia / Serosa.



Notice that each part of the GI tract has

its own histological structure, for example the oral cavity lining is made of non-keratinized squamous stratified epithelium (In addition to the pharynx and the esophagus). -Remember the skin is keratinized squamous stratified epithelium-

Now as we move through the stomach, the small and the large intestines we will notice that the lining becomes simple columnar epithelium until we reach the anal canal and the rectum which are lined with non-keratinized stratified squamous epithelium (because there's some kind of friction especially in the anal canal) and at the opening of the anal canal we will find hair follicles that will later on turn into keratinized cells.

- 3- **Differentiate between different parts of the GI tract.** Ex: the peptic ulcer is common in the duodenum (mainly the first part) where there are several glands (Brunner's gland) in the submucosa of the duodenum for protection (this statement will be explained later on).
- 4- **Appreciate the histopathology of the GI tract:** we study the normal histology of the GI tract in order to understand the pathological issues. For example if a patient comes with a stomach ulcer we always assume it is cancer of the stomach :O until it's proven otherwise. (Peptic ulcer for example).

✚ **Extra explanation (the doctor didn't mention this):** the stomach ulcers are very rare and in most cases if they present they will transform into cancer unlike the duodenal ulcers which occur commonly and rarely transform into cancer.

-we need to know the normal histology of the organ so when we take the biopsy we will be able to identify any abnormalities in the tissue.

- 5- Describe the histological basis of some clinical problems: for example we will study how smoking affects the stomach by causing cancers, as well as ischemia which will eventually cause gastritis and ulcers.

## **# General histological structure and characteristics of the Digestive Tract:**

- As mentioned previously the GI tract is generally composed of four main layers :
  - A-Mucosa.
  - B- Submucosa.
  - C- Muscularis externa.
  - D- Adventitia / Serosa.

Now let's study each layer independently:

### **A. Mucosa.**

**Three parts:**

**1-Lining Epithelium.**

**2-Lamina Propria.**

**3-Muscularis Mucosae.**

#### **1) Lining epithelium :**

- i. The upper part of GI tracts is lined with stratified squamous non-keratinized epithelium (oral cavity, pharynx and the esophagus).
- ii. The stomach, small and large intestines are lined with simple columnar epithelium.
- iii. The rectum and the anal canal are lined with stratified squamous non-keratinized epithelium, **WHY!!!!**

= in sites of friction in the GI tract (rectum, anal canal and oral cavity) we need mitosis (regeneration) and it occurs rapidly in stratified squamous epithelium, and a typical injury takes around 6 hours to regenerate.

## 2) Lamina Propria:

- Loose connective tissue.
- Rich in blood and lymph vessels and nerves and smooth muscle cells.
- Sometimes containing glands in most of the small intestine and the large intestine (for secretion) and lymphoid tissue.

## 3) Muscularis Mucosae: a thin layer consisting of one or two ribbons smooth muscle cells separating the mucosa from the submucosa- help in changing the shape of the mucosa-. The muscles form either:

- I. A thin inner circular layer.
- Or
- II. An outer longitudinal layer.

→ Basic mucosal forms in the GI tract according to the main function {type-function relationship}:

- Protective (regenerative): stratified squamous epithelium that is found in the oral cavity, pharynx, the esophagus and the anal canal.
- Secretory: the mucosa consists of a long closely packed compound branched tubular glands, found in the stomach.
- Absorptive: the mucosa is arranged in fingerlike projections called villi with intervening short glands called crypts. That is typical for the small intestine.

-In the duodenum some crypts extend from the muscularis mucosa to the submucosa (Brunner's Gland) {absorptive function}.

-The duodenum also receives the pancreatic duct and the common bile duct (from the liver and the gall bladder) so it completes the digestion of fat {digestive function}.

• **Absorptive/protective:** the mucosa is arranged into closely packed tubular glands specialized for water absorption and mucus secreting -goblet cells- and it lines the **whole large intestine** to protect it from friction caused by feces.

**B-Submucosa:** composed of dense connective tissue with:

- 1- Many blood vessels.
  - 2- Lymph vessels.
  - 3- A submucosal nerve plexus (called **Meissner's plexus**)→  
An Autonomic nerve plexus responsible for the contraction of the muscles in mucosa (Muscularis Mucosae), it's sympathetic and (mainly) parasympathetic plexus called enteric nerve plexus.
- It may also contain glands (**only** in the duodenum and the esophagus) and lymphoid tissue.

**✚ Explain:** The duodenum contains several glands in its submucosa.

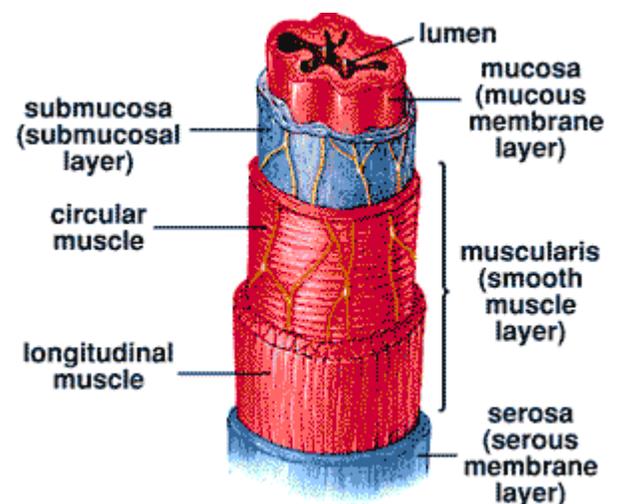
To neutralize the acidity that comes with the chyme from the stomach to prevent the formation of peptic ulcers {protective mechanism}

### C-Muscularis externa:

#### → Contains:

- I. Smooth muscle cells that are spirally oriented and divided into two sublayers - according to the main direction of the muscle cells follow:-

1. The internal circular sublayer (close to the lumen).
2. The external longitudinal sublayer.



#### \*Responsible for the peristaltic movement of the GI tract.

- II. Myenteric (or Auerbach's) nerve plexus, which lies between the two muscle sublayers → mainly parasympathetic plexus (with some sympathetic

fibers) responsible for contraction of smooth muscles for peristaltic movement, also it's (Auerbach's plexus) responsible for the secretion of glands (secretomotor).

- III. Blood and lymph vessels in the connective tissue between the muscle sublayers.

#### D-Serosa/adventitia:

**\*Serosa:** a thin layer of loose connective tissue-part of the peritoneum in the abdominal cavity-, rich in:

- 1- Blood and lymph vessels.
- 2- Adipose tissue.
- 3- And contains simple squamous covering epithelium (mesothelium).

**\*Adventitia:** a thick connective tissue outside the abdomen in places where the digestive organ is bound to other organs or structures (EX: the tissue covering the thoracic part of the esophagus).

-consists of connective tissue containing:

1. Vessels.
2. nerves

NOTICE: there's **no mesothelium.**

## The oral cavity:

### 1. Functions of the oral cavity :

#### 1) Formation of the bolus (اللقمة):

- a. Teeth → grinding of food.
- b. Tongue → mixing the food with the secretions of the

#### minor glands for

emulsification of food, then the bolus (on dorsum of the tongue) is pushed from the oral cavity to the pharynx.

2) Tasting: and it's the function of the taste buds on the dorsum of the anterior two-thirds of the tongue.

3) Articulation (اللفظ/النطق).

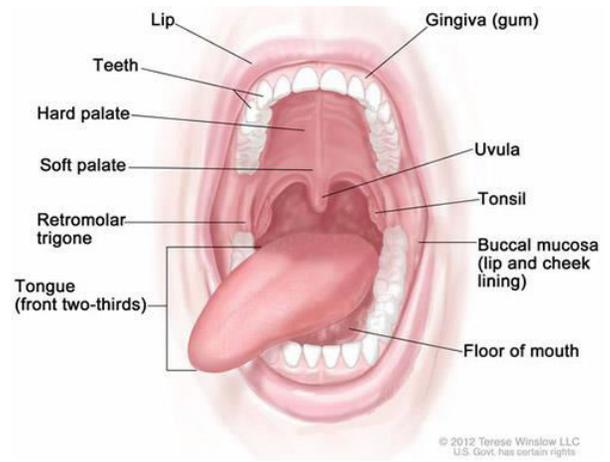
### 2. Walls of the oral cavity :

- I. The roof: consists of the hard and soft palates.
- II. The floor: is formed mainly of soft tissues, which include:
  - Muscular diaphragm.
  - The tongue.
- III. The lateral walls (cheeks): are muscular and merge anteriorly with the lips surrounding the oral fissure (the anterior opening of the oral cavity).
- IV. The posterior aperture: is the oropharyngeal isthmus, which opens into the oral part of the pharynx.

### 3. The oral cavity is divided into two regions :

- I. The outer **ORAL VESTIBULE**.
- II. The inner **ORAL CAVITY PROPER**.

### 4. The lining of the oral cavity:



-The oral cavity is lined with stratified squamous keratinized or non-keratinized epithelium. (Depending on the region)

- **The importance of the keratin layer (in Parakeratinized tissues) :**  
It protects the oral mucosa from damage during masticatory function and it presents mostly in the gingiva (gum), dorsum of the tongue and hard palate.

:: the parakeratinized term is used to describe the epithelium in the inner oral cavity which used to be non-keratinized before injury/infection. \*this is irreversible\*

#### 5. The glands of the oral cavity :

- a) Large salivary glands (in pairs): Parotid glands (on the left and on the right), the submandibular glands and the sublingual glands.
- b) The minor glands: labial gland (in lips), palatial glands (in palates), and lingual glands (in the tongue).

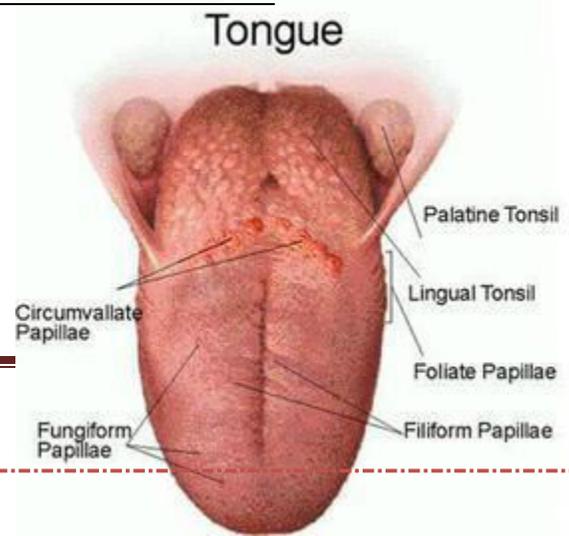
- Types of secretions :

1. Mucous secretion (contains mucinogen).
2. Serous secretion (contains enzymes, proteins and antibodies).
3. Mixed (mucous + serous)

- The amount of secretions in the oral cavity is (0.5- 1.5) liters per day to maintain the moisturization of the oral cavity for proper articulation and to prevent the bacterial growth and ulceration.

### The tongue:

1. The tongue is a mass of striated muscles (intrinsic and extrinsic muscles) covered by a mucous membrane whose structure varies according to the region.



2. It is divided vertically by the median sulcus into two halves (left and right) with identical structures on both halves, and horizontally by a “V” shaped boundary (sulcus terminalis and foramen cecum) into anterior two-thirds and posterior third.

3. The dorsum of the anterior 2/3 of the tongue is covered by a great number of small eminences called lingual papillae (taste buds).

• Types of papillae :

- a. Circumvallate papillae (circular surrounded by a groove).
- b. Fungiform papillae (mushroom-like).
- c. Foliate papillae.
- d. Filiform papillae.

:: The first three are associated with the taste buds (tasting of sweet, salty, sour and bitter substances).

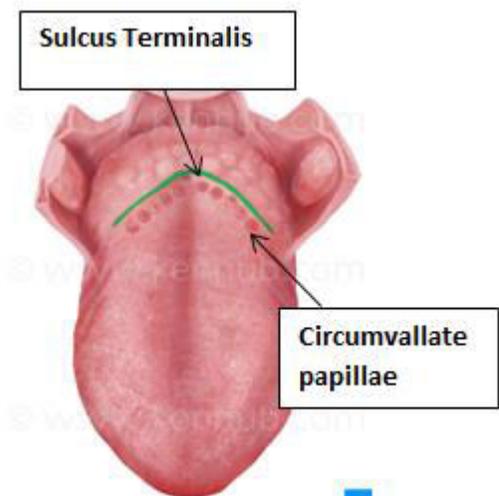
• Now let's discuss each type of papillae individually.

a. Circumvallate papillae:

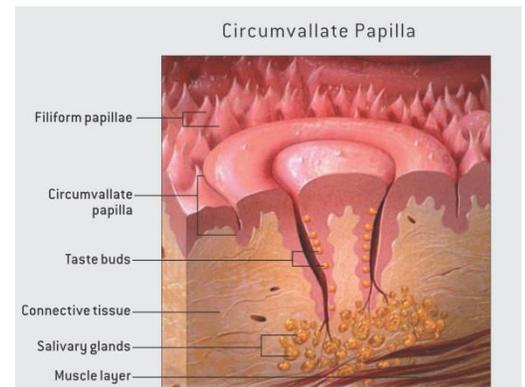
- i. Usually numbering between about (7 or 8)-12.
- ii. They are located anteriorly to the sulcus terminalis.(They develop with the posterior third but then they are located in the anterior 2/3)

:: In the slides it's

mentioned that they are distributed in the V region in the posterior portion of the tongue. The posterior portion here is indicating the part of the tongue that's closer to pharynx “not the posterior third behind the sulcus terminalis”.

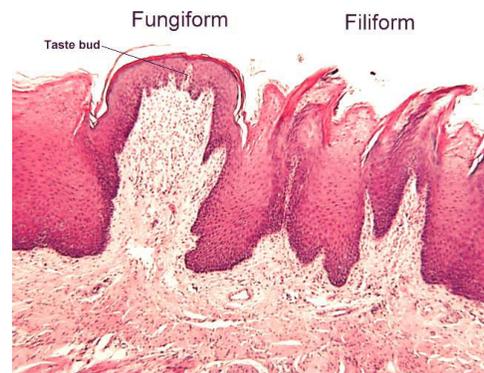


- iii. The periphery of each papilla is encircled with a groove that contains several taste buds (we will discuss the types of taste buds in the practical lectures).
- iv. Numerous serous (von Ebner's) glands drain their contents into the groove.
- v. The glands (von Ebner's) also secrete a lipase that probably prevents the formation of a hydrophobic layer over the taste buds that would hinder their function.
- vi. The presence of the grooves (forming a moat-like structure شبيه بالخندق) provides a continuous flow of fluid over the great number of taste buds present along the sides of these papillae.  
 :: This flow of secretions is important in removing food particles from the vicinity of the taste buds so that they can receive and process new gustatory stimuli.



**b. Fungiform papillae:**

- i. Resemble mushrooms because they have a narrow stalk and a smooth-surfaced, dilated upper part.
- ii. They contain scattered taste buds on their upper surfaces.
- iii. They are irregularly interspersed among the filiform papillae.



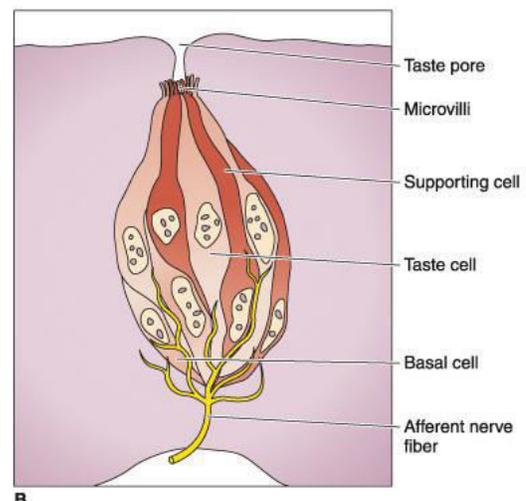
**c. Foliate Papillae :**

- i. They are poorly developed in humans.

- ii. They consist of two or more parallel ridges and furrows on the dorsolateral surface of the tongue.
- iii. They contain many taste buds.
- d. **Filiform Papillae :** (The doctor didn't mention anything about them so these are extra information just to help you differentiate between the types of papillae so you don't have to memorize them ☺ )
  - i. They are the most numerous of the four main types of papillae.
  - ii. The main job of the filiform papillae is to act as an abrasive coating, which helps give the tongue a cleaning and rasping action.
  - iii. Their function is not associated with taste buds.

- **The structure of the taste buds:** The taste buds are composed of three types of cell :
  1. Basal cells.
  2. Supporting cells.
  3. Taste cells/gustatory cells/bipolar cells (they have small projections /microvilli on the upper pole and they are connected to the afferent nerve fibers on the lower pole).

:: The taste cells convert the chemical stimuli (we consider the dissolving material a chemical stimulus) to an electrical sensation and through the afferent nerve fibers - chorda tympani of facial nerve – this electrical sensation is sent to the



gustatory (taste) center in the brain.

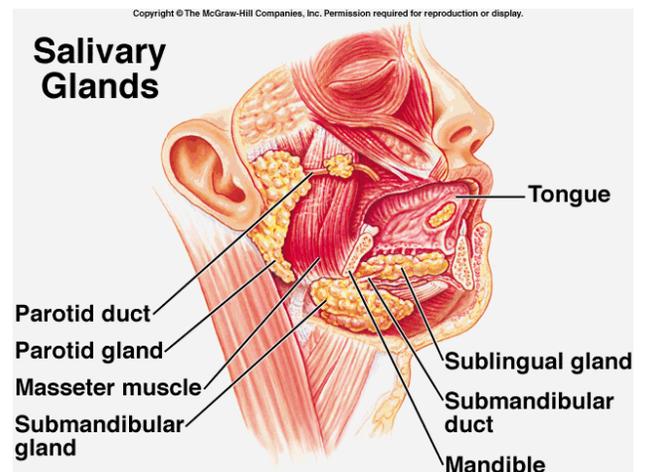
- 4- The dorsum of the posterior third of the tongue is devoid (lacks) of the taste buds but it is rich with lymphatics.
  - There are two types tonsils in the posterior third of the tongue:
    - a. Lingual tonsil (single).
    - b. Palatine tonsils (on both sides of the oropharyngeal isthmus).
- 5- The upper surface of the tongue is covered with parakeratinized stratified squamous epithelium.
- 6- The lower surface of the tongue is connected to the floor of the mouth and covered with mucosa (nonkeratinized stratified squamous epithelium).

### • The salivary glands :

➤ The general structure of the salivary glands :

- ❖ The glands are surrounded by a capsule, of connective tissue.
- ❖ Inside, the glands are divided into parts called lobes & lobules (smaller) by the septa coming from the capsule.
- ❖ Blood vessels and nerves go into the lobules.
- ❖ There are 3 main types of cells in the major salivary glands:

#### 1. Serous cells:



- They are shaped like a pyramid with a broad base resting on the basal lamina and a narrow apical surface with short, irregular microvilli facing the lumen.
- They have circular nuclei (central or basal) and basophilic cytoplasm.
- They are joined together -by junctional complexes- to form a spherical mass of cells called acinus, with a small lumen in the center.
- This structure can be thought of as a grape attached to its stem; the stem corresponds to the duct system.
- They exhibit characteristics of polarized protein-secreting cells. (Serous-secreting cells).

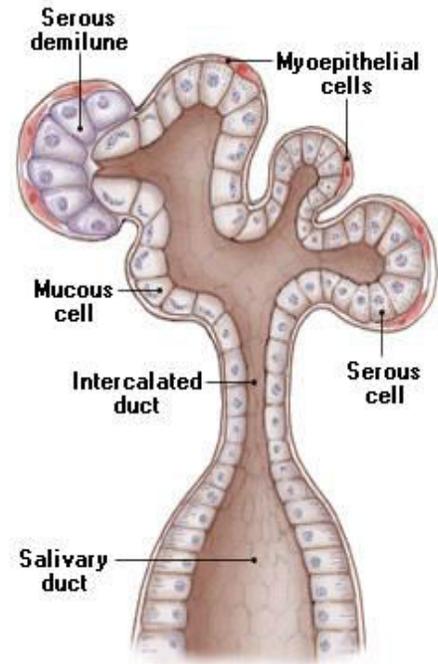
## 2. Mucous cells:

- They are usually cuboidal to columnar in shape and wide.
- Their nuclei are oval flattened and pressed toward the bases of the cells.
- The boundaries between cells are distinct.
- They are joined together to make tubules- which are very small tubes- consisting of cylindrical arrays of secretory cells surrounding a lumen.
- They exhibit the characteristics of mucus-secreting cells containing glycoproteins important for the moistening and lubricating functions of the saliva.
- Most of these glycoproteins are called mucins and contain 70%-80% carbohydrate moieties in their structures.

## 3. Myoepithelial cells:

- They are found between the basal lamina and the basal side of the plasma membrane of the cells.
- They form secretory end pieces and intercalated ducts (to a lesser extent), which form the initial portion of the duct system.
- Myoepithelial cells surrounding each secretory portion -usually two to three cells per secretory unit- are well developed and branched (and are sometimes called basket cells).

- Myoepithelial cells associated with intercalated ducts are spindle shaped and lie parallel to the length of the duct.
- These cells show several characteristics that resemble smooth muscle cells, including contractility (myo → smooth muscles).
- They establish intercellular junctions (such as desmosomes) among themselves and with secretory cells.
- Functions :
  - i. Prevention of end piece distention during secretion due to the increase in intraluminal pressure (The main function).
  - ii. Acceleration of the secretion of saliva by contraction of these cells.



❖ **The structure of the duct system :**

- a. Intercalated ducts: lined by simple cuboidal epithelial cells (about five), which have the ability to divide and differentiate into secretory or ductal cells.
  - :: Remember → secretory end pieces empty into the intercalated ducts.
- b. Striated ducts:
  - Formed by joining of several short intercalated ducts.
  - Lined by simple columnar cells.
  - Characterized by radial striations that extend from the bases of the cells to the level of the central nuclei.
  - When viewed in the EM, the striations consist of infoldings of the basal plasma membrane with numerous elongated mitochondria that

are aligned parallel to the infolded membranes; this structure is a characteristic of ion-transporting cells.

- The striated ducts of each lobule converge and drain into ducts located in the connective tissue septae separating the lobules, where they become interlobular or excretory ducts.
- ✓ Striated ducts and intercalated ducts are called intralobular ducts (especially the striated ducts).
- c. Excretory ducts (interlobular or interlobar):
  - They are initially lined with pseudostratified or stratified cuboidal epithelium, but the more distal parts of the excretory ducts are lined with stratified columnar epithelium containing a few mucus-secreting cells, and the last part of the duct is lined with stratified squamous epithelium.

✚ What are the differences between the serous acinus and the mucous tubules?!!

	serous acini	mucous tubules
Type of cells	Basal or central rounded nuclei	Basal flattened nuclei.
The lumen	Narrow lumen.	Wide lumen.
Other	The base is basophilic, The apex is acidophilic.	Between the cells there are distinct boundaries.

	(Because of the presence of secretory granules).	
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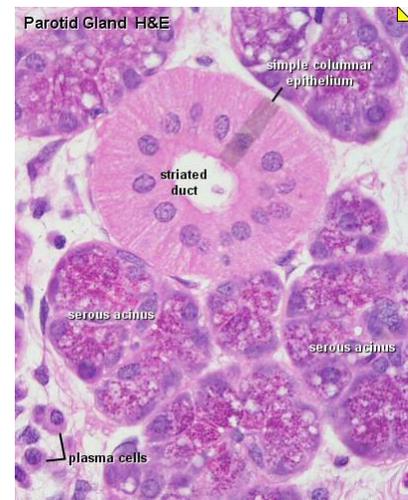
➤ Types of salivary glands:

1. Major salivary glands.
2. Minor salivary glands.

1) The major salivary glands:

I. The parotid glands:

1. Present in front of the ear (par- = next to, -otid = ear) and above the ramus of the mandible on both sides (left and right).
2. They are branched acinar gland (their secretory portions are composed exclusively of serous cells).
3. Most of their secretions are serous secretions (contain enzymes, proteins and antibodies).
4. Contain secretory granules that are rich in proteins and have a high amylase activity (which is responsible for most of the hydrolysis of ingested carbohydrates).
5. Intercalated and striated ducts are easily observed within the lobules, due to their length.
6. The duct of the parotid gland crosses the masseter muscle and then it pierces the buccinator muscle,



finally it opens in the oral cavity at the level of the upper second molar tooth.

7. They are covered by two capsules (outer capsule & the capsule of the gland / connective tissue).
8. The connective tissue surrounding them contains many plasma cells (secrete IgA) and lymphocytes.

## II. Submandibular (submaxillary) glands:

1. They lie in the submandibular fossa of the mandible.
2. They are branched tubuloacinar glands (contain serous acini & mucus tubules).
3. They produce mixed secretions (mucous + serous) the mucous part is described to have a vacuole for dissolving mucous.
4. Divided into two parts: superficial part & deep part (which lies between mylohyoid muscle and hyoglossus muscle).
5. The duct (Wharton's duct) begins in the deep part of the gland and opens under the tongue.
6. In humans, 90% of the end pieces of the submandibular gland are serous acinar, whereas 10% consist of mucous tubules with serous demilunes.
7. The cells that form the demilunes in the submandibular gland secrete the enzyme lysozyme, whose main activity is to hydrolyze the walls of certain bacteria.
8. Striated ducts are easily observed in the human submandibular gland, but intercalated ducts are very short.

## III. Sublingual glands :

1. Under the tongue in the floor of the mouth.
2. They are branched tubuloacinar gland formed of serous and mucous cells.
3. Their secretions are mostly mucus secretions; because mucous cells predominate in this gland while serous cells are present almost exclusively on demilunes of mucous tubules.
4. They have 7-10 ducts opening with the submandibular ducts under the tongue.
5. Intralobular ducts are not as well developed as in other major salivary glands.

## 2) Minor salivary Glands:

### I. Properties :

- Non-encapsulated glands.
- They are distributed throughout the oral mucosa and submucosa.
- Minor salivary glands are usually mucous (except von Ebner's glands ).
- Small groups of secretory units produce saliva.
- Saliva is conducted to the oral cavity by short ducts, with little modification of its content.
- Lymphocyte aggregates are commonly observed within minor salivary glands, associated with IgA secretion.

II. There are numerous minor glands distributed throughout the oral cavity and they are named after the part they are present in such as: buccal, labial, lingual, palatal ... etc.

III. Von Ebner's glands ( one of the most important minor glands):

- Found in the groove circling the circumvallate papillae on the dorsal surface of the tongue near the sulcus terminalis.
- They secrete a purely serous fluid (the only exception in minor glands).

→Note: please go back to the slides and read them to make sure you know everything (I tried to add everything mentioned in the slides) just in case I forgot something.

**Remember,**

**“Pain is temporary. It may last a minute, or an hour, or a day, or a year, but eventually it will subside and something else will take its place. If I quit, however, it lasts forever.” Lance Armstrong.**

و الله ولي التوفيق

***The End***