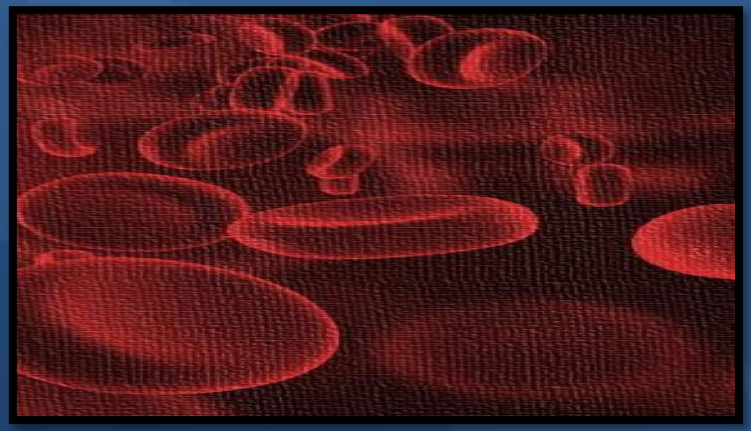
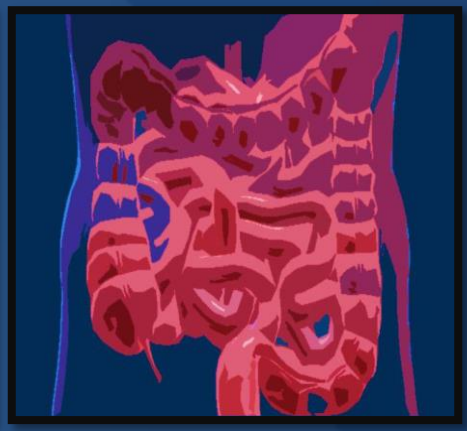
Physiology Team

LECTURE 2

Physiology of Salivary gland





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GASTOINTISTINAL TRACT

OBJECTIVES

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At the end of this lecture, student should be able to describe:

- Mastication and Chewing reflex.
- Salivary glands:
- Secretory unit (Salivon)
- Secretion of saliva and its characteristics.
- Composition of saliva.
- Secretion of water & electrolytes by salivary glands.
- Saliva and its flow rate.
- Functions of saliva.
- Control of secretion by sympathetic and parasympathetic nervous systems.
- Unconditioned and conditioned reflexes.

MIND MAP

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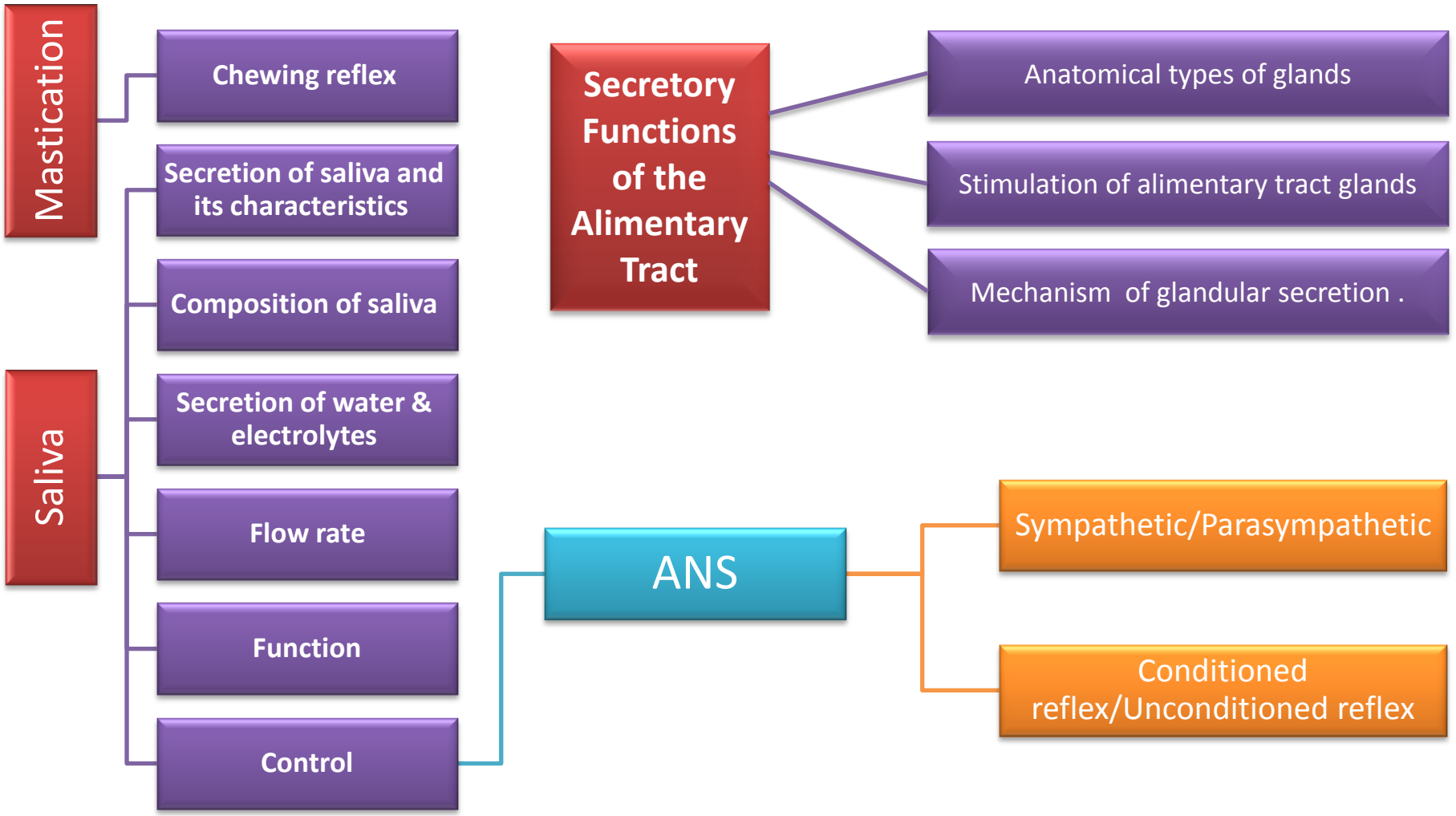

Mastication (Chewing)

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Bolus is a rounded mass of food that has been masticated and mixed with saliva.

Functions:

- To lubricate the **bolus** with salivary secretion
- To breakdown the bolus to small particles
- To begin digestion of carbohydrate (amylase)

Teeth organization:

- Anterior teeth (incisors) for cutting
- Posterior teeth (molars) for grinding

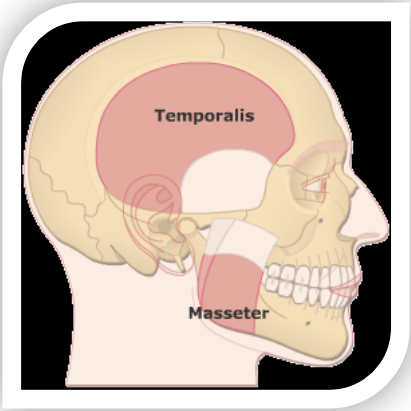
Chewing muscles are innervated by cranial nerve V (trigeminal):

- Masseter
- Temporalis
- Lateral and Medial Pterygoid

Taste center (Hypothalamus):

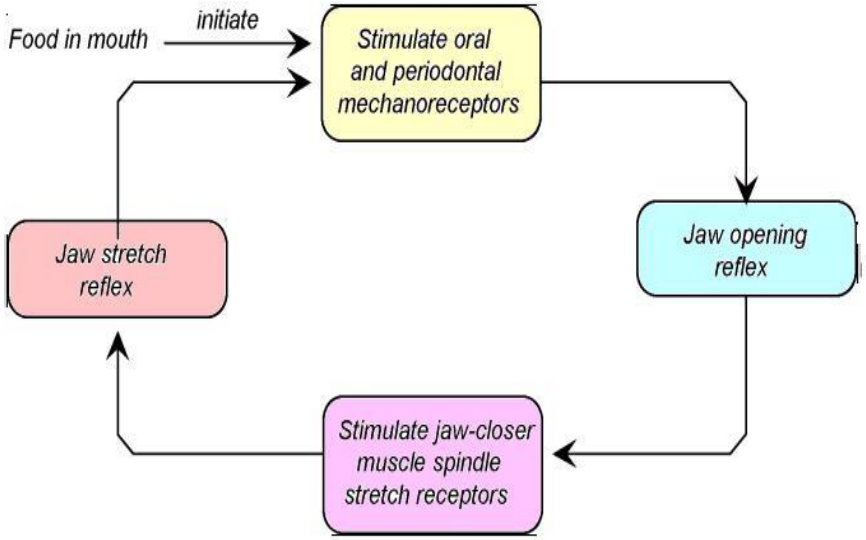
rhythmical chewing movements

Chewing reflex & stretch reflex



Chewing reflex & stretch reflex :

- The presence of a bolus of food in the mouth at first initiates reflex inhibition of the muscles of mastication, which allows the lower jaw to drop.
- The drop in turn initiates a stretch reflex of the jaw muscles that leads to rebound contraction.
- This automatically raises the jaw to cause closure of the teeth, but it also compresses the bolus again against the linings of the mouth, which inhibits the jaw muscles once again, allowing the jaw to drop and rebound another time; this is repeated again and again.



Simply, when there is a bolus in the mouth this will inhibit the muscles of mastication causing the jaw to drop and open. When the jaw drops, this initiates the stretch reflex and causes contraction and closure of the jaw. And again the bolus will inhibit the muscle of mastication and so on.

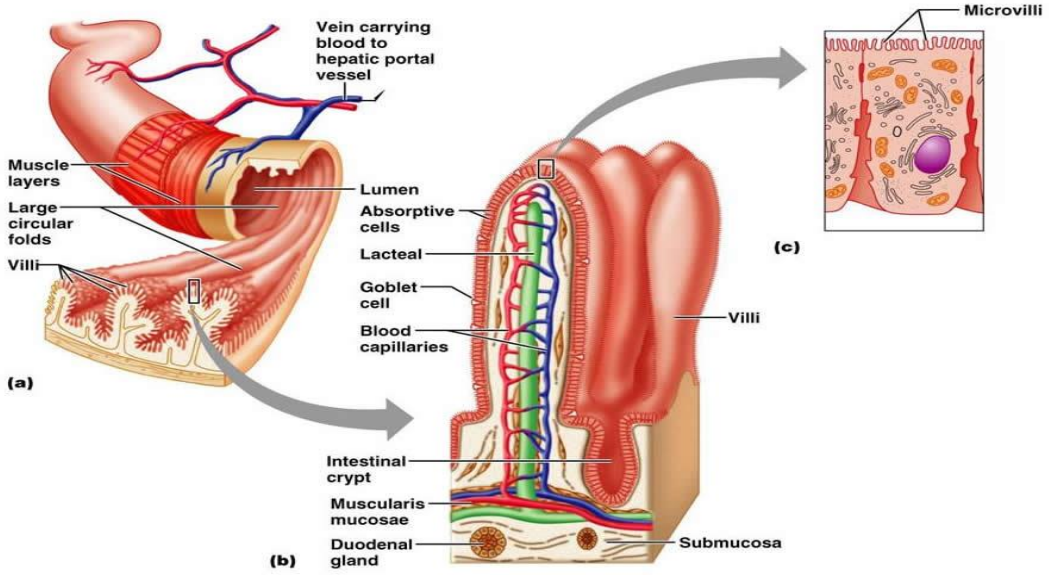
Anatomical type of glands

1- Single-cell mucous glands (**goblet cells**), they produce mucus.

2- Crypts of Lieberkühn at the mucosal pits in small intestine (they represent invaginations of the epithelium into the submucosa) ,releasing Digestive Enzymes.

3- Tubular glands that include an acid and pepsinogen-secreting gland (stomach).

4- Salivary glands, pancreas, and liver. They contain million of **acini** lined with secreting glandular cells feeding into a system of ducts that empty in the alimentary tract.



- The effect of food contact with the epithelium: activating enteric nervous system:

The mechanical presence of food in a particular segment of the GI tract usually causes the glands to secrete moderate to large quantities of juices. The types of stimuli that do this are:

(1) tactile stimulation.

(2) chemical irritation.

(3) distention of the gut wall.

- Regulation of Glandular Secretion by Hormones:

In the stomach and intestine, several *GI hormones* help regulate the volume and character of the secretions. They are liberated from the GI mucosa in response to the presence of food in the lumen of the gut. The hormones then are absorbed into the blood and carried to the glands, where they stimulate secretion.

Mechanism of glandular cell secretion

Males' Slide

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1) The nutrient material needed for formation of the secretion must first diffuse or be actively transported by the blood in the capillaries into the base of the glandular cell.
2) Mitochondria use oxidative energy to form ATP.
3) Energy from the ATP, along with appropriate substrates provided by the nutrients, is then used to synthesize the organic secretory substances in the *endoplasmic reticulum* and *Golgi complex*.
4) In the Golgi complex, the materials are modified, added to, concentrated, and discharged into the cytoplasm in the form of *secretory vesicles*.
5) These vesicles remain stored until nervous or hormonal control signals cause the cells to extrude the vesicular contents through the cell's surface, *exocytosis*.

Salivary Glands

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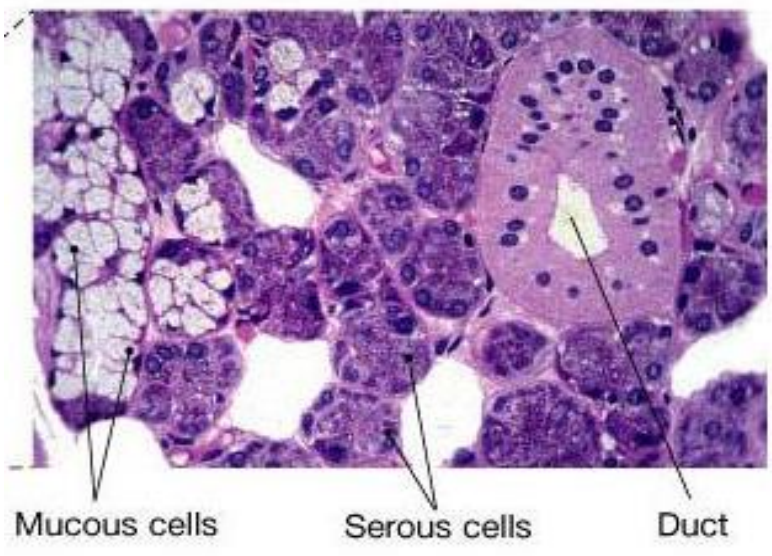
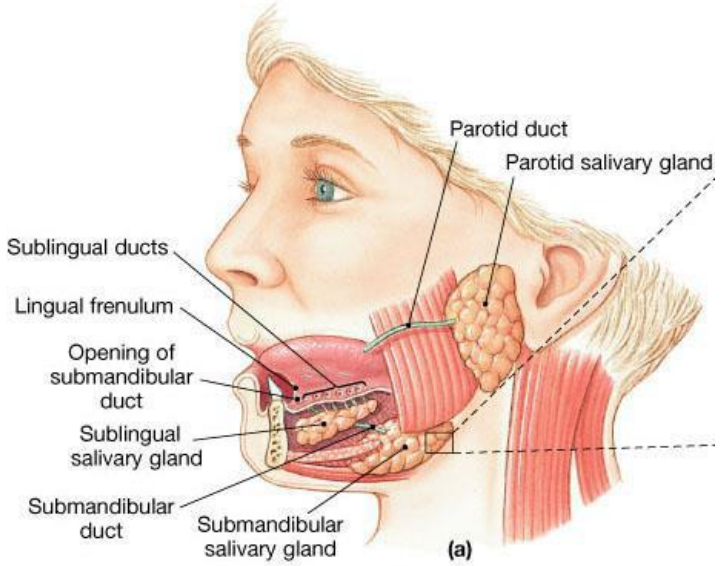
The principal glands of salivation are:

- Parotid glands.
- Submandibular (Submaxillary) glands.
- Sublingual glands
- Smaller glands (scattered) in the mucosa of tongue, palate, etc.





Secretary Unit (Salivon)

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- Salivary glands are typical exocrine glands.
- The basic unit "salivon" consists of:

Exocrine glands are glands that secrete their products through ducts onto an epithelium rather than directly into the blood stream

1- Acinus
- Initial secretory process.
- Has 2 types of cells: serous & larger mucous cells.

2- Intercalated duct
- Initial portion of duct.

3- Striated duct
- Modification of secretory product.

4- Myoepithelial cells
- Surround acinus and intercalated duct.
- Contraction moves saliva "they stimulate emptying of contents from acini and intercalated duct therefore increase the salivary flow".
- Prevents development of back pressure (prevent saliva to go back to acini).

Secretion of Saliva

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Saliva contains two major types of secretion:

1- Aqueous fluids (a serous secretion) :

- Water, ions and enzymes such as ptyalin (an α-amylase)
- Parotid, Submandibular and Sublingual glands. (Parotid gland is purely serous it doesn't contain mucus!)

2- Mucus secretion (mucin) :

- Submandibular and Sublingual glands only!

Characteristics of Saliva

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Daily secretion of saliva = 800-1500 mL. around 1 L/day **(Water: (0.5 L saliva/day)**

Specific gravity: 1002-1010 more than water

It is hypotonic. Concentrations of Na & Cl is less than plasma. It is the only hypotonic secretion in GI

pH: 6-7

Composition: Water (99.5%) and solids (0.5%) which include organic and inorganic constituents.

Organic constituents of Saliva

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1- Enzymes	• Alpha-amylase (from parotid glands) • Lingual lipase • Kallikrein (protease, from acinar cells): Catalyzes production of bradykinin (vasodilator) from alpha-globulin and Increases local blood flow. • Muramidase (lyses muramic acid of Staphylococcus) • Lactoferrin (deprive iron from bacteria so it'll be inactive), lysozymes
2- IgA and epithelial growth factor	-------
3- Mucus	• Mucus is a thick secretion composed mainly of water, electrolytes, and glycoproteins • It is an excellent lubricant and a protectant for the wall of the gut because of the following: 1) It has adherent qualities that make it adhere tightly to the food. 2) It causes food particles to adhere to one another. It helps in stool formation 3) It coats the wall of the gut and prevents actual contact of most food particles with the mucosa. Specially in the stomach, protecting the gastric mucosa from the high acidity 4) It has a low resistance for slippage. 5) It is strongly resistant to digestion by the GI enzymes. 6) The glycoproteins of mucus have amphoteric properties, (buffering small amounts of either acids or alkalies).

Inorganic constituents of Saliva

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The inorganic (electrolyte) constituents include:	
Na+, Cl-	Their concentration is less than those of plasma
K+, HCO3-	higher concentration than that in plasma
Ca++ and Ph+3	Same as in plasma

- The concentration of these ions depends on the rate of salivary flow (Discussed in details in slide 16)

At low flow rate, salivary secretions have:

- High K +and HCO3-
- Low Na+ and Cl–

Secretion of water and electrolytes by salivary glands

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The secretion of H2O & electrolytes occurs in two stages. First, a primary secretion in the acini; which is secondarily modified at the level of the striated ducts.	
1- The primary acinar secretion. From the acini	2- The striated ducts modify the primary secretion
❑ Is isotonic to plasma. The amylase concentration and the rate of its secretion vary with the level and type of stimulation. ❑ The electrolyte composition is similar to that of plasma.	❑ By extracting Na+ & CL- from, and adding K+ & HCO3- to the saliva. Na+ is actively reabsorbed followed by Cl unaccompanied by H2O, and K+ is secreted while HCO3- is actively secreted. ❑ This process is influenced by aldosterone. ❑ Because the ducts remove more Na+ & Cl- ions from saliva than they add K+ and HCO3-, saliva becomes progressively more hypotonic as it flows through the ducts .

Secretion of water and electrolytes by salivary glands

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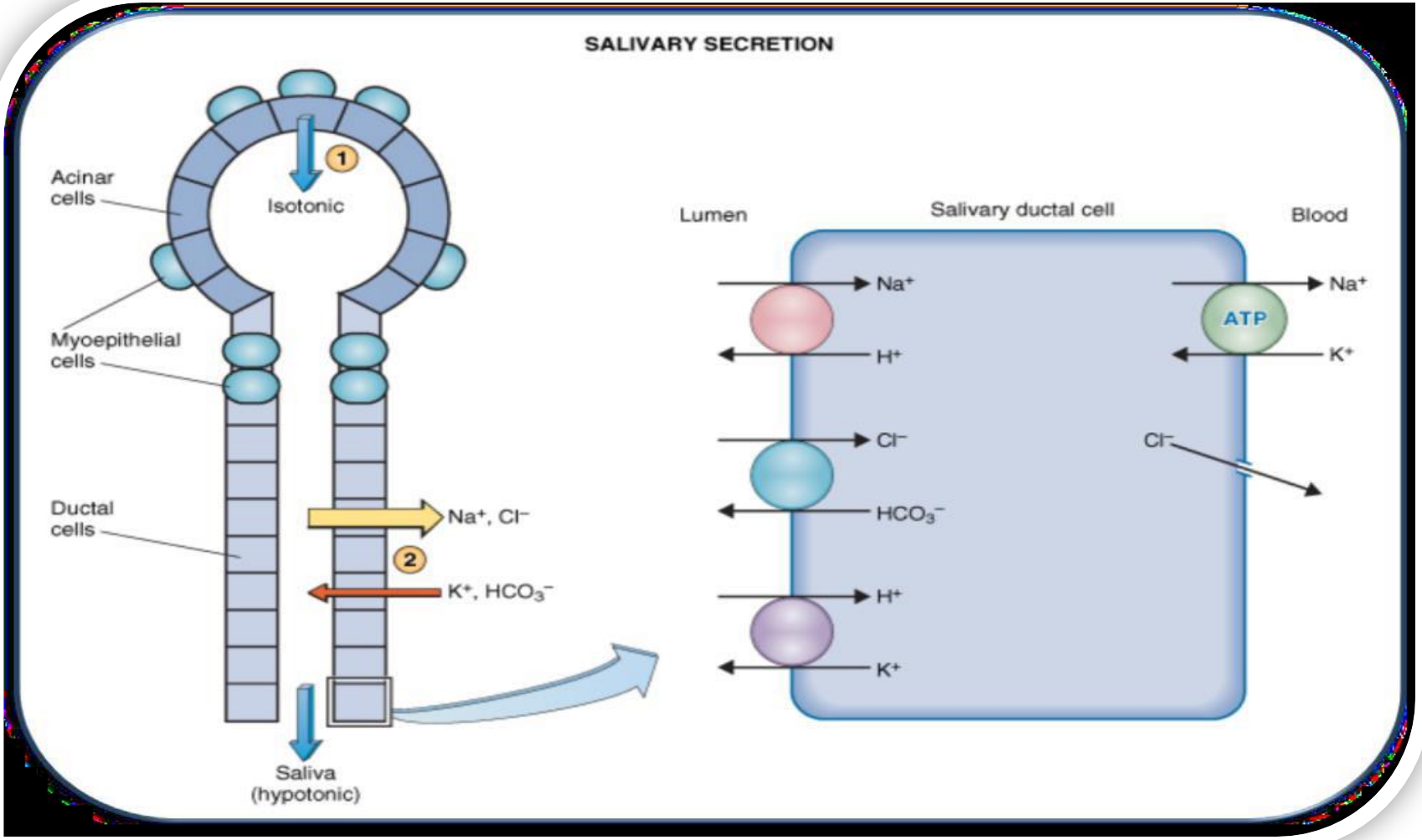

Slides | Important | Females' Notes | Explanation | Males' Notes

Secretion of water and electrolytes by salivary glands

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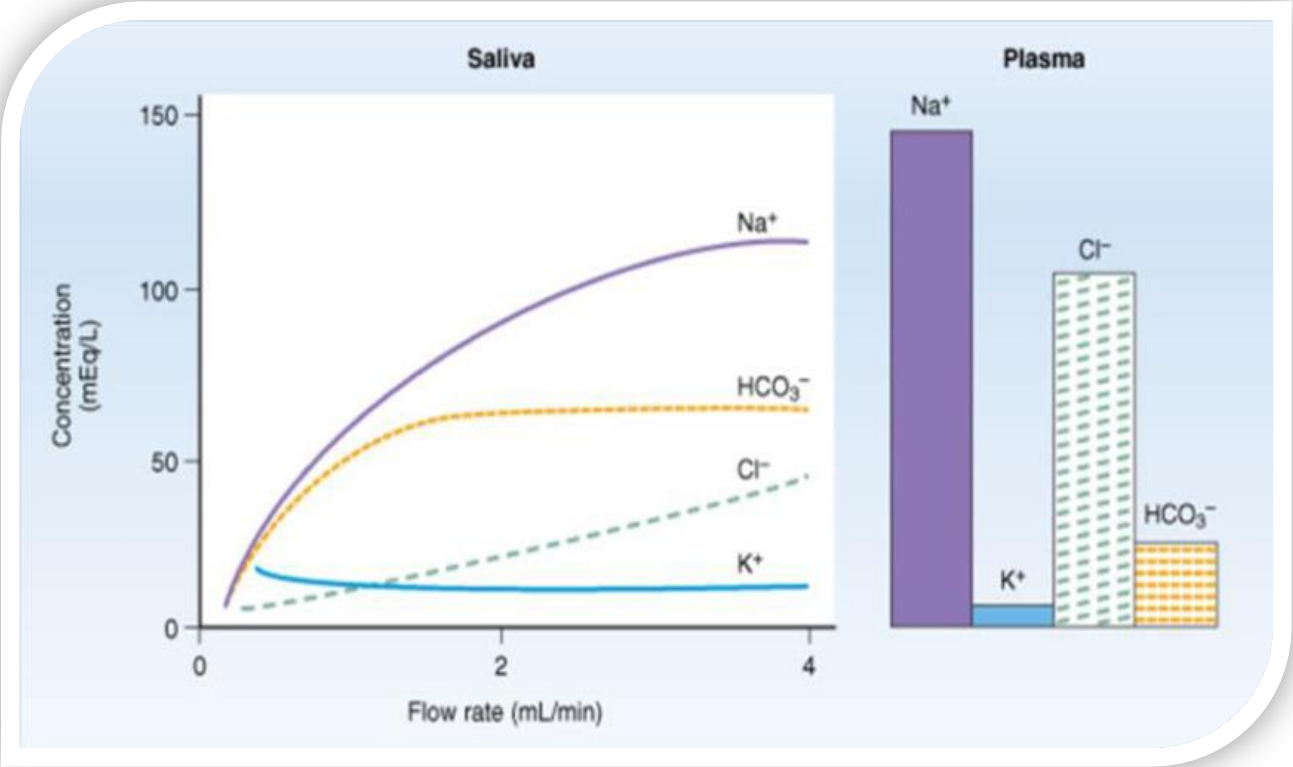
The concentration of electrolytes depends on the flow rate as follows:

Under resting conditions	Under maximum secretion	Excess aldosterone secretion
The concentration of Na+ and Cl- in saliva are 1/7 their concentration in plasma.	The concentration of Na+ and Cl- in saliva rises to 1/2-2/3 their concentration in plasma. No time for reabsorption	NaCl reabsorption and K+ secretion increase so that NaCl concentration in saliva decreases to almost zero, while K+ concentration increases.
The concentration of K+ is 7 times greater than in plasma.	The concentration of K+ falls to only 4 times that of plasma.	Aldosterone is secreted from the adrenal cortex. Its function is to increases Na absorption by the kidney.
The concentration of HCO3- is 2-3 times that of plasma.	----------	

Secretion of water and electrolytes by salivary glands



You can see the differences in concentration

Functions of Saliva

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1. Saliva moistens and lubricates food and thus facilitates swallowing.
2. Saliva keeps the oral mucosa moist and so helps movement of tongue and lips in speech.
3. Saliva has a digestive function: → next slide!
4. By acting as a solvent, saliva is important for the sense of taste. Any substance must first dissolve in saliva before it can be sensed by the taste buds.
5. Saliva prevents the deteriorative process of oral mucosa in several ways "protective function": → next next slide xD!
6. Buffering action, saliva *neutralizes any acids* that may result from bacterial action, also swallowed saliva may help to neutralize gastric HCl in empty stomach.
7. The epidermal *growth factor* in salivary secretion is responsible for healing of ulcers in the mucous membrane of oral cavity.

3. Saliva has a digestive function:

* Breaks down starch to less complicated forms.
* Protein digestion starts in the stomach.

1. Ptyalin (Salivary alpha-amylase):

- It is secreted mainly from parotid gland.
- It cleaves Alpha-1,4-glycosidic bonds and breaks down starch to maltose, dextrins and maltotriose.
- Its optimum pH = 6.8.
- Inactivated at pH 4 but continues to work for sometime in unmixed food in Orad portion of stomach for about half an hour and is arrested only when gastric acid penetrates the food mass.

Works in the stomach for half an hour → mixing of food with gastric juice "HCL" → ↓ pH → inactivation

2. Lingual lipase:

It is secreted from serous salivary glands on the tongue; it breaks down triglycerides "lipids" into monoglycerides and fatty acids. Its action may continue in the stomach after food is swallowed.

5. Saliva prevents the deteriorative process of oral mucosa in several ways:

"protective function"

a. The flow of saliva helps wash away the pathogenic bacteria as well as the food particle that provide their metabolic support.
b. Saliva contains several factors that *destroy bacterial* as: lysozymes , proteolytic enzymes and thiocyanate ions **{by entering the bacteria wall where they become bactericidal}**. Lactoferrin can deprive bacteria of iron.
c. Saliva contains significant amount of protein antibodies (IgA) that can destroy the oral bacteria.

→ So if there's a damage in the salivary glands, there will be ulceration and infection in the mouth!

Control of Salivary Secretion

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Unique aspect of control of salivary secretion:

- Secretion rate depends ***entirely*** on neural control – autonomic nervous system (ANS).
- Both Parasympathetic and Sympathetic lead to increase secretion
- Composition is modified by Aldosterone:
  1. Increases Na+ , Cl- reabsorption.
  2. Increases K+ secretion

- Controlling is by neural and hormonal.
- Secretion depends on neural control ONLY because the food stays in the mouth for limited time so we need something quick, hormonal control takes time!
- Parasympathetic = watery secretion, Sympathetic = viscous (concentrated) secretion.
- Parasympathetic and Sympathetic don't have contradiction معاكسة action.
- Parasympathetic and Sympathetic are complementary to each other!
- Aldosterone only modifies without affecting the secretion rate.

Control of Salivary Secretion

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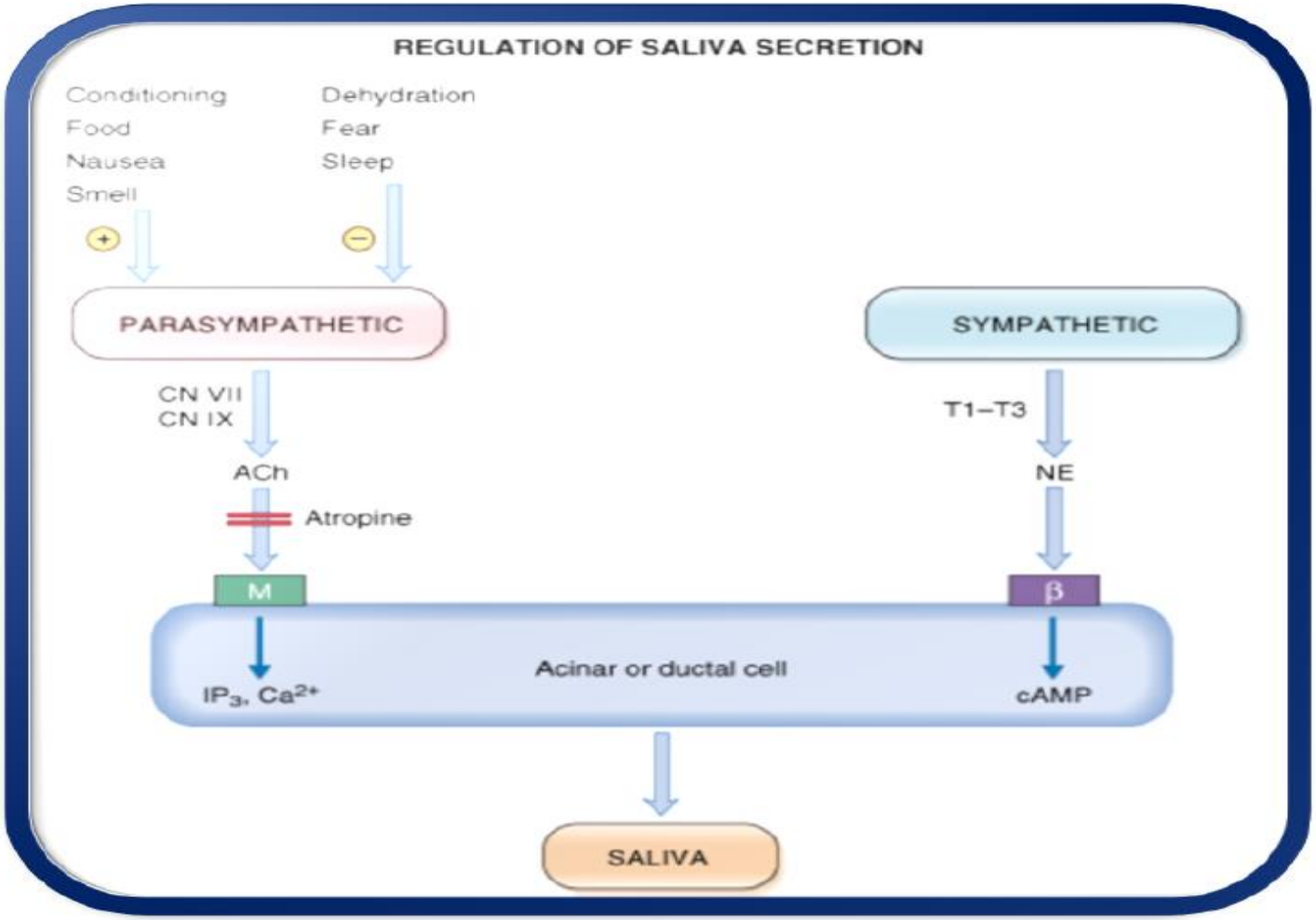
	Parasympathetic	*Sympathetic*
Origin	Salivary nucleus in medulla and pons.	Intermediolateral gray
Outflow	CN VII & IX	T1-T3
Transmitter	Ach	Norepinephrine
Stimulates	• The secretion (protein poor, high k and HCO3). • The contraction of myoepithelial cell. • The metabolic rate "active". • The blood flow due to marked vasodilatation. This occurs due to the release of kallikerin enzyme from active gland tissues which cause conversion of α2 globulin into bradykinine, a potent vasodilator. • The direct innervation of blood vessels. • The growth and development of different cells.	• Secretion (mostly enzymes. • Contraction of myoepithelial cell. • Metabolic rate. • Growth and development of different cells.
	- Increases stimulation in response to: Conditioned reflexes (taste, smell,Tactile). - Decreases stimulation due to: Sleep, fear, dehydration. - Sectioning (blocking) of parasympathetic markedly decreases flow & leads to atrophy.	- Sectioning of sympathetic nerves has minimal impact on secretion.
	Increases the rates of GI secretion, especially in the upper portion of the tract: salivary glands, esophageal glands, gastric glands, pancreas, Brunner's glands in the duodenum and the distal portion of the large intestine.	A sole stimulation: promote a slight Increase. Superimposed stimulation with copious glandular secretion: reduce the secretion due to VC.

Control of Salivary Secretion



Unconditioned and conditioned reflexes

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Salivary secretion is controlled exclusively by nervous mechanism through:

Unconditioned reflex

- The presence of food in the mouth stimulates general receptors and especially taste receptors.
- Impulses travel along afferent nerves to the salivary nuclei in brain stem.
- Efferent impulses "sympathetic or parasympathetic" travel along autonomic nerves to salivary glands to stimulate salivary secretion. This reflex is innate and is not acquired by learning.

Conditioned reflex

- Psychic stimulation: Seeing, smelling, hearing or even thinking about appetizing food can result in secretion of saliva.
- Initial impulses arise in the parts of the brain concerned with these special sensations from eyes, nose etc. and stimulates the salivary centers.
- In human, mouth watering on seeing or thinking of food provides evidence of this psychic reflex. Acquired.

Unconditioned and conditioned reflexes

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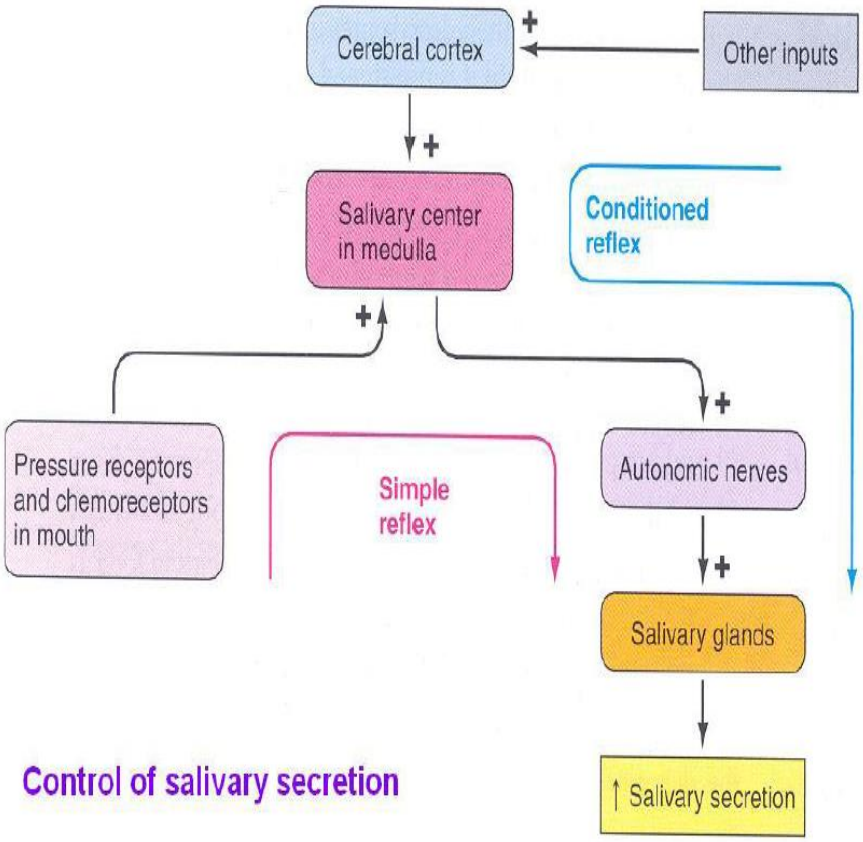

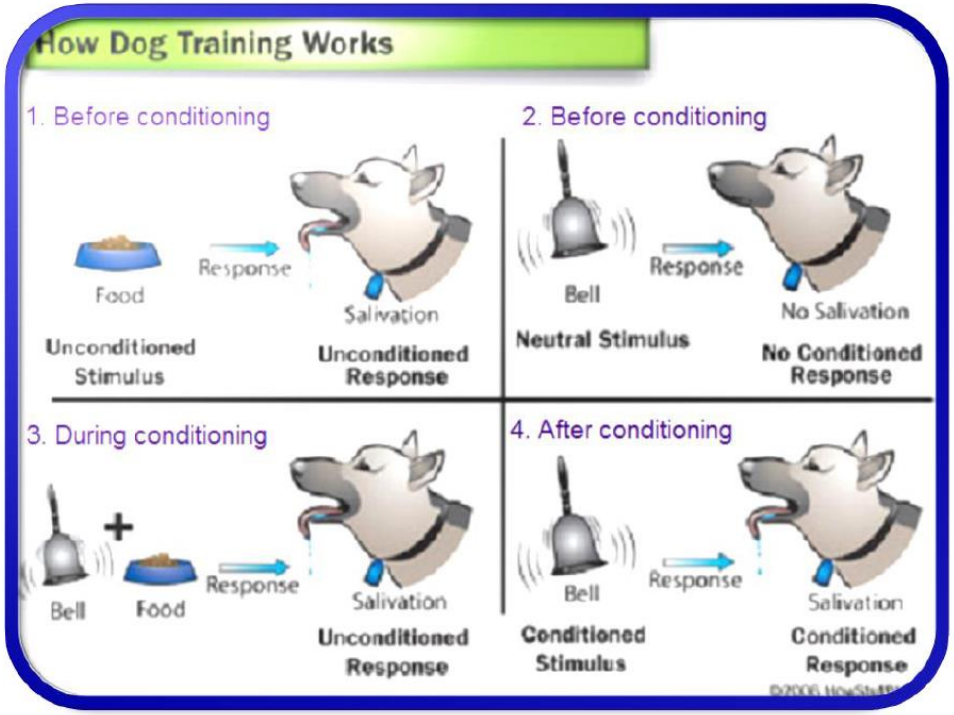

SUMMARY

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- Mastication is the process of chewing food.
- Muscle of mastication are innervated by trigeminal nerve.
- The principle glands of salivations are; parotid, submandibular, and sublingual.
- The secretory unit of saliva is salivon and it consists of; acinus, intercalated glands, striated glands and myoepithelial cells.
- Saliva contains two major types of secretion; aqueous (serous) and mucus.
- Parotid glands is purely serous.
- The main function of mucus is lubricant and protectant.
- The concentration of ions depends on the salivary flow rate.
- Secretion of water & electrolytes occurs in two stages.
- Saliva facilitates swallowing, helps in speech, has digestive function, protective function, buffering action and is responsible for healing of ulcers.
- Salivary alpha-amylase is secreted from parotid gland and breaks down starch to less complicated forms.
- Lingual lipase is secreted from serous salivary glands on the tongue and breaks down lipids.
- Secretion rate depends *entirely* on neural control.
- Both Parasympathetic and Sympathetic lead to increase secretion.
- ANS controls secretion by two reflexes: Unconditioned and conditioned.
- GI secretion in Jejunm and ileum and the 1st 2/3 of the large intestine is stimulated via local neuronal or hormonal stimuli.
- Most of digestive secretion are formed in response to the presence of food in the alimentary tract and they provide adequate digestion.

QUESTIONS

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Q1- If you take a sample from parotid glands, what type of cells would you expect to see?

A- Serous B-Mucus C- A+B

Q2- Which one of the following is true regarding myoepithelial cells?

A- Their luminar membrane contains 3 transportor; Na-H exchange, Cl-HCO_3 exchange and H-K exchange

B- It increases the salivary flow rate.

C- Their basolateral membrane contains Na-K ATPase.

Q3- Conditioned reflex is:

A- acquired B- not acquired

Q4- Secretion rate depends on:

A- Hormonal control B- Neural control C- Both

Q5- Which phenomenon in salivary ducts explains why the final secretion is hypotonic relative to the primary secretion of the acinar cells?

A- Secretion of water.

B- Absorption of more solute than water.

C- Secretion of more solute than water.

1-A
2-B
3-A
4-B
5-B

THE END

Physiology Team

If there are any Problems or Suggestions,
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