Mastication, Salivary Gland Secretion & Swallowing

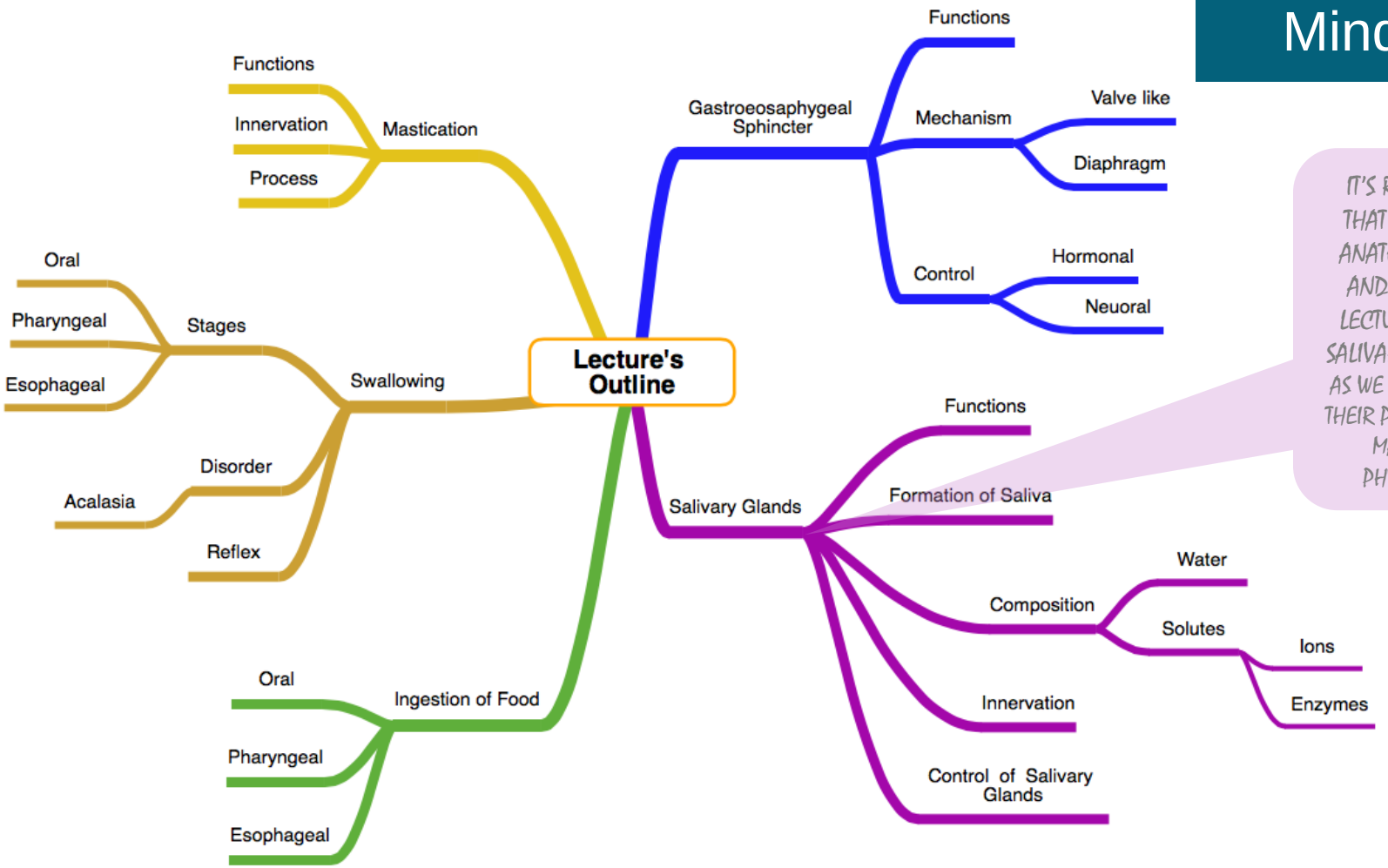
Color index

- Important
- Further explanation
- From males' slides

Contents

Please check out this link before viewing the file to know if there are any additions/changes or corrections. The same link will be used for all of our work Physiology Edit

Mind map



IT'S RECOMMENDED THAT YOU STUDY THE ANATOMY/HISTOLOGY AND BIOCHEMISTRY LECTURES ABOUT THE SALIVARY GLANDS FIRST! AS WE MAINLY RULED OUT THEIR PART AND FOCUSED MAINLY ON THE PHYSIOLOGY PART

4 Major Activities of GI Tract:

Motility → **Secretion** → **Digestion** → **Absorption**

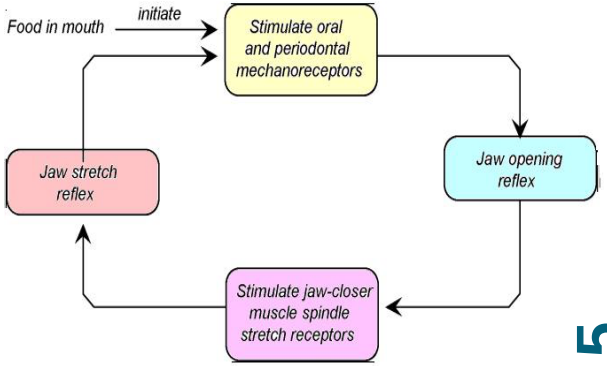
Motility	Discussed in other lecture.
Secretion	✧ **The functions of Secretory Glands:** ✓ **Secretion of digestive enzymes** ✓ **Provide mucus for lubrication and protection** Most digestive secretions are formed only in response to the presence of food in the alimentary tract, and the quantity secreted in each segment of the tract is almost exactly the amount needed for proper digestion.
Digestion	✧ The process of breaking –Food- large molecules (That do not pass cell membranes) into small molecules in order to pass through cell membranes. ✧ Digestion is performed by producing complex proteins called **enzymes**. ✧ which is of 2 types: ✓ Mechanical ✓ Enzymatic
Absorption	Discussed in other lecture.

- The **oral cavity** provides us with both the mechanical and chemical digestions:
  - ✓ Mechanical: Mastication[1]
  - ✓ Chemical: Saliva ➔ Salivary amylase (will be discussed next)

Mastication (chewing)

Is a type of mechanical digestion, the teeth are designed for chewing.

✧ **Functions**	✓ To lubricate the bolus with salivary secretion ✓ To breakdown the bolus to small particles ✓ To begin digestion of carbohydrate (α-amylase)
✧ **Innervation**	5th Cranial nerve (Trigeminal)
✧ **Process**	By a reflexes (chewing & stretch): food bolus in the mouth initiate the reflex ➔ inhibiting muscles of mastication➔drop of lower jaw-stretch of jaw muscles ➔ contraction of jaw muscles ➔ followed by inhibition of muscles of mastication..



1: مضغ

Salivary Glands (Secretion of Saliva)

- **3 major pairs of salivary glands:**
  - ✓ Parotid → Purely serous
  - ✓ Submandibular
  - ✓ Sublingual

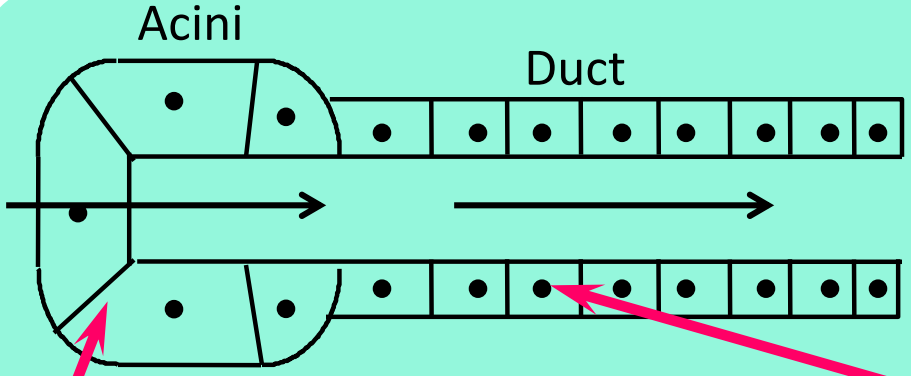
  → Mixed
- **Minor salivary glands:**
  - ✓ Small buccal glands → Purely mucous

800 to 1500 ml of fluid is secreted in a day.

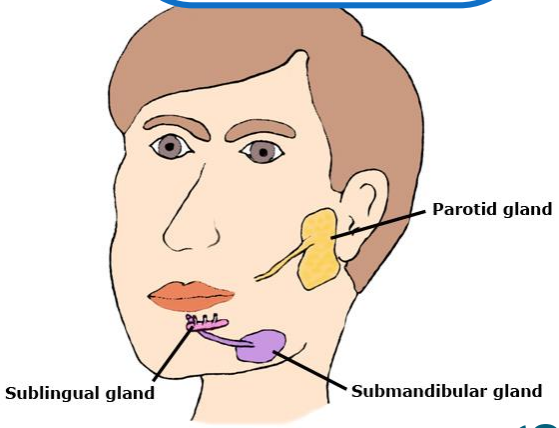
= 1/5 of the total plasma volume

with pH = 6-7

- **The Secretory Unit "salivon"**



Saliva formed in acini flows down DUCTS to empty into the oral cavity.



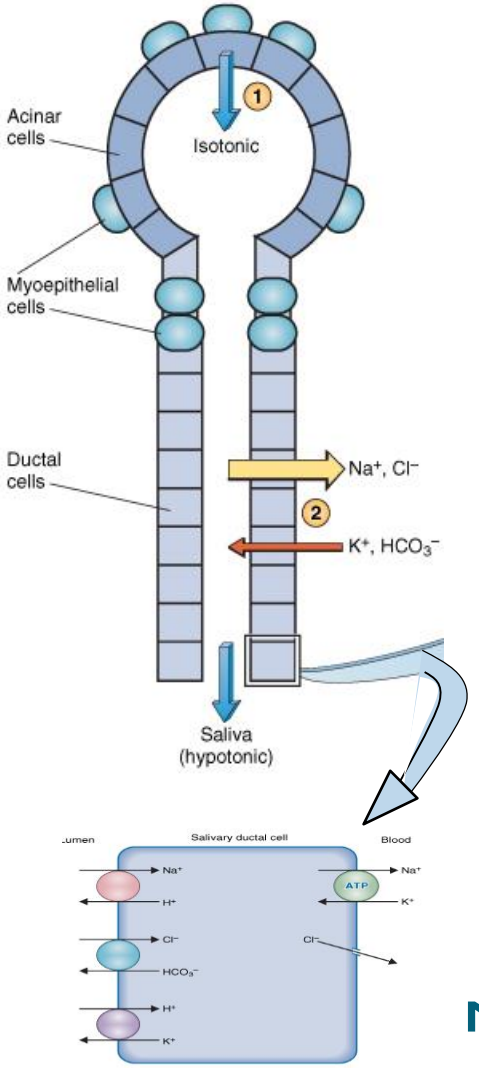
Formation of Saliva

The formation of saliva happens at 2 stages:

1. **Primary Saliva**
2. **Final Saliva**

Stage	1.Primary Saliva	2.Final Saliva
Where?	Acini	Ducts
Type of solution	Isotonic	Hypotonic
Secretion	• Ptyalin (α-amylase) • Mucus (Musin) • ECF	• K+ • HCO3-
Absorption	-	• Na+ (active) -ATP - • Cl- (passive)

Final salivary secretion is a **hypotonic** Aqueous fluid



Composition of Saliva

- Water (99.5%)
- Solutes (0.5%)

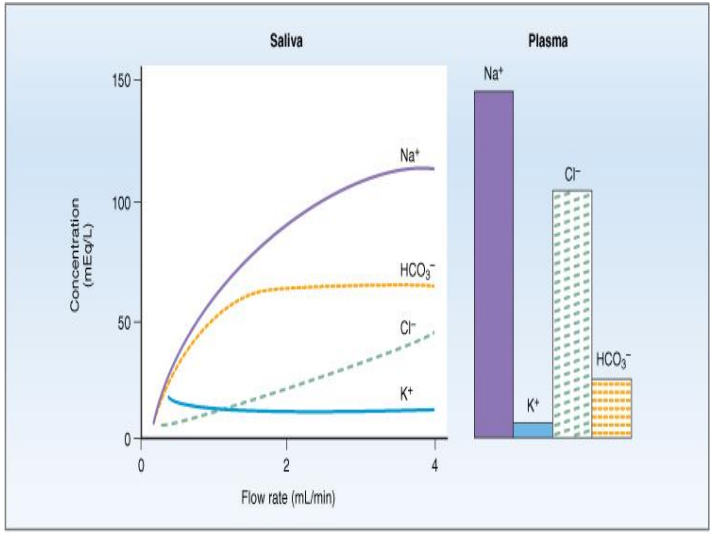
Composition of Saliva in more details

- Water (99.5%)
- Solutes (0.5%)
  - **Ions**
    - Na ↓
    - K ↑
    - HCO_3 ↑
    - Cl ↓
  - **Enzymes**
    - ?-amylase
    - Lingual lipase
    - Kallikrein

These conc. are under normal rate

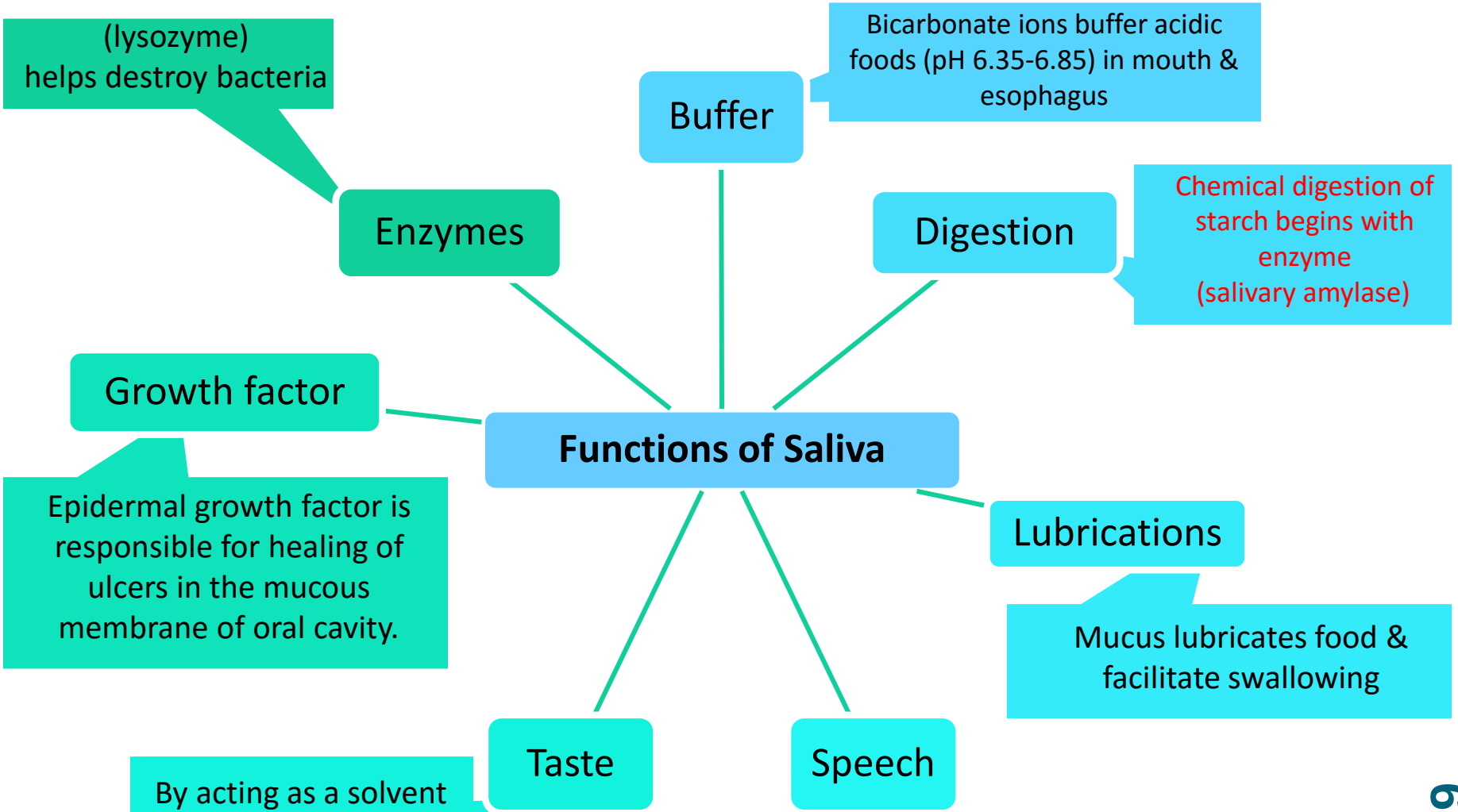
(a protease from acinar cells, which is not secreted into the salivary secretion):
Catalyzes production of bradykinin (good vasodilator) from α2-globulin
Bradykinin increases local blood flow

Concentration of ions & Flow Rate



The concentrations of these ions are altered with altered flow rates..

Think of it as you increase the flow there's no time for the ducts to modify the saliva.


(lysozyme)
helps destroy bacteria
Enzymes
Buffer
Bicarbonate ions buffer acidic foods (pH 6.35-6.85) in mouth & esophagus
Digestion
Chemical digestion of starch begins with enzyme (salivary amylase)
Growth factor
Epidermal growth factor is responsible for healing of ulcers in the mucous membrane of oral cavity.
Functions of Saliva
Lubrications
Mucus lubricates food & facilitate swallowing
Taste
By acting as a solvent
Speech

Control of Salivary Secretion

Salivary secretion is controlled exclusively by nervous mechanism through

Unconditioned Reflex

Innate and not acquired by learning

Presence of food in mouth

+

Taste receptors

Afferent

Salivatory nuclei in brain stem

Along autonomic fibers

Efferent

+

↑Salivary secretion

Conditioned Reflexes

Seeing, smelling, hearing or thinking about food

+

impulses arise in the parts of the **brain** concerned with these special sensation

+

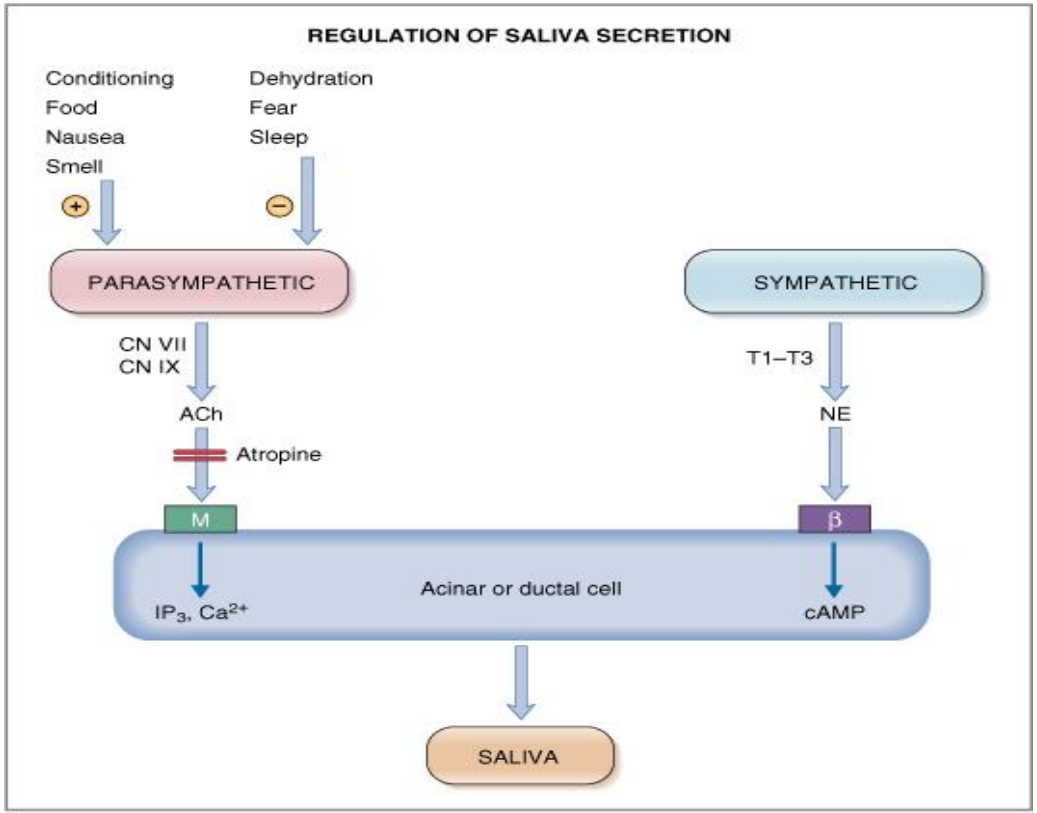
In humans, mouth watering on seeing or thinking of food provides evidence of this **psychic reflex**.

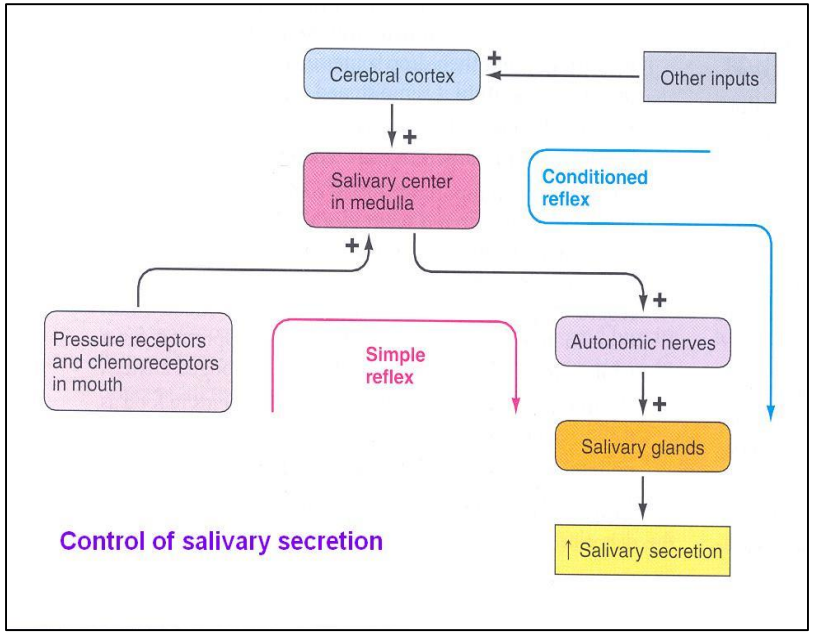
Nerve Supply to Salivary Glands

Sympathetic Nerves	Parasympathetic Nerves
○ Originate in the **superior cervical ganglion** and reach the 3 pairs of salivary glands through **blood vessels**	○ Originate in **brain stem** in: ✓ **Superior salivary n. ➔ VII CN** ➔Submandibular and sublingual. ✓ **Inferior salivary n ➔ IX CN** ➔Parotid gland.
○ Act on mucous cells and produce small amount of **viscous secretion.** ○ **Cause vasoconstriction.** Which in turn decreases the blood supply to the gland therefore will decrease the secretion.	○ Increase the synthesis and secretion of salivary amylase and mucin producing **watery secretion** (they act on serous) ○ **Causes vasodilatation** due to marked (via release of kallikri) = Increases blood flow. ○ Enhances the transport activities of ductal epithelium. ○ Stimulates glandular growth and metabolism.

Stimulation of both sympathetic and parasympathetic nerves cause contraction of myoepithelial cells that empty the acinar contents into the ducts, thus augments (Increases) the salivary secretion.

Summary


REGULATION OF SALIVA SECRETION
Conditioning
Food
Nausea
Smell
Dehydration
Fear
Sleep
PARASYMPATHETIC
SYMPATHETIC
CN VII
CN IX
ACh
Atropine
T1–T3
NE
M
β
Acinar or ductal cell
IP3, Ca2+
cAMP
SALIVA


Cerebral cortex
Other inputs
Salivary center in medulla
Conditioned reflex
Pressure receptors and chemoreceptors in mouth
Simple reflex
Autonomic nerves
Salivary glands
↑ Salivary secretion
Control of salivary secretion

STAGES OF SWALLOWING (DEGLUTITION)

- **Swallowing is the ordered sequence of events that propel food from the mouth to the stomach.**

- **Swallowing is initiated voluntarily in the mouth, but thereafter is under involuntary or reflex control. The reflex portion is controlled by the swallowing center in the medulla.**

Stages of Swallowing:

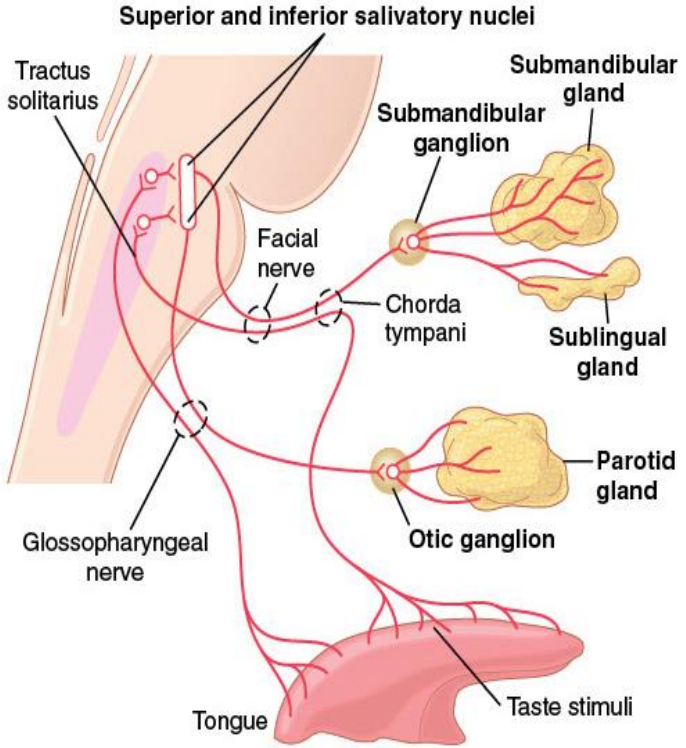
- **Oral stage (voluntary)**
- **Pharyngeal stage (involuntary)**
- **Esophageal stage (involuntary)**

Oral stage: is initiated voluntarily when the tongue forces a bolus of food (upward and backward against the palate) toward the pharynx which contains high density of somatosensory receptors. The activation of these receptors initiates the involuntary swallowing reflex in the medulla. From here on, swallowing becomes entirely automatic and can not be stopped.

Pharyngeal stage: Four Steps : 1. Soft palate is pulled upward 2. the epiglottis moves to cover opening of larynx 3. the upper esophageal sphincter relaxes allowing food to move from pharynx to esophagus and 4. peristalsis wave of contraction initiated in the pharynx moves food from pharynx through the upper esophageal sphincter. Breathing is inhibited during the pharyngeal stage of swallowing.

INGESTION OF FOOD

- **Swallowing (deglutition): The pharynx plays a role in respiration as well as swallowing.**
- **Generally swallowing can be divided into**
- **(a) an oral stage (voluntary),**
- **(b) a pharyngeal stage (involuntary)**
- **(c) an esophageal stage (involuntary)**



(I) Oral Stage of Swallowing (Voluntary):

The first stage of swallowing involves the voluntary rolling of the chewed food posteriorly into the pharynx by the upward and backward pressure applied by the tongue against the palate.

MECHANISM OF SWALLOWING

(II) Pharyngeal stage of Swallowing (involuntary): At the pharynx, the bolus of food stimulates epithelial swallowing receptor areas all around the pharynx opening and impulses from this area pass to the brain stem (swallowing center) and accordingly initiate a series of autonomic pharyngeal muscle contractions as follows: (5 steps):

(1)The soft palate is pulled upward to close the posterior nares which prevents the food from entering the nasal cavities.

(2) The palatopharyngeal folds on each side of the pharynx are pulled medially to approximate each other. These folds form a sagittal slit through which food must pass into the posterior pharynx.

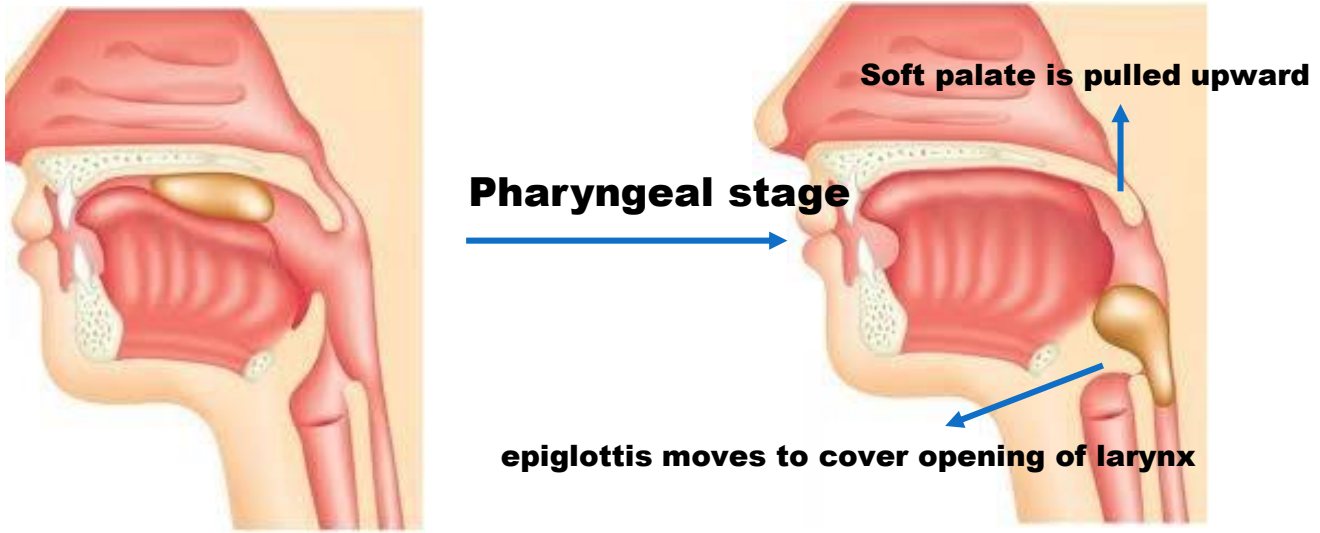
(3) The vocal cords of the larynx are strongly approximated and the larynx is pulled upward and anteriorly by the neck muscles. These actions and the ligaments that prevent the epiglottis from moving upward, cause the epiglottis to swing backward over the opening of the larynx. All these effects prevent food from going into the nose and trachea. Destruction of the vocal cords or the muscle that approximate them can cause strangulation.

(4) The upward movement of the larynx pulls up and enlarges the opening to the esophagus. The upper esophageal sphincter (or the pharyngoesophageal sphincter) relaxes and allows food to move freely from the posterior pharynx into the upper esophagus.

(5) Once the larynx is raised and the pharyngoesophageal sphincter relaxes, the entire muscular wall of the pharynx contracts (superior, middle, then inferior parts) propelling the food by peristalsis into the esophagus.

SWALLOWING REFLEX

-Swallowing movements are produced by a central pattern generator located in the medulla oblongata.
-It has been established on the basis of microelectrode recordings that the swallowing network includes two main groups of neurons.
One group is located within the dorsal medulla and contains the generator neurons involved in triggering, shaping, and timing the sequential or rhythmic swallowing pattern.
Interestingly, these generator neurons are situated within a primary sensory relay, that is, the nucleus tracts solitarii.
The second group is located in the ventrolateral medulla and contains switching neurons, which distribute the swallowing drive to the various pools of moto neurons involved in swallowing.



INGESTION OF FOOD (CONTINUED)

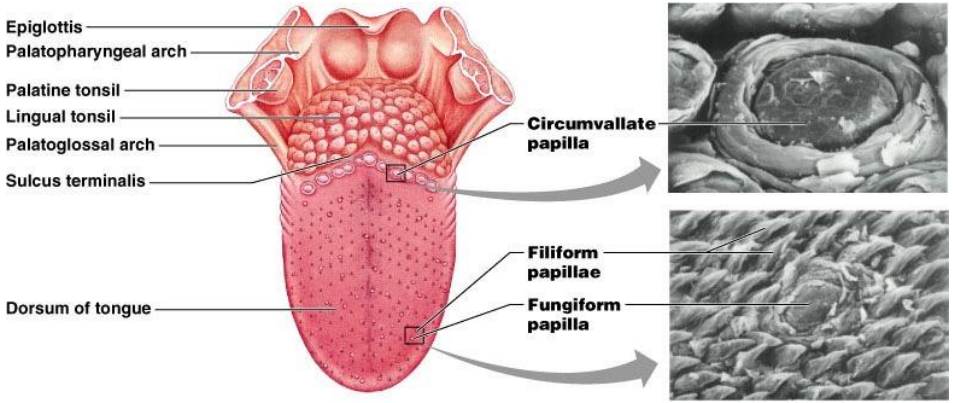
-Nervous initiation of the pharyngeal stage of swallowing: Sensory impulses from the mouth are received by the nucleus tractus solitarius (NTS) via the medulla oblongata through the trigeminal and glossopharyngeal nerves.

-The most sensitive areas of the posterior mouth and pharynx for initiating the pharyngeal stage of swallowing are located in a ring around the pharyngeal opening including the tonsillar pillars. The successive stages of swallowing are then automatically initiated by neuronal areas of the reticular substance of the medulla and lower portion of the pons (collectively called the deglutition or swallowing center).

-The motor impulses to the pharynx and upper esophagus are transmitted from the swallowing center by the 5th, 9th, 10th, and 12th cranial nerves and few of the superior cervical nerves.

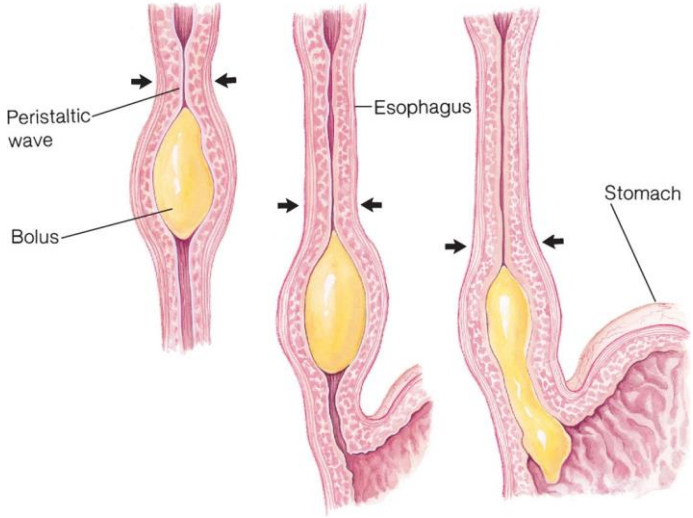
-Effect of the Pharyngeal Stage of Swallowing on Respiration: The entire pharyngeal stage of swallowing occurs in < 6 sec, during which time the swallowing center inhibits the respiratory center in the medulla which stops respiration during the swallowing cycle.

In summary, the pharyngeal stage of swallowing is a reflex act initiated by the voluntary movement of food into the back of the mouth which stimulates involuntary pharyngeal sensory receptors to elicit the swallowing reflex.



INGESTION OF FOOD (CONTINUED)

- **(III) Esophageal stage:**
- **The esophagus is a conduit to move food rapidly from the pharynx to the stomach.**
- **The esophageal stage is controlled partly by the swallowing reflex and partly by the enteric nervous system (ENS).**
- **When bolus of food passes through the upper esophageal sphincter, the swallowing reflex closes the sphincter so food cannot reflux into the pharynx.**
- **The musculature of the pharyngeal wall and upper 1/3 of esophagus (striated muscles) are innervated by vagus (10th cranial) & glossopharyngeal nerves (9th cranial), while the musculature of the lower two thirds of the esophagus is smooth muscle (controlled by the vagus through connections with the esophageal myenteric nervous system).**
- **In case of vagotomy* enteric nervous system takes over.**



recall: the Enteric Nervous System is the nervous system of GI tract. It lies entirely in the wall of the gut. The enteric nervous system is composed mainly of two plexuses:
(1) the myenteric plexus; controls mainly the gastrointestinal movements.
(2) the Meissner's plexus; controls mainly gastrointestinal secretion and local blood flow.

*a surgical operation in which one or more branches of the vagus nerve are cut

ESOPHAGEAL STAGE (CONTINUED)

It exhibits two types of peristaltic movements, primary and secondary peristalsis.

The primary peristalsis is simply a continuation of the peristaltic wave that begins in the pharynx and spreads into the esophagus during the pharyngeal stage of swallowing, This wave passes from the pharynx to the stomach in 8-10 sec.

If this primary peristaltic wave fails to move the food to the stomach, then the distention in the esophagus caused by the food will initiate secondary peristaltic wave which will continue until all the food is emptied into the stomach.

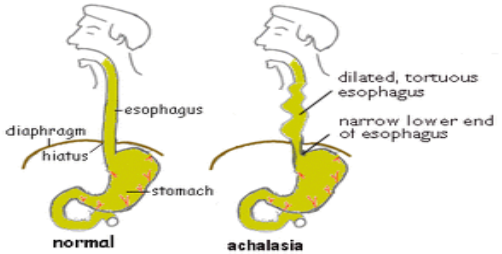
FUNCTION OF GASTROESOPHAGEAL SPHINCTER

- Receptive relaxation of the stomach.

Simply, When the esophageal peristaltic waves reaches the stomach through the food which reach the lower esophageal sphincter it causes an inhabitation to the peristaltic movement of the stomach via inhibition to the my enteric plexus "Which is responsible for GI motility".

- Function of the Lower Esophageal Sphincter (Gastroesophageal Sphincter).

Basically this sphincter is formed by circular muscles and its locate above the gastroesophegeal junction 3 cm. the important point is that this sphincter is TONICALLY contract and when the bolus reaches the sphincter it causes a " receptive relaxation " which finally end into a relaxation to this sphincter. If the process failed this will lead to accumulation of the food on the sphinchter and this process called ACALASIA.



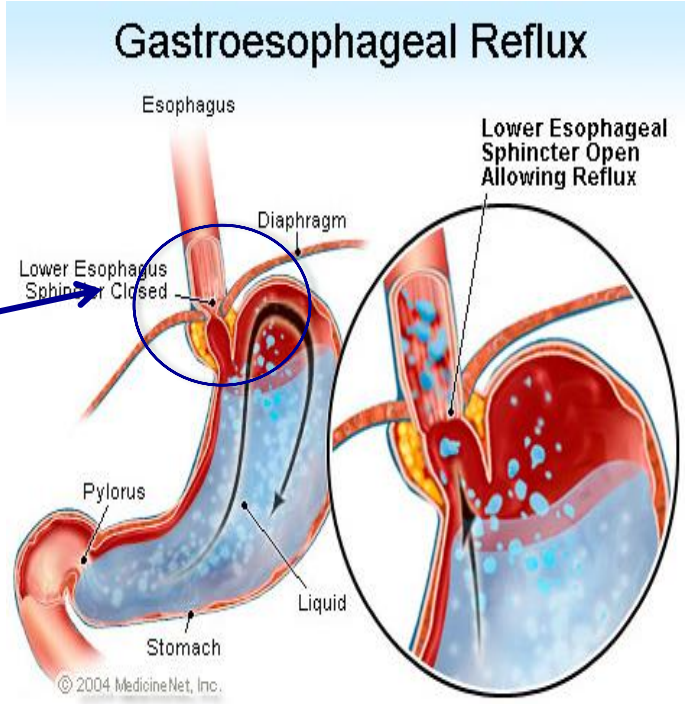
Tonic contraction means usually partially contract all the time.

Receptive relaxation is an inhalation to the motility by inhabits the my enteric plexus

FUNCTION OF GASTROESOPHAGEAL SPHINCTER “CONTINUE”

- Additional Prevention of Esophageal Reflux by Valve-like Closure of the Distal End of the Esophagus**.**

This another “protective stage” which prevent the gastroesophageal reflux.
As we can see in the picture, there’s short portion of the esophagus that extends slightly into the stomach and that caves the esophagus inward in response to increased intra-abdominal pressure.



RECALL! We had a similar valve like this one in the urinary bladder which prevent the reflux of the urine into ureter.

Cave means hollow out as if making a cave or opening “كهف”

FUNCTION OF GASTROESOPHAGEAL SPHINCTER (CONTINUED)

We have three mechanism which keep the valve close.

(1) Valve-like Closure mechanism.

(2) Diaphragm helping mechanism.

(3) Hormonal and neural mechanism.

VALVE-LIKE CLOSURE MECHANISM.

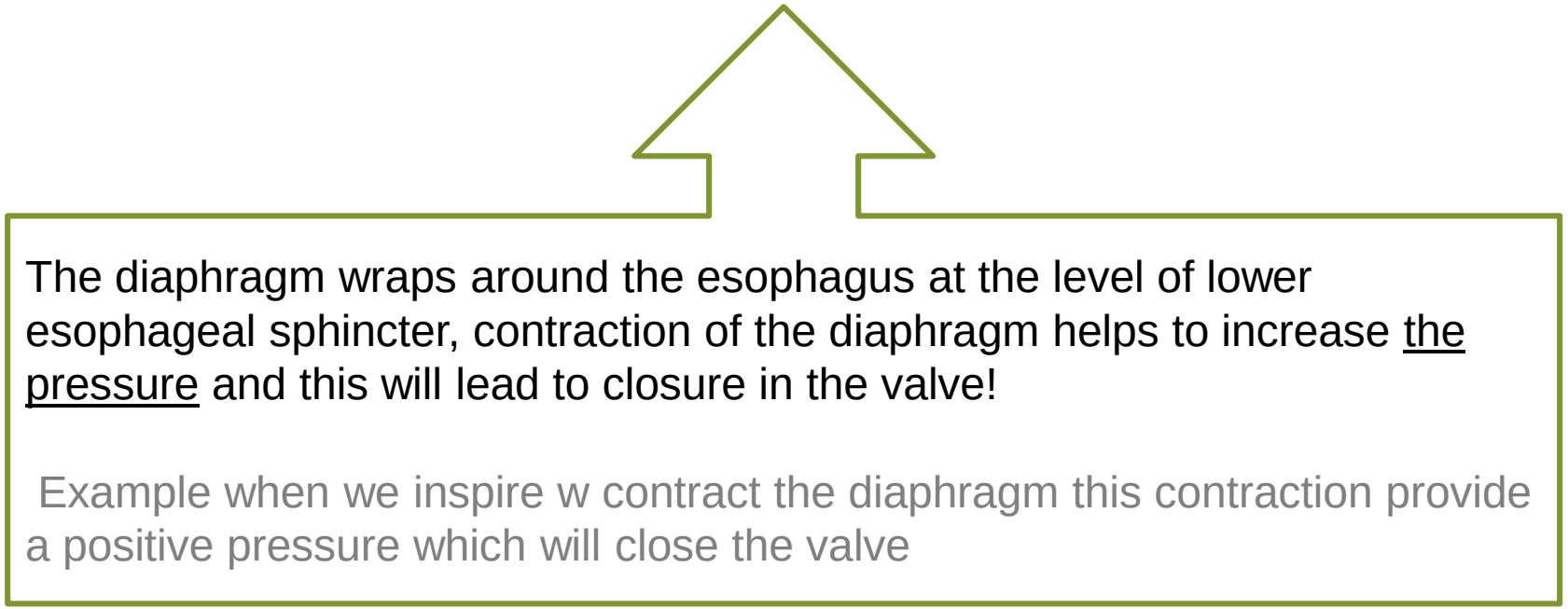
We got a resting pressure about 15-30 mmhg.

This valve lies immediately beneath the diaphragm and is exposed to a positive intra-abdominal pressure “ex. Gastric juice & obesity & pregnancy…”. This flutter-valve closure of the lower esophagus by the increased intra-abdominal pressure prevents the high pressure in the

we have to keep in mind that one of the factors that open and close the valve is the pressure!

This is another brief explanation: when we have an increase in intra-abdominal pressure through what I mentioned above this will lead to push the flutter valve upward and prevent this food to get back into esophagus.

DIAPHRAGM HELPING MECHANISM.



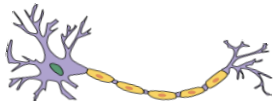
The diaphragm wraps around the esophagus at the level of lower esophageal sphincter, contraction of the diaphragm helps to increase the pressure and this will lead to closure in the valve!

Example when we inspire w contract the diaphragm this contraction provide a positive pressure which will close the valve

HORMONAL AND NEURAL MECHANISM.

- Contraction of the circular musculature of the sphincter is regulated by nerves &hormones & neurotransmitter.
- Between swallows, tonic vagal cholinergic impulses maintain contraction to keep the sphincter closed.

Neuronal mechanism:



During swallowing, efferent inhibitory impulses from vagus nerve cause the sphincter to relax. The transmitter probably being nitric oxide (NO) or vasoactive intestinal peptide (VIP).

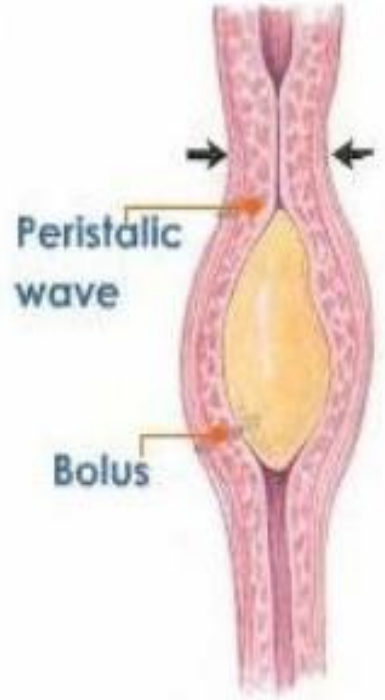
Hormonal mechanism:

The gastrin hormone, released from the stomach by food, contracts LES. Secretin and cholecystokinin (CCK), are released from the upper small intestine, relax the LES.

ACALASIA

الموضوع بسيط صمام وعيا ينفتح و تجمّع الأكل فوق
بس تعرفون «الفلسفة فلسفة»

- A condition due to high resting pressure at the LES that fails to relax during swallowing. As a result, food transmission from the esophagus into the stomach is prevented.
- Physiological basis of this condition is either pathology of or absence of the myenteric plexus containing VIP & NO in the lower third of esophagus.
- The musculature of the lower esophagus instead remains contracted and the myenteric plexus has lost the ability to transmit a signal to cause relaxation of the LES.



wonderful video that
explains the whole story

MCQs

Answer key: 1.C, 2.D, 3.C, 5.A, 6.C, 7.C & 8.B

1- Which phenomenon in salivary ducts explains why the final salivary secretion is hypotonic relative to the primary secretion of the acinar cells?
A. Secretion of water
B. Absorption of water
C. Absorption of more solutes than water
D. Secretion of more solute than water

2- Food in oral cavity under goes what kind of digestion?
A. Mechanical
B. Chemical
C. Radiation
D. Both A & B

3- Which ONE of the following is *most correct* about sympathetic stimulation over salivary glands:
A. Decreases salivary secretion initially
B. Increase watery secretion of saliva
C. Decreases salivary secretion when vasoconstriction superimposes
D. Increases salivary secretion

5- The estimated amount of saliva secreted a day normally is:
A. 800 to 1500 ml
B. 700 to 800 ml
C. 800 to 1500 l
D. 8 to 15 ml

6- The process of mastication is initiated by:
A. Stretch reflex
B. Jaw drop
C. Food bolus inhibiting jaw muscles
D. Jaw muscles contraction

7- Which ONE of the following is not a function of saliva:
A. Buffer
B. Speech
C. Antioxidant
D. Immunity

8- Which ONE of the following is a feature of unconditional reflex:
A. Psychic reflex
B. Innate

MCQs

Answer key: 9-B, 10- C, 11-A, 12-C, 13-B, 14- D, 15-D

9- swallowing center is located
A. in spinal cord
B. in the medulla
C. in the cerebellum
D. in the mid brain

10- When does swallowing becomes entirely automatic
A. 1st stage of swallowing (chewing)
B. 2nd stage (Pharyngeal stage)
C. 3rd stage (Esophageal stage)
D. its never autonomic

11- Function of the palatopharyngeal folds
A. force food to pass into the posterior pharynx.
B. prevent relapse of food
C. prevents the food from entering the nasal cavities.
D. cause the epiglottis to swing backward

12- The esophageal stage is controlled
A. the swallowing reflex
B. the enteric nervous system
C. the swallowing reflex and partly by the enteric nervous system
D. only the parasympathetic system

13- the lower Esophageal Sphincter is formed by
A. longitudinal muscles
B. circular muscles
C. longitudinal muscles and circular muscles

14- which of the following is a mechanism which keeps the valve (of the Gastroesophageal Sphincter) closed.
A. Valve-like Closure mechanism.
B. Diaphragm helping mechanism.
C. Hormonal and neural mechanism.
D. all of the above

15- which of the following cause the sphincter to relax.
A. Nitric oxide (NO)
B. Secretin
C. Cholecystokinin
D. All of the above

SAQs

Q1: Mention one of the function glands secretion in GIT.
Ans: Provide mucus for lubrication and protection.

Q2: List 3 ions in saliva, and their concentration compared to plasma.
Ans: Na (Low), K (High) and Cl (Low).

Q3: Mention three enzymes presented in saliva.
Ans: □-amylase, Lingual lipase and Kallikrein.

Q4: List 5 functions of saliva:
1- Speech
2- Buffer
3- Chemical digestion
4- Taste
5- Lubrication

Q5: What is the origin of parasympathetic innervation to the parotid gland?
Ans: Inferior salivary nucleus

Q6: List the three major salivary glands and the type of secretion of each.
1- Parotid gland (serous)
2- Submandibular gland (serous and mucous)
3- Sublingual gland (serous and mucous)

Q6: how the does the Diaphragm help in the valve closure mechanism.

Ans: The diaphragm wraps around the esophagus at the level of lower esophageal sphincter, contraction of the diaphragm helps to increase the pressure and this will lead to closure in the valve.

Q7: What is achalasia?

Ans: A condition due to high resting pressure at the LES that fails to relax during swallowing. As a result, food transmission from the esophagus into the stomach is prevented.

Q8: during the Pharyngeal stage of Swallowing, explain the helping mechanism of the of palate, the palatopharyngeal folds, and the vocal cords.

Ans:

(1) The soft palate is pulled upward to close the posterior nares which prevents the food from entering the nasal cavities.

(2) The palatopharyngeal folds on each side of the pharynx are pulled medially to approximate each other. These folds form a sagittal slit through which food must pass into the posterior pharynx.

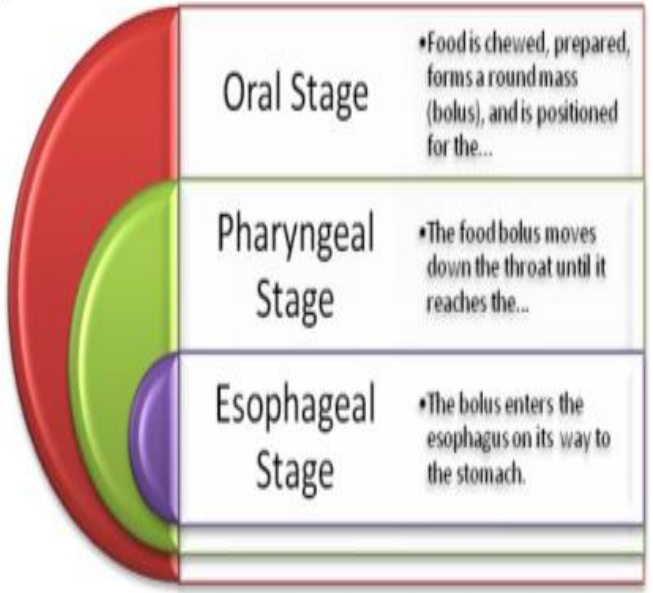
(3) The vocal cords of the larynx are strongly approximated and the larynx is pulled upward and anteriorly by the neck muscles. These actions and the ligaments that prevent the epiglottis from moving upward, cause the epiglottis to swing backward over the opening of the larynx. All these effects prevent food from going into the nose and trachea. Destruction of the vocal cords or the muscle that approximate them can cause strangulation.

Q9: how does the swallowing reflex function?

Ans: the swallowing reflex center is located in the medulla oblongata. It triggering the timing of the rhythmic swallowing pattern. Generator neurons are situated within a primary sensory relay, that is, the nucleus tractus solitarii. which is transmitted by the 5th, 9th, 10th, and 12th cranial nerves and few of the superior cervical nerves.

Thanks for checking our work

Good Luck



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There is no elevator to success, you have to take the Stairs