Digestive System

Salivary glands, swallowing & physiology of esophagus

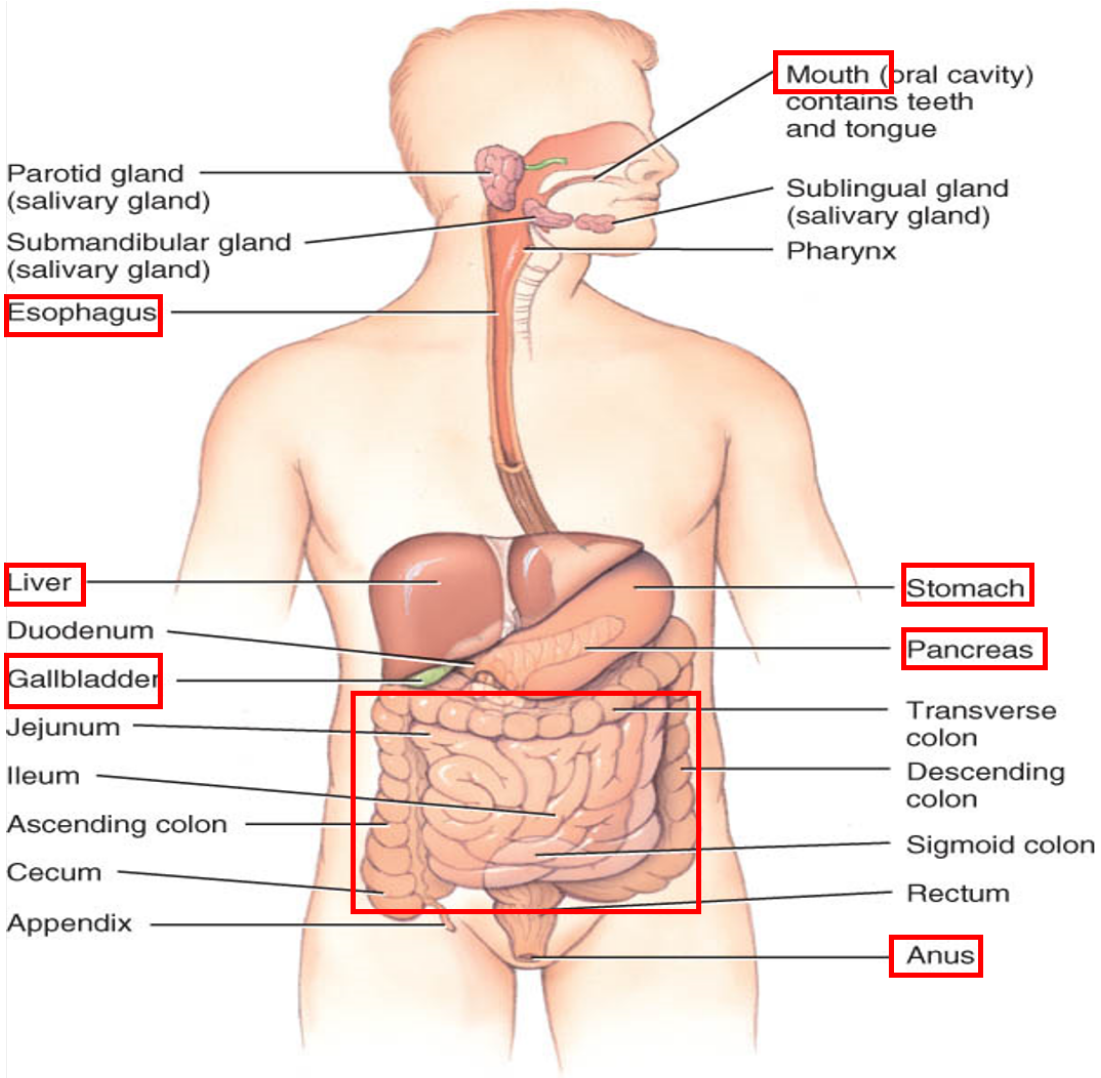
Dr. Hana Alzamil

Objectives

- Mastication & chewing
- Salivary glands
- Secretion of saliva
- Contents of saliva
- Functions of saliva
- Control of salivary secretion
- Swallowing
- Types of esophageal peristalsis
- Function of lower esophageal sphincter

Structure of GI Tract

- Arranged linearly in following sequence
  - Mouth,
  - Pharynx
  - Esophagus,
  - Stomach,
  - Small intestine,
  - Large intestine, and anus
- Other structures of GI tract (glands)
  - Salivary glands, pancreas, liver, and gallbladder



Right lateral view of head and neck and anterior view of trunk

Functions

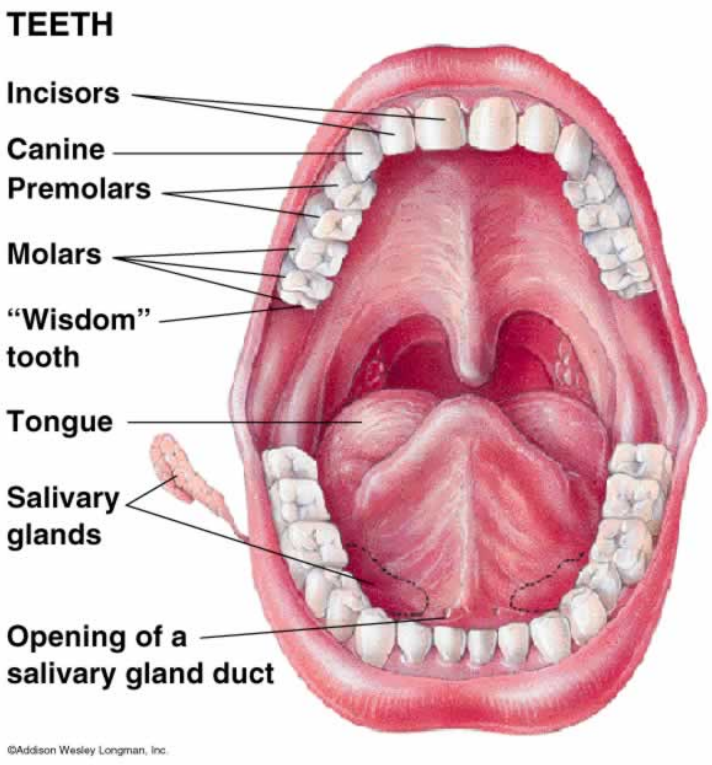
- 4 major activities of GI tract
  1. **Motility**
     - Propel ingested food from mouth toward rectum
  2. **Secretion**
     - Aid in digestion and absorption
  3. **Digestion**
     - Food broken down into absorbable molecules
  4. **Absorption**
     - Nutrients, electrolytes, and water are absorbed

Why Food Must be Digested?

Why Food Must be Digested?

- Nutrients in food are large molecules which cannot pass through the cell membranes.
- They must be broken down into molecules that are small enough to pass through the cell membranes.
- This process is called **digestion**.
- **Digestion** is the breaking down of large, complex food molecules into small, simpler molecules.
- Two types of Digestion
  - **Mechanical** & **Chemical**
- Digestion is performed by producing complex proteins called **enzymes**.

Mouth



- **Oral cavity**:

mechanical, chemical digestion

- Salivary glands**:**

saliva lubricates food

  - Saliva = mucus,
  - *salivary amylase* (starch breakdown)

- **Mastication:**

teeth chew food

Digestion in the Mouth

- **Mechanical digestion (mastication / chewing)**
  - Teeth are designed for chewing
  - Chewing muscles are innervated by 5th CN
  - Chewing process is caused by a reflex (food bolus in the mouth initiate the reflex by inhibiting muscles of mastication- drop of lower jaw-stretch of jaw muscles leads to contraction- followed by inhibition of muscles of mastication

Digestion in the Mouth

- **Chemical digestion**
  - Salivary amylase
    - Starch digestion at pH of **6.5** or **7.0**
    - Continues to digest for another **1 hour** in stomach
    - Stomach **acid inactivates** it
    - Substrate – **starch**
    - Product - **maltose**

Salivary glands

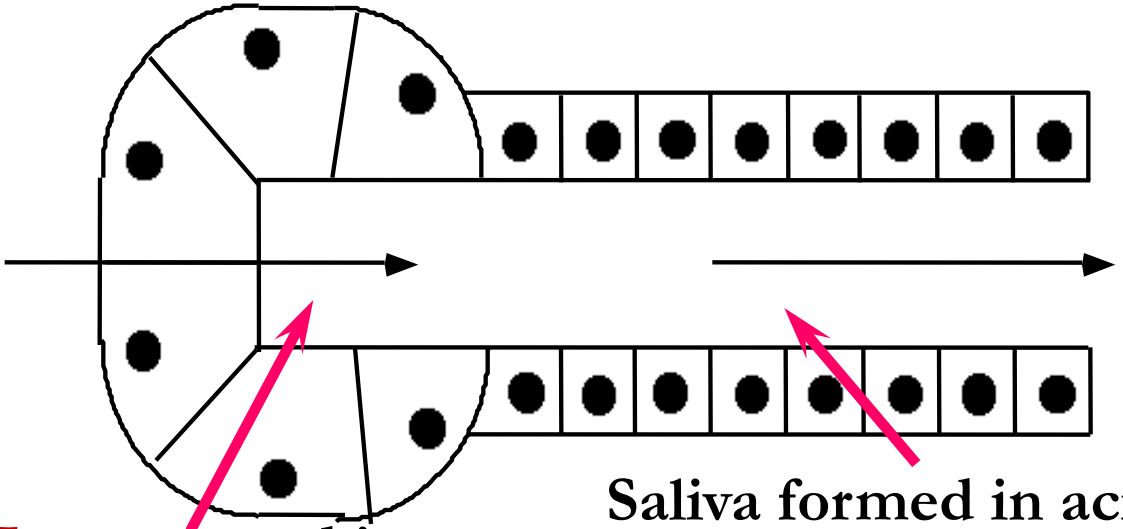
- Saliva secretion
- **800 - 1500** ml of fluid is secreted in a day
- This represents about **1/5** of the total plasma volume
- This fluid is not lost as most of it is swallowed and **reabsorbed** by the gut
- There are 3 pairs of salivary glands:
  - Parotid
  - Submandibular
  - Sublingual

Salivary glands

- There are many **small buccal glands** scattered in the mucosa of the mouth and pharynx discharge their secretion into the mouth.
- 2 types of cells in the acini:-
  - **Serous cells** which contain granules and secrete electrolytes, water and the enzyme ptyalin (amylase).
  - Larger **mucous cells** which secrete mucus and protein called mucin

THE SECRETORY UNIT

The basic building block of all salivary glands

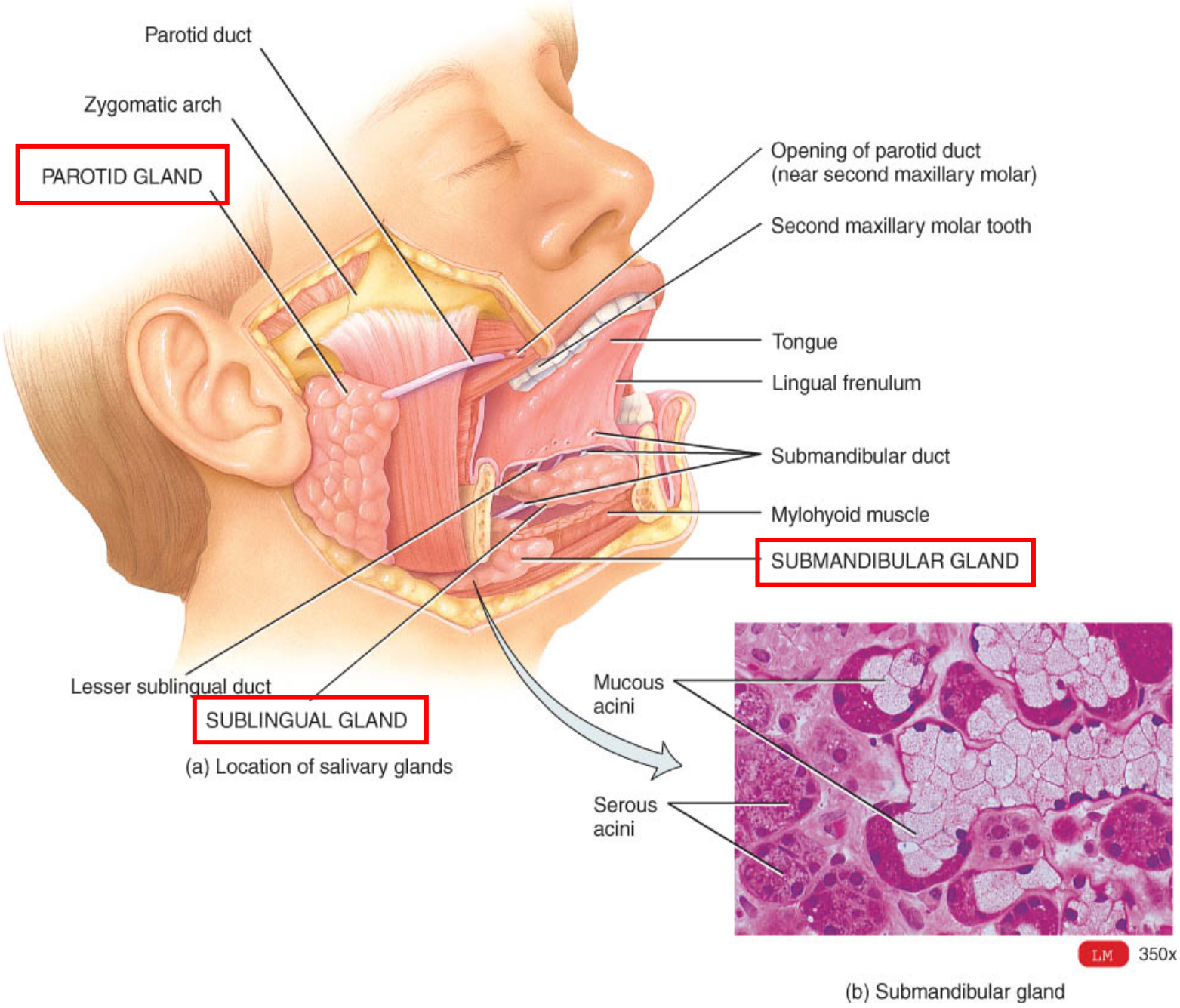


ACINI - water and ions derived from plasma

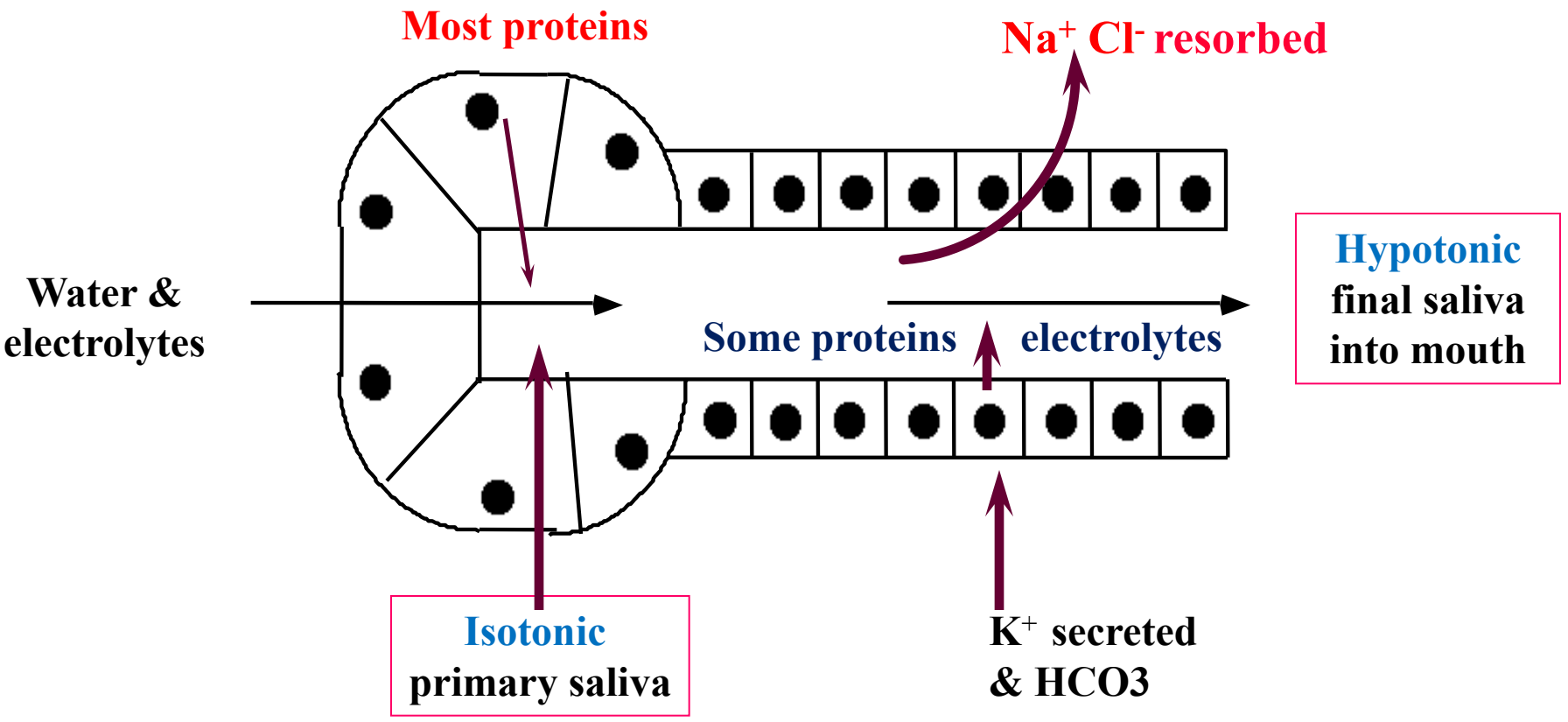
Saliva formed in acini flows down DUCTS to empty into the oral cavity.

Salivary glands

- An acinus may be purely serous or purely mucous or mixed.
  - Purely serous: parotid gland
  - Mixed: submandibular & sublingual glands.
  - Purely mucous: buccal glands
- The epithelial cells lining the intralobular ducts are metabolically very active and responsible for active transport of electrolytes
- Myoepithelial cells are found between the basement membrane and the cells lining the lumen of acini and intralobular ducts, they contract and increase salivary flow


Parotid duct
Zygomatic arch
PAROTID GLAND
Opening of parotid duct
(near second maxillary molar)
Second maxillary molar tooth
Tongue
Lingual frenulum
Submandibular duct
Mylohyoid muscle
SUBMANDIBULAR GLAND
Lesser sublingual duct
SUBLINGUAL GLAND
(a) Location of salivary glands
Mucous
acini
Serous
acini
LM
350x
(b) Submandibular gland

TWO STAGE HYPOTHESIS OF SALIVA FORMATION



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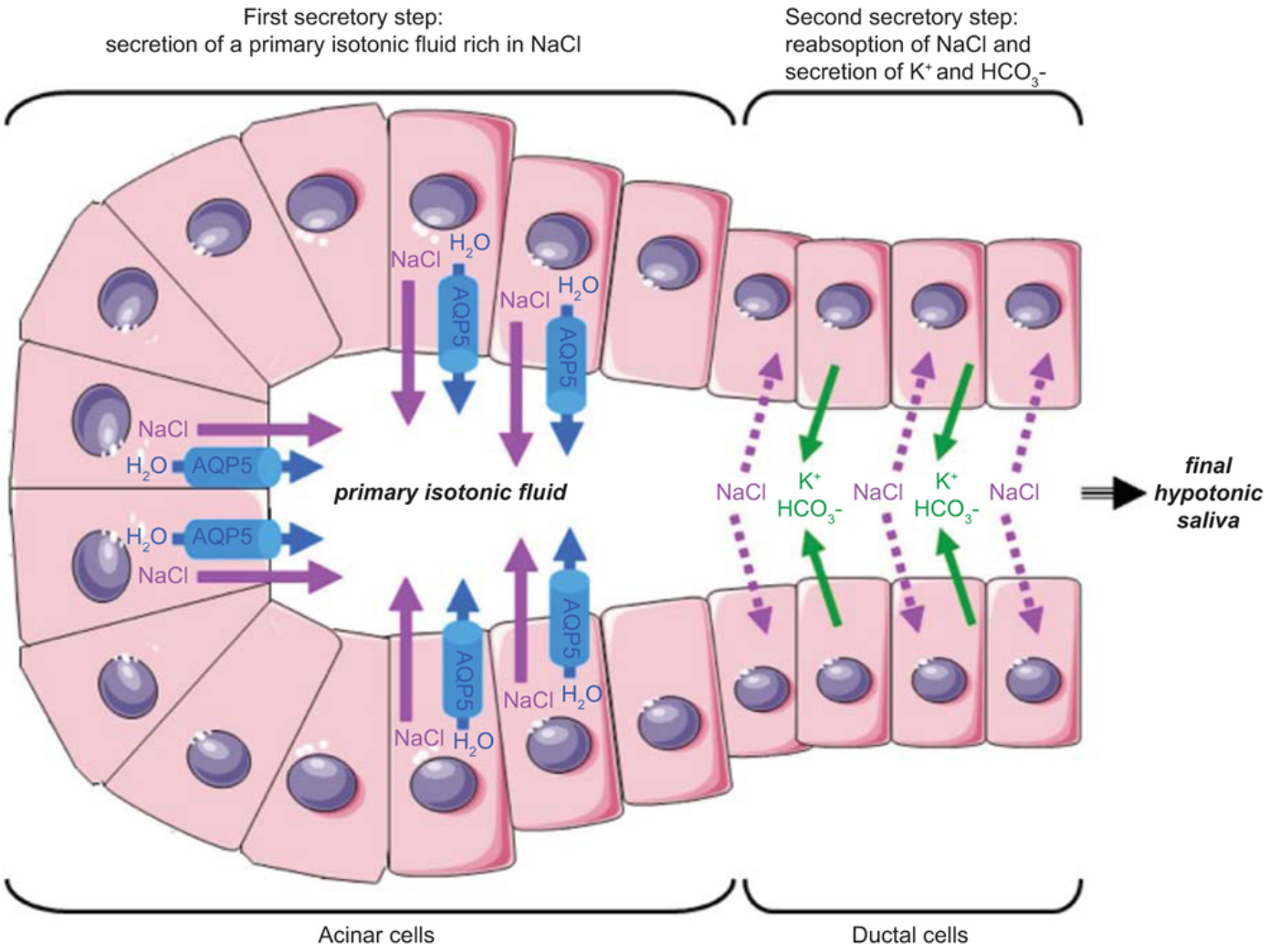
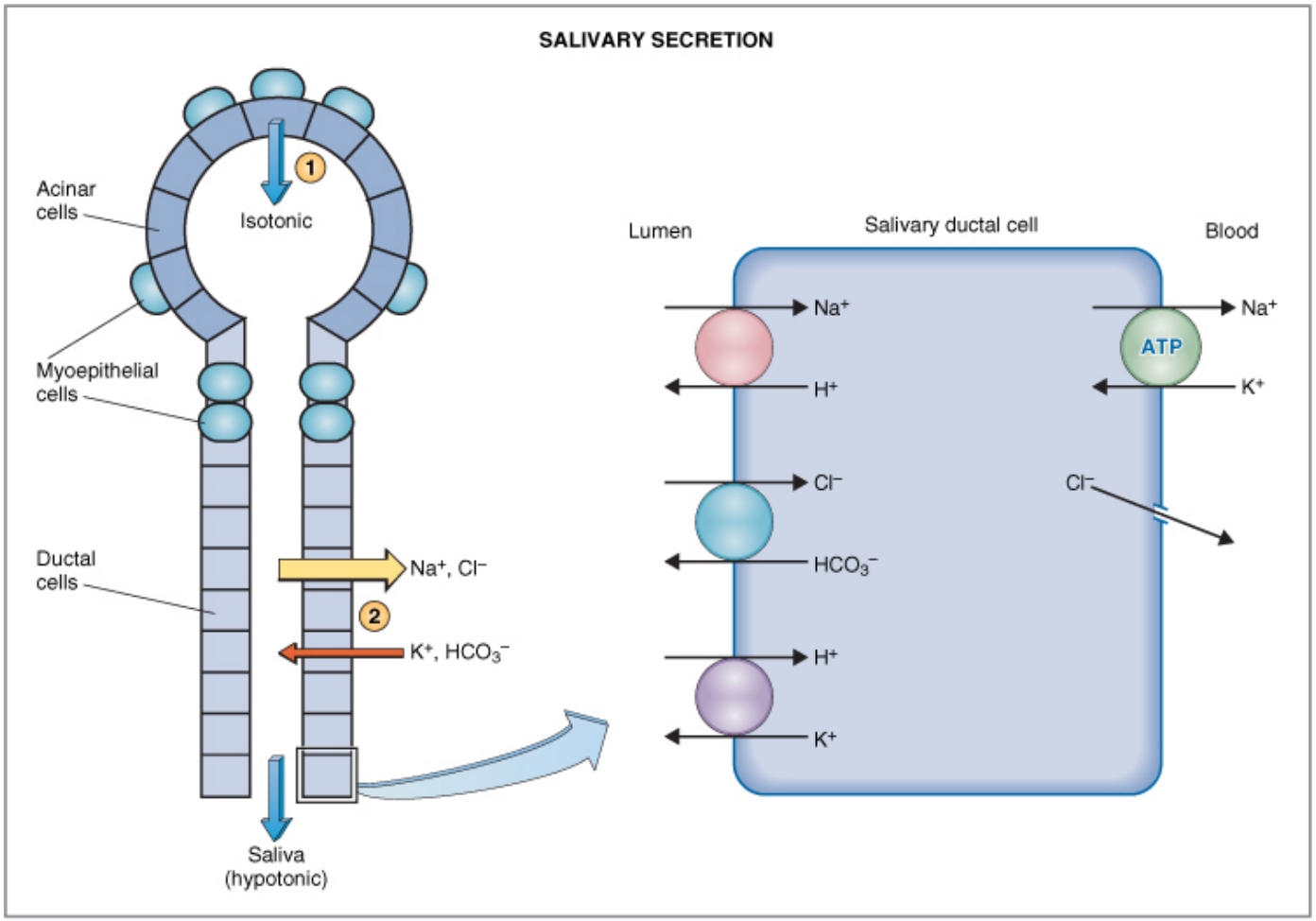




Mechanism of salivary secretion. Initial saliva is produced by acinar cells (*1*) and subsequently modified by ductal epithelial cells (*2*). ATP, Adenosine triphosphate

Salivary glands

- **Saliva Composition**
  - 99.5% water and 0.5% solutes
- **Saliva Functions**
  - Bicarbonate ions buffer acidic foods (pH 6.35-6.85) in mouth & esophagus
  - Chemical digestion of starch begins with enzyme (salivary amylase)
  - Mucus lubricates food & facilitate swallowing

Salivary glands

Functions

- Facilitate speech
- By acting as a solvent, saliva is important for the sense of taste
- Epidermal growth factor is responsible for healing of ulcers in the mucous membrane of oral cavity.
- Enzyme (lysozyme)helps destroy bacteria

Control of salivary secretion

- Salivary secretion is controlled exclusively by nervous mechanism through:
- Unconditioned reflex
- Conditioned reflexes.

Control of salivary secretion

1- Unconditioned reflex:-

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

2- Conditioned reflex

- 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 and stimulates the salivatory centers.
- In humans, mouth watering on seeing or thinking of food provides evidence of this psychic reflex.

- ***Nerve supply of salivary glands***

- ***I- Sympathetic nerves***

  Originate in the superior cervical ganglion and reach the 3 pairs of salivary glands through blood vessels

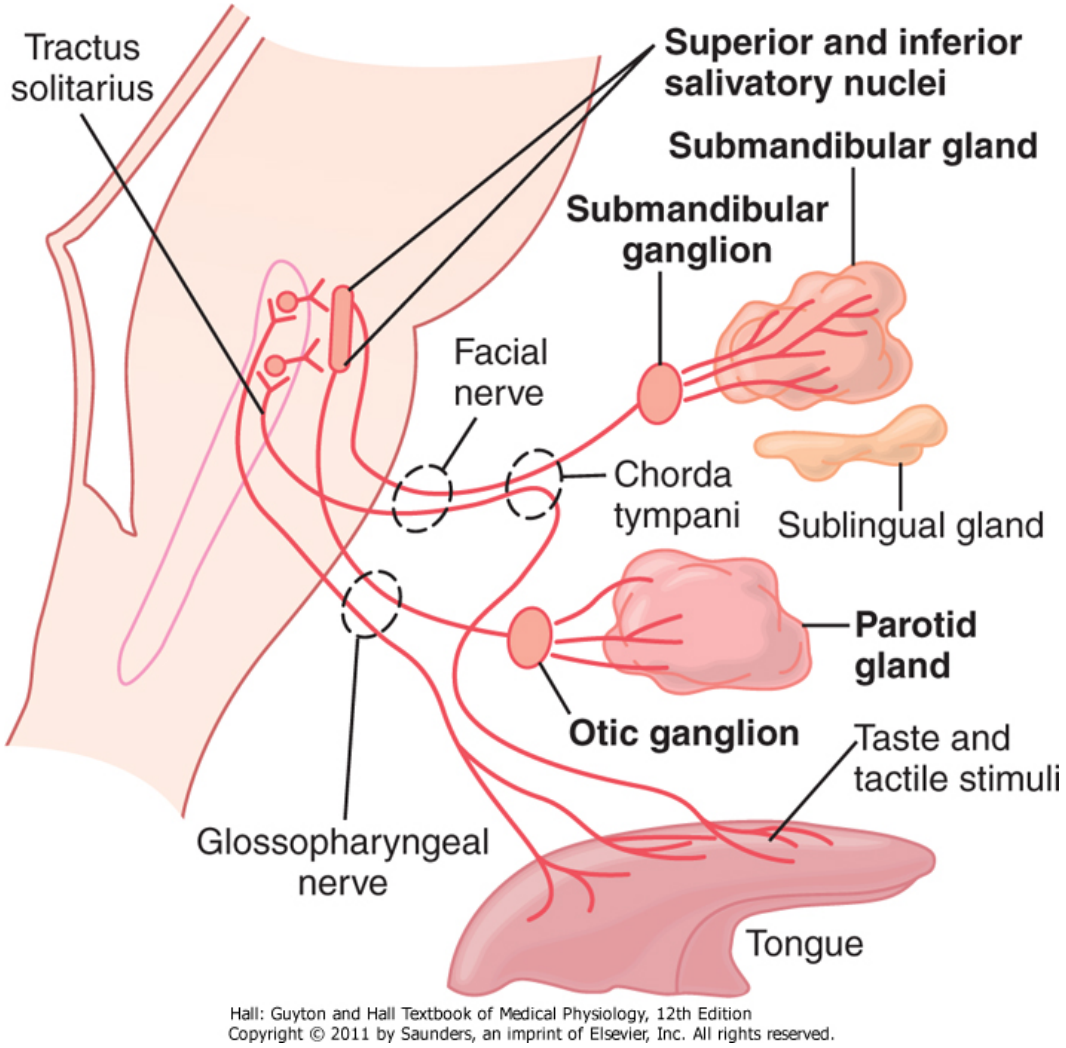
- ***Functions:-***
- Act on mucous cells and produce small amount of viscous secretion.
- Cause vasoconstriction.

II- Parasympathetic nerves

- ***Originate in the superior & inferior salivary nuclei in brain stem.***
  - ***Fibers from the superior salivary nucleus leave in VII cranial nerve supply both submandibular and sublingual glands.***
  - ***Fibers from the inferior salivary nucleus leave the medulla in IX cranial nerve supply the parotid gland.***

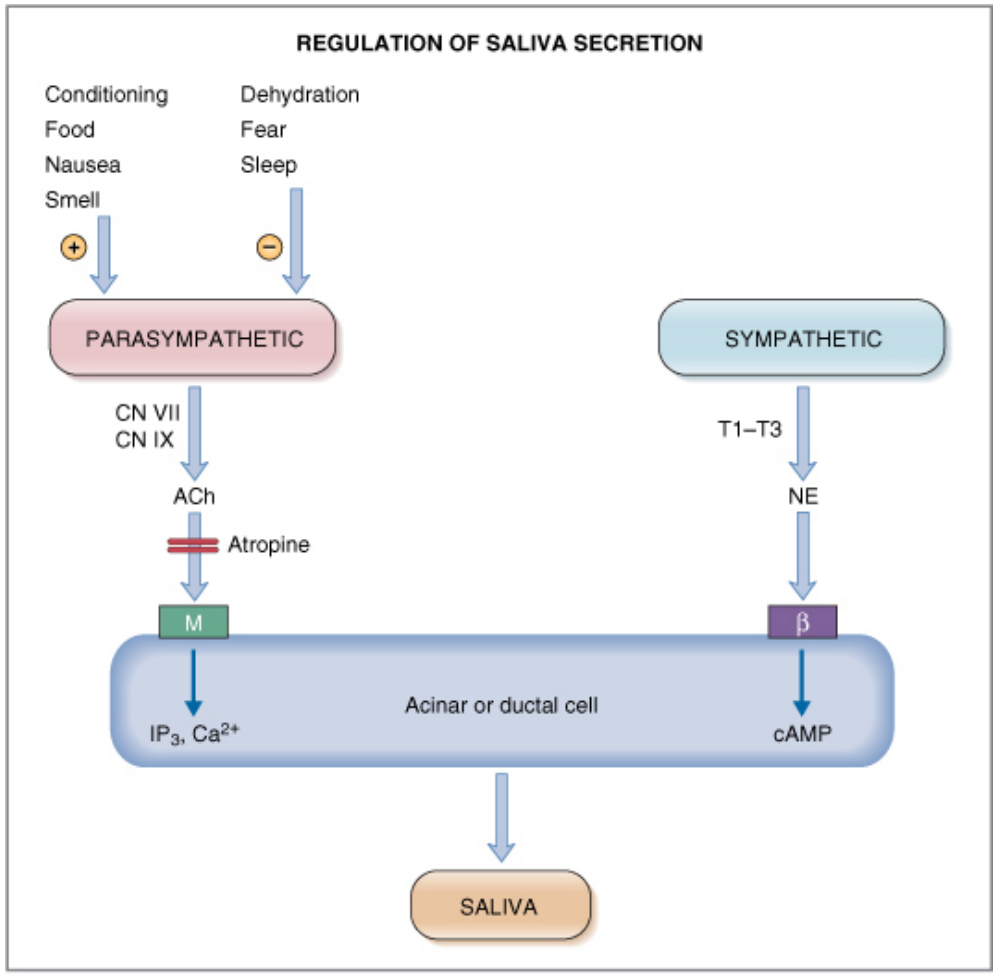
- ***Functions:-***

- ***Increase the synthesis and secretion of salivary amylase and mucin producing watery secretion (they act on serous cells).***
- ***Enhances the transport activities of ductal epithelium.***
- ***Increases blood flow due to marked vasodilatation (via release of kallikrin enzyme from active gland tissues) which cause conversion of α2 globulin into bradykinine, a potent vasodilator.***
- ***Stimulates glandular growth and metabolism.***

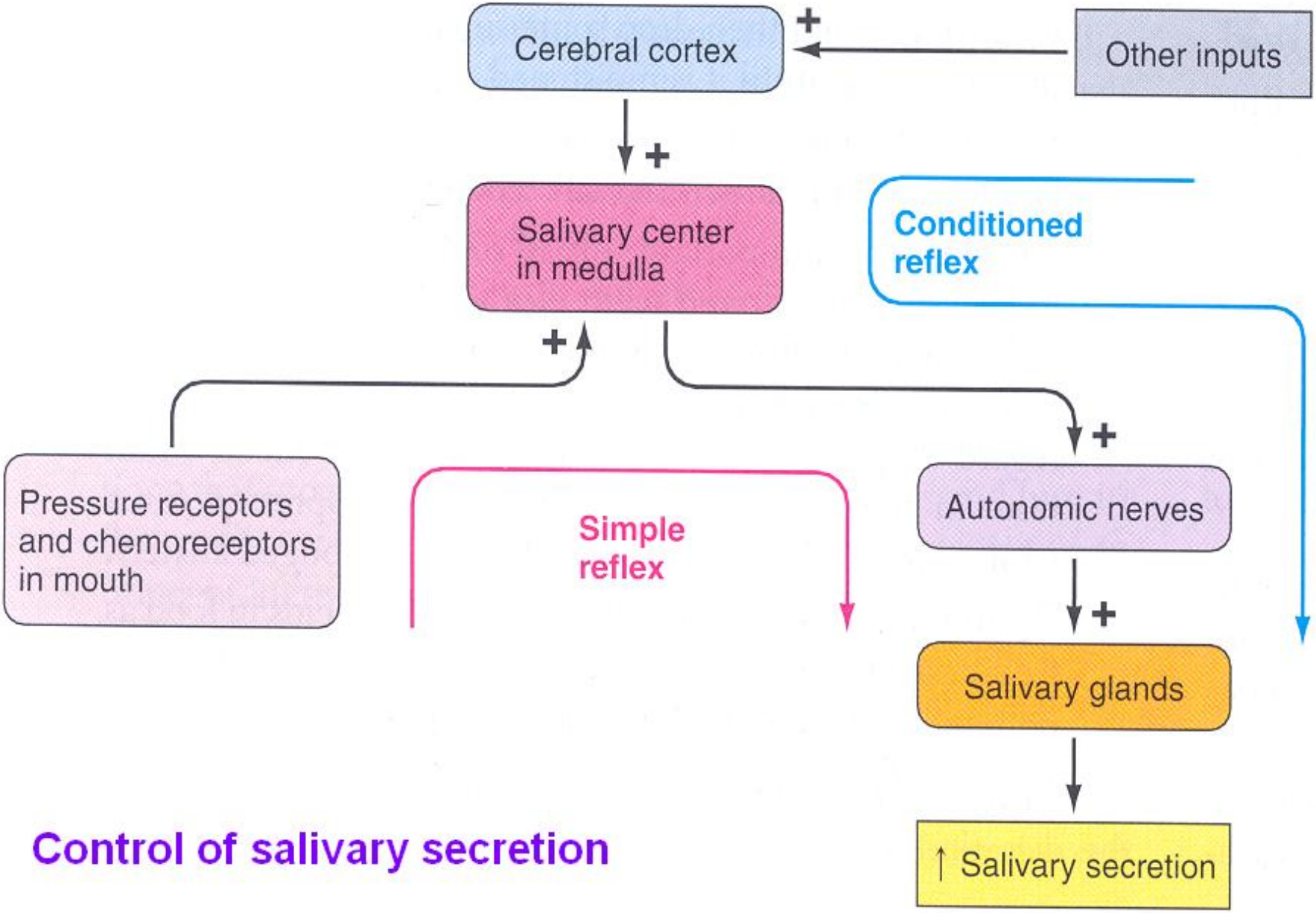


Parasympathetic nervous regulation of salivary secretion

Regulation of salivary secretion by the autonomic nervous system. ACh, Acetylcholine; β, β receptor; cAMP, cyclic adenosine monophosphate; CN, cranial nerve; M, muscarinic receptor; NE, norepinephrine; T1-T3, thoracic segments.



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

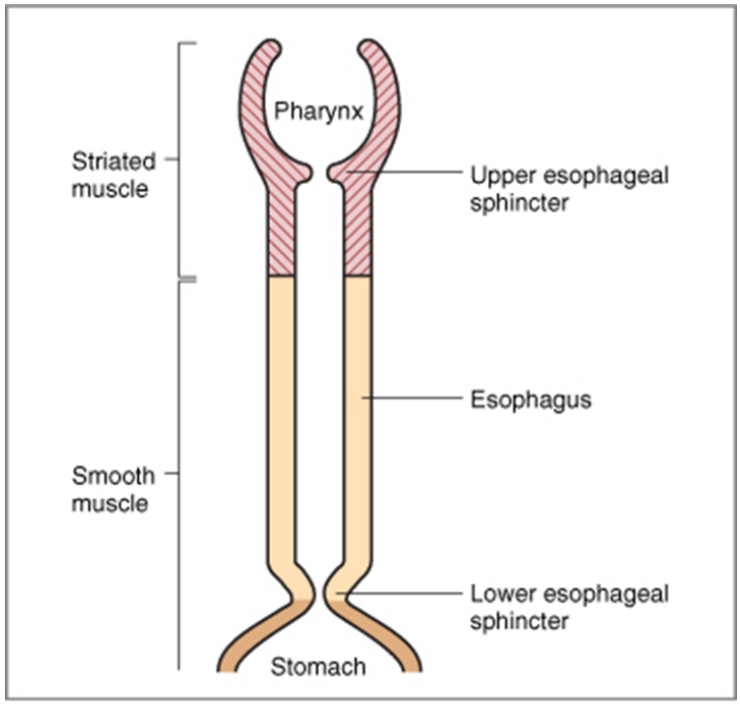


Control of salivary secretion

Esophagus

- Collapsible muscular tube that conveys food from pharynx to stomach (10 inches long)
  - Inner circular muscle
  - Outer longitudinal muscle
- Food passes through quickly

  because of **peristalsis**



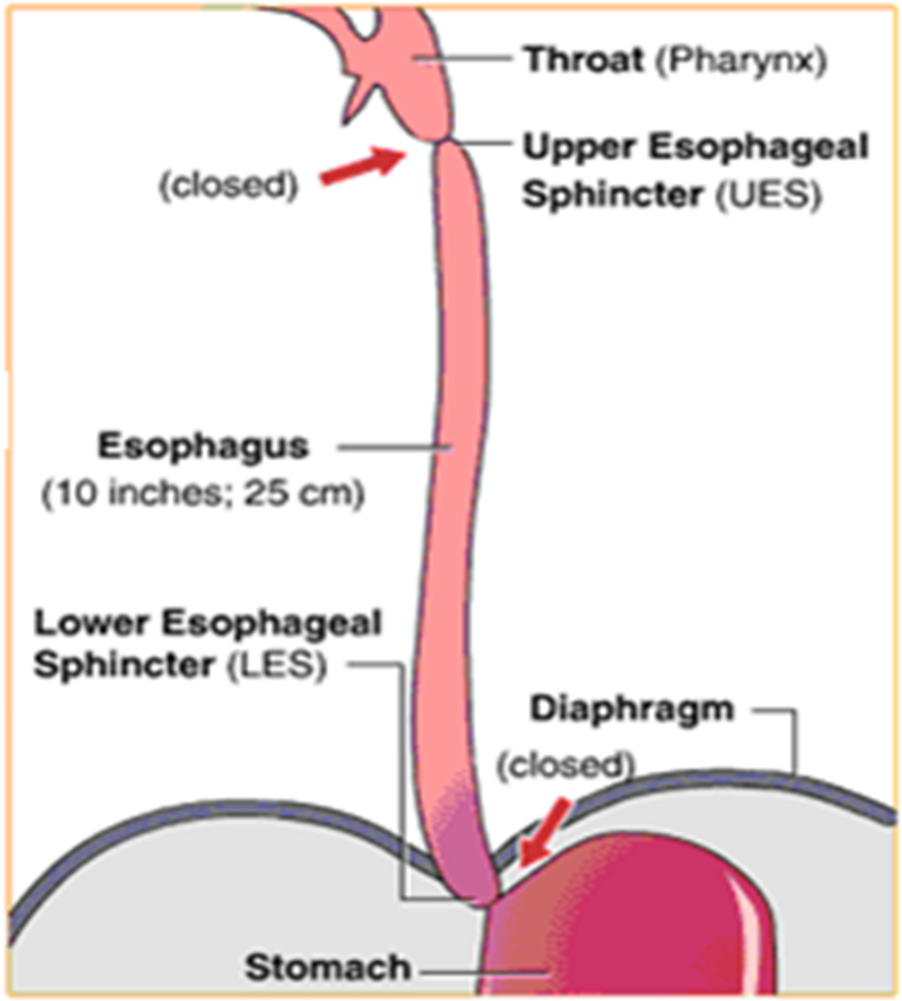
Physiologically

The esophagus is divided into three functionally distinct regions:

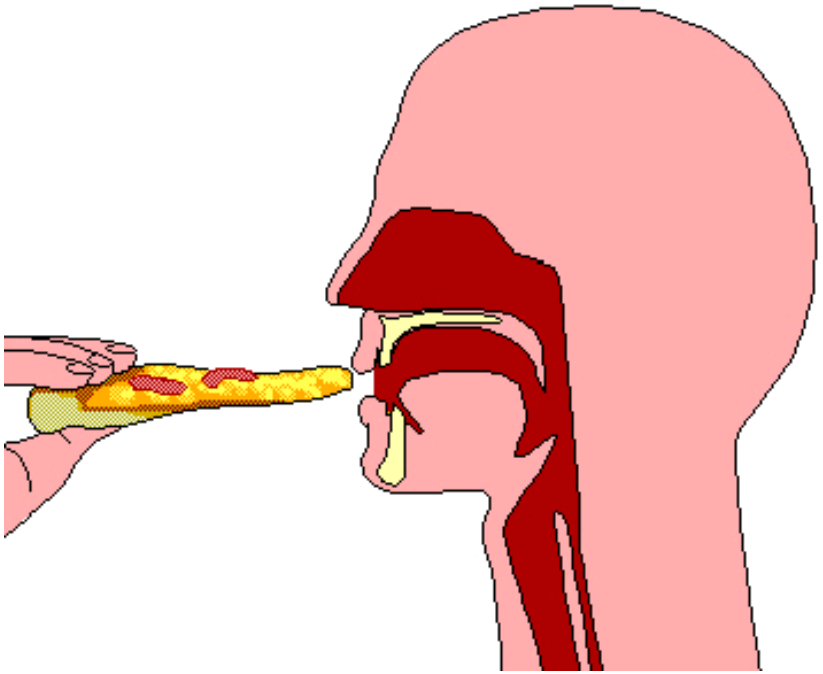
Upper esophageal sphincter.

Esophageal body.

Lower esophageal sphincter.



Swallowing (deglutition)



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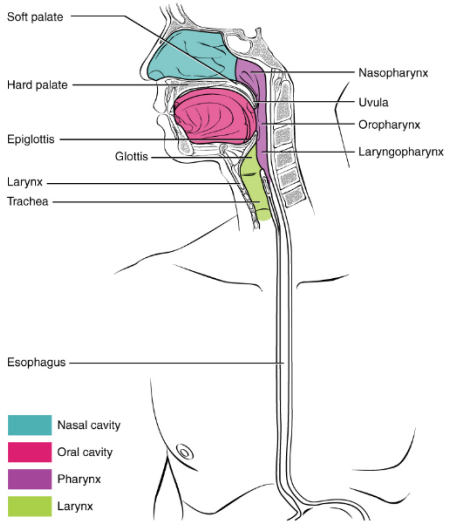
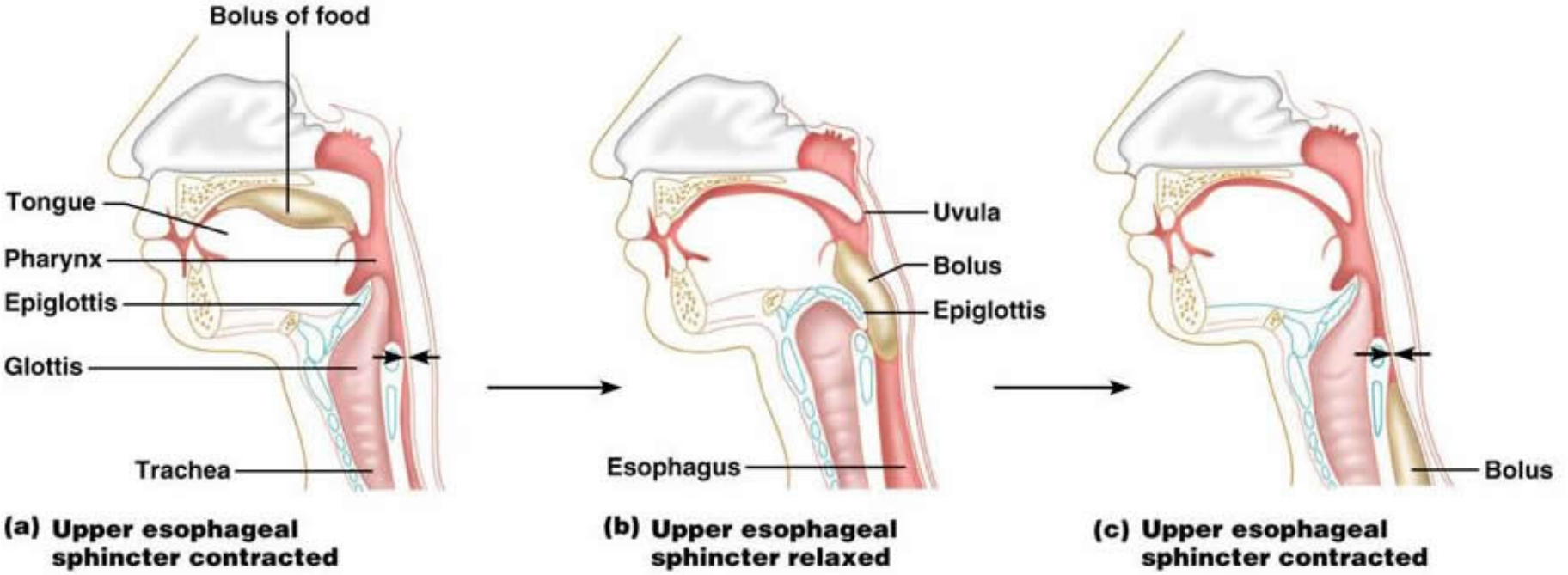
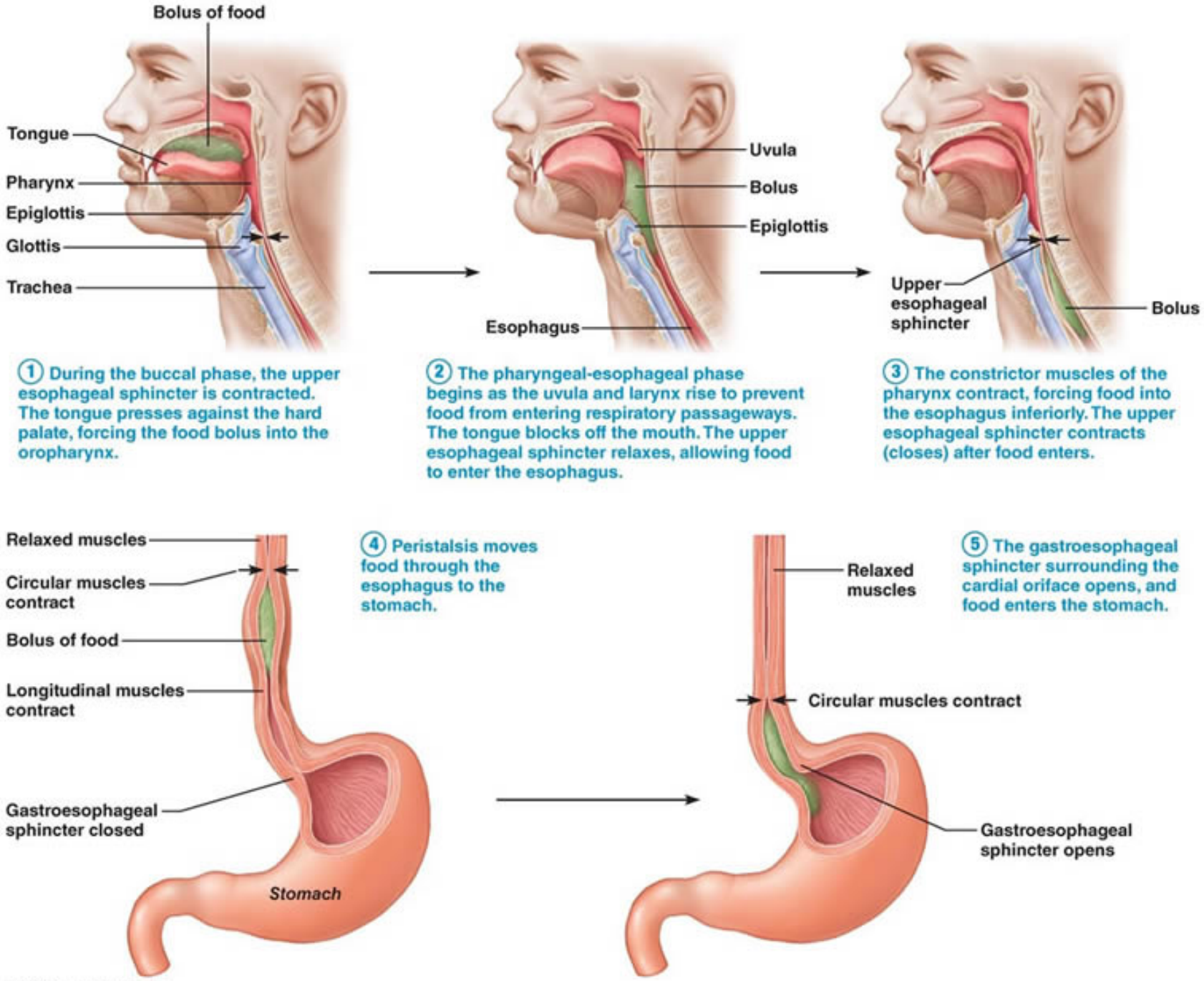
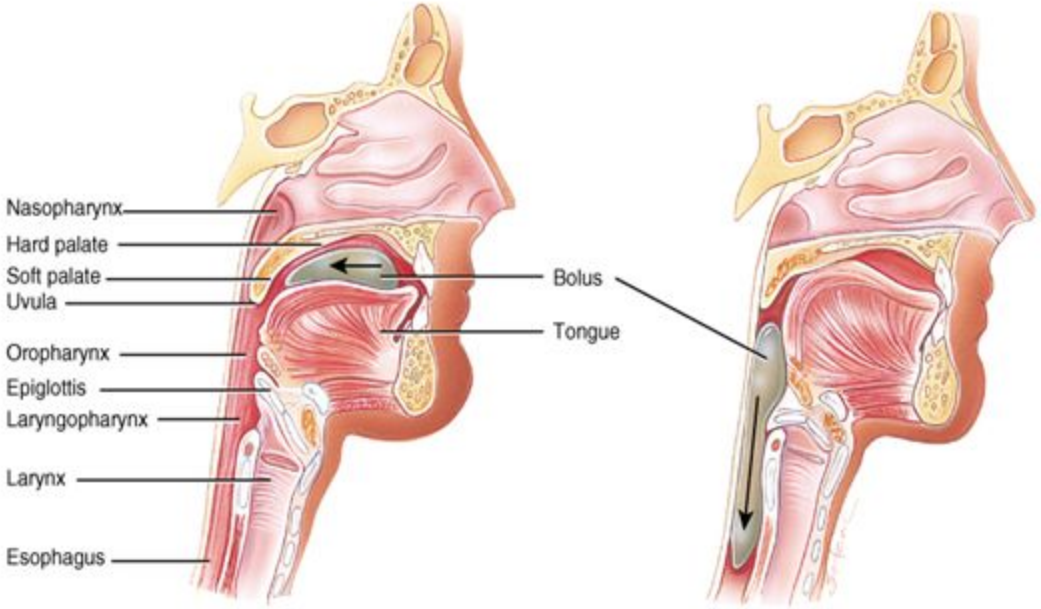
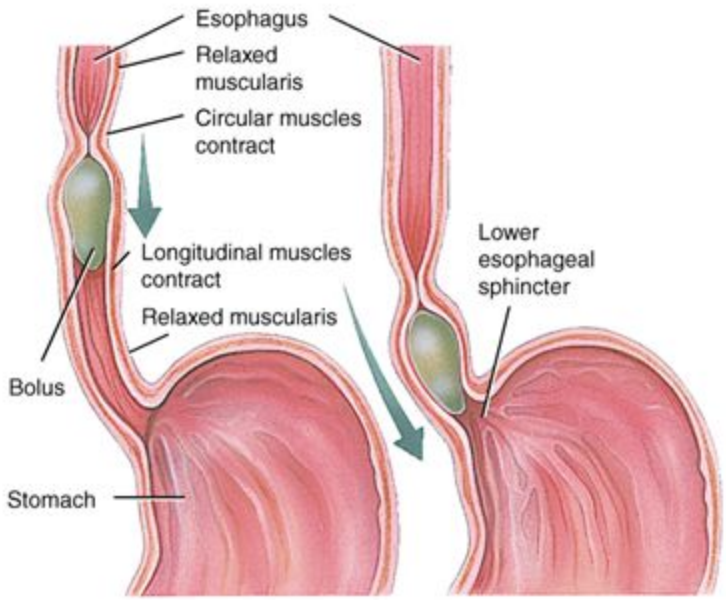






Physiology of the Esophagus - Swallowing





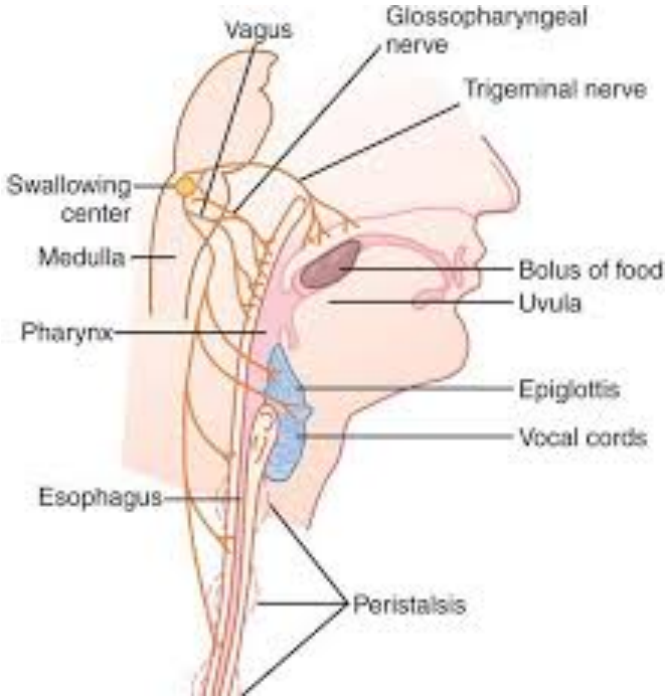
- ***Voluntary phase***---tongue pushes food to back of oral cavity
- ***Involuntary phase----pharyngeal stage***
  - breathing stops & airways are closed
  - soft palate & uvula are lifted to close off nasopharynx
  - vocal cords close
  - epiglottis is bent over airway as larynx is lifted
  - controlled by autonomic nervous system

Esophageal stage

- Peristalsis pushes food down
  - circular fibers behind bolus
  - longitudinal fibers in front of bolus shorten the distance of travel
- Travel time is 4-8 seconds for solids and 1 sec for liquids
- Lower sphincter relaxes as food approaches

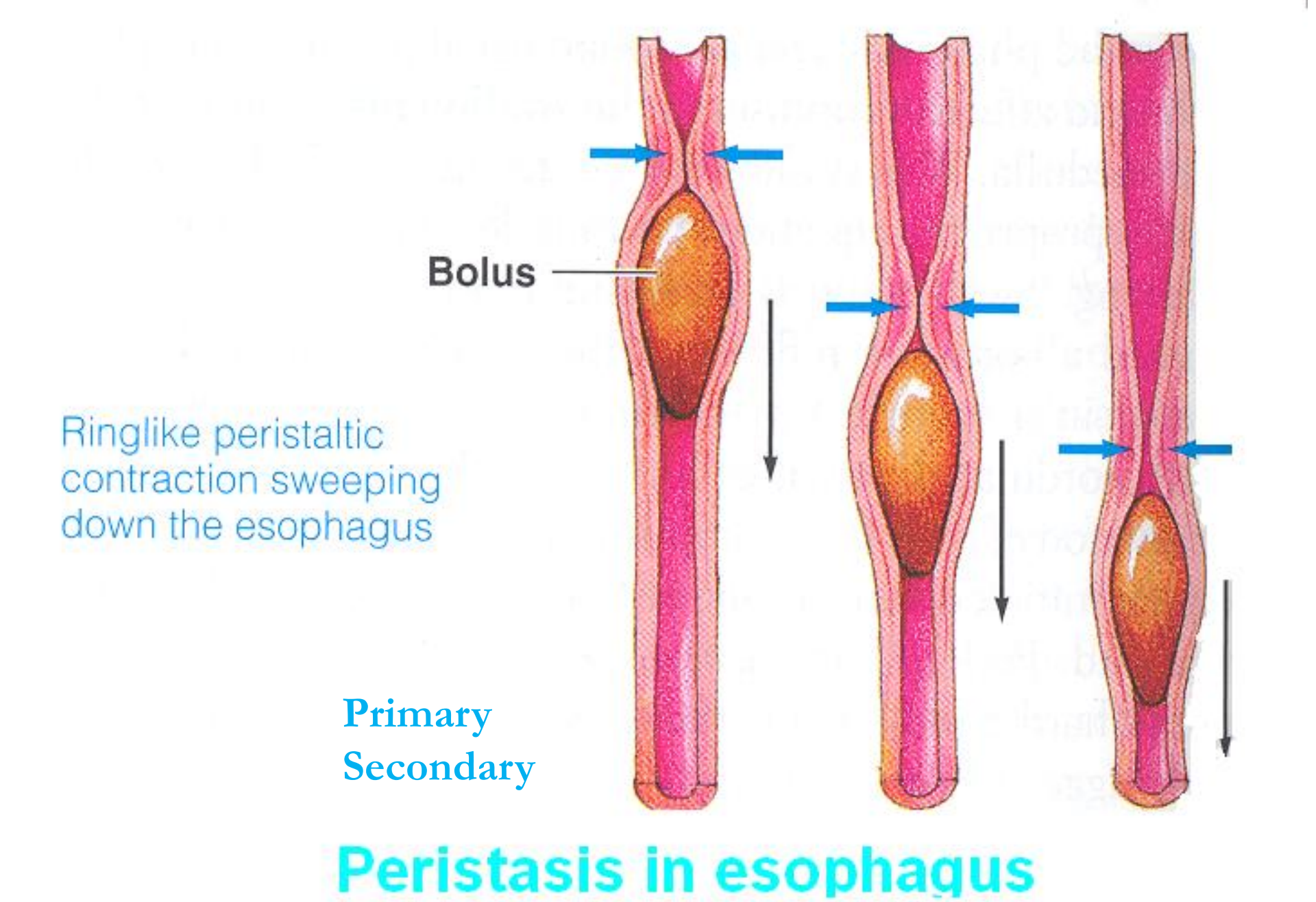
Nervous initiation of pharyngeal stage of swallowing

- Impulses transmitted from pharyngeal opening (greatest sensitivity at tonsillar pillars)
- Sensory nerves in 5^{th} & 9^{th} CN carry impulses to swallowing center in medulla & lower pons
- Motor impulses transmitted by 5^{th} ,9^{th},10^{th} and 12^{th} CN to pharynx and upper esophagus
- Swallowing center inhibit respiratory center during swallowing



Function of lower esophageal sphincter

- Also known as gastroesophageal sphincter
- Extends **3cm above** its junction with stomach
- Formed by circular muscles
- Normally remains tonically constricted
- Relaxes ahead of esophageal peristaltic wave
- Helps to **prevent reflux** of gastric juice
- **Valvelike mechanism** of short portion of esophagus that extend slightly into the stomach also helps in preventing reflux



Peristasis in esophagus

Thank You