ANATOMY AND PHYSIOLOGY OF **SWALLOWING**

KHALEEL ALYAHYA, PHD, MSC, MED

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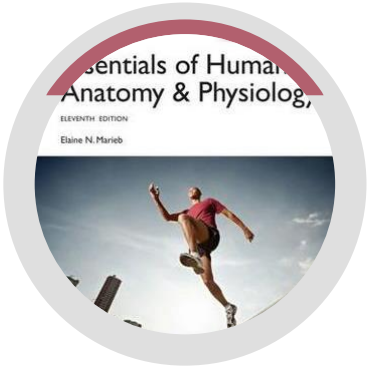
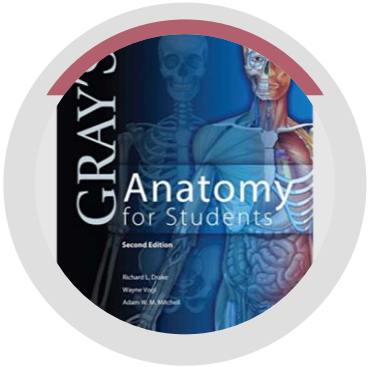
RESOURCES



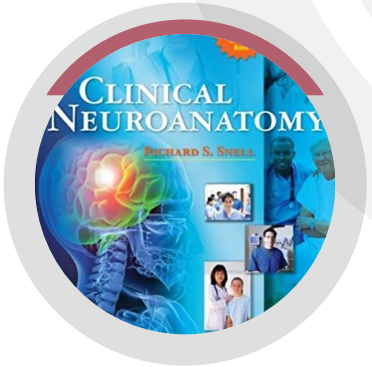
ESSENTIAL OF HUMAN ANATOMY & PHYSIOLOGY

By Elaine Marieb



GRAYS ANATOMY

By Drake, Vogl & Mitchell



CLINICAL NEUROANATOMY

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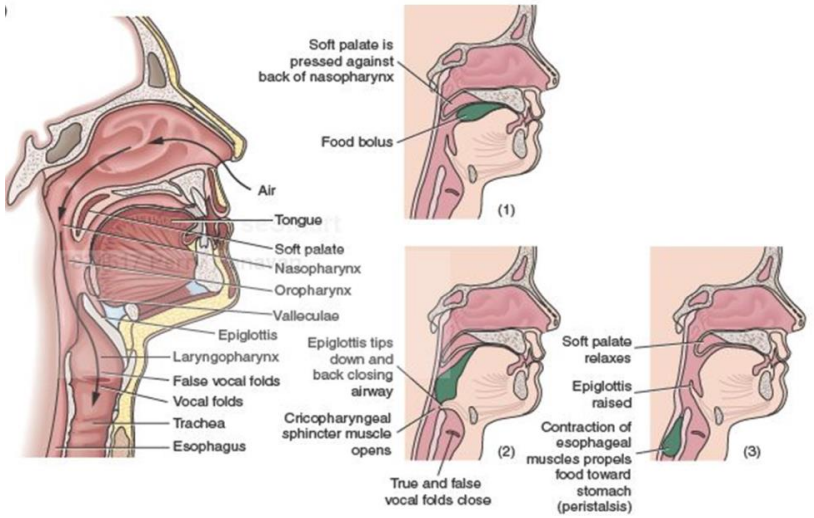
INTRODUCTION

- Swallowing involves coordinated activity of muscles of oral cavity, pharynx, larynx and esophagus.
- The whole process is partly under voluntary control and partly reflexive in nature.
- Swallowing by definition involves passage of bolus of food (solid/liquid) from the oral cavity to stomach via the pharynx and esophagus, passing over the entrance to laryngeal vestibule.
- Voluntary control of swallowing involves control of jaw, tongue, degree of constriction and length of pharynx and closure of laryngeal inlet.



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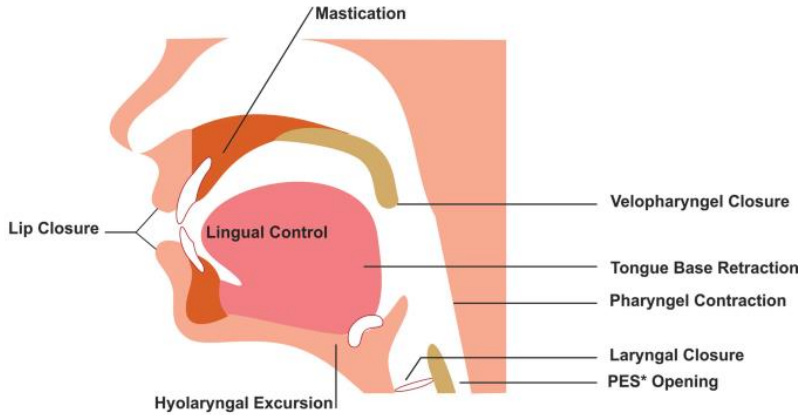
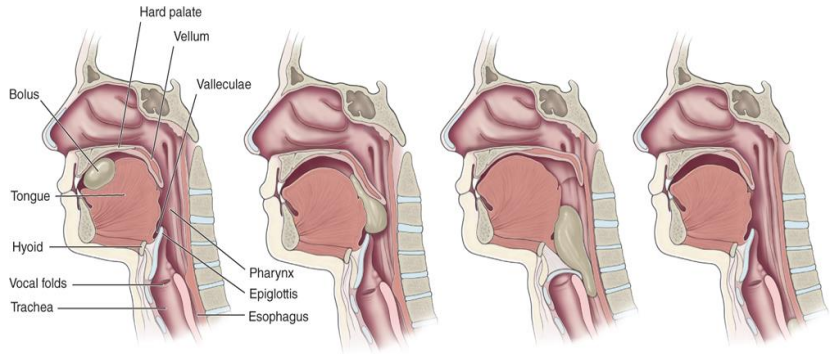
COMPONENTS

- Passage of bolus from oral cavity to stomach.
- Protection of airway.
- Inhibition of air entry into the stomach.



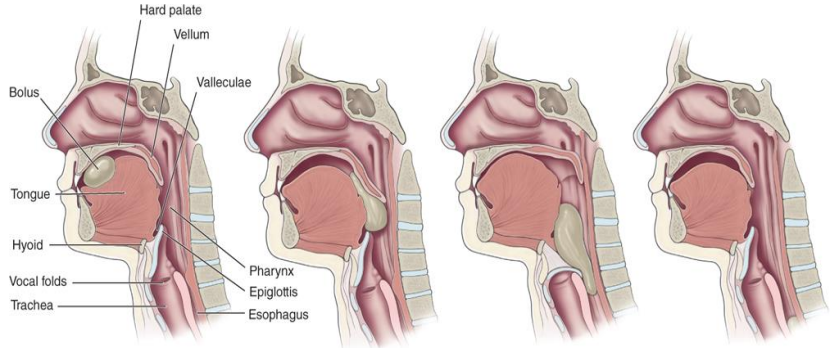
SWALLOWING PHASES

- There are three stages of swallowing:
    1. **Oral**
    2. **Pharyngeal**
    3. **Esophageal**



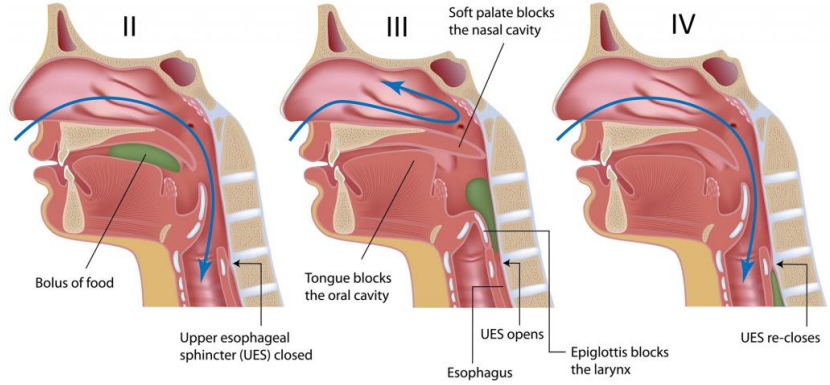
ORAL PHASE

- In this phase, food is prepared for swallowing by the process of mastication.
- This phase is divided into:
    - **Oral preparatory phase.**
    - **Oral phase proper.**
- This phase is under voluntary control.



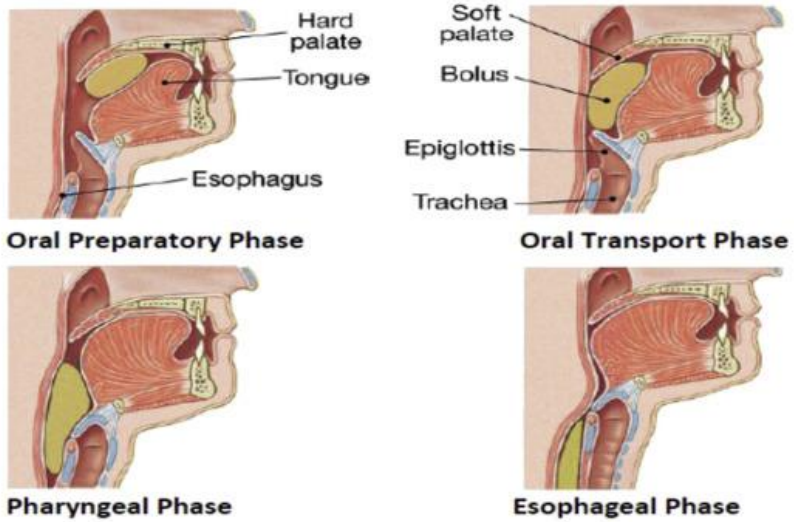
ORAL PREPARATORY PHASE

- This phase involves breaking down of food in the oral cavity.
- During this phase, the food is chewed and mixed with saliva making it into a bolus which can be easily swallowed.
- The elevators of **lower jaw** play an important role in bolus preparation.
- **Tongue** also plays a vital role in bolus formation by the action of its intrinsic muscles which alters its shape.



ORAL PREPARATORY PHASE

- The extrinsic muscles of tongue also changes its position within the oral cavity to help chewing the food by dental occlusion.
- Occlusal action of the lips help in creating an effective seal preventing the bolus from dribbling out of the oral cavity.
- The action of buccinator muscle helps in pushing the bolus out of the vestibule into the oral cavity proper.
- Salivary glands produce saliva which contains mucus, which binds the food together and helps in bolus formation.



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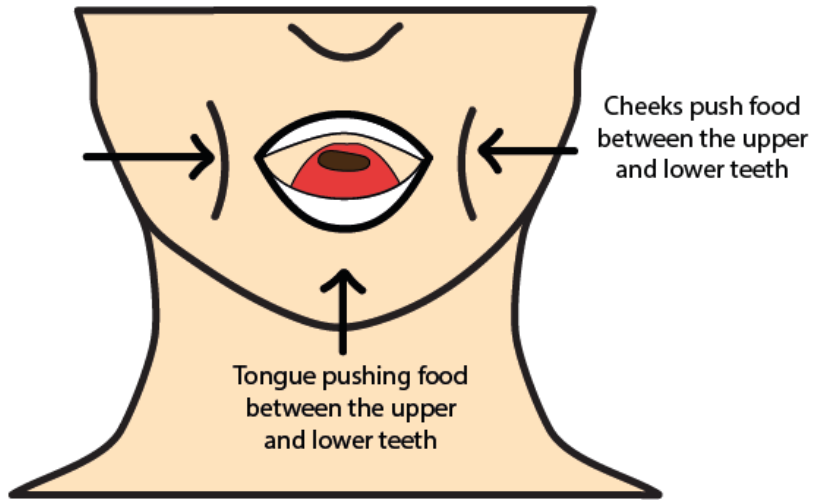
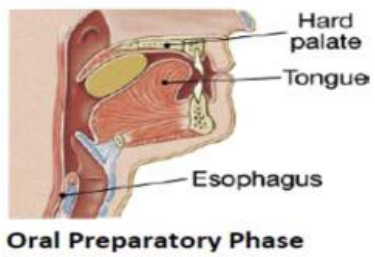
BOLUS FORMATION

- This is the most important function of preparatory phase.
- This involves continuous transfer of food from oral cavity to oropharyngeal surface of tongue.
- Bolus accumulates on the oropharyngeal surface of tongue due to repeated cycles of upward and downward movement of the tongue.
- The actions of the tongue and jaw muscles in bolus formation are aided by:
    - **Lips** in maintaining a seal.
    - **Buccinator muscle** in returning food from the vestibule into the oral cavity.
    - **Soft palate** in preventing nasal regurgitation and premature movement of material into the oropharynx.

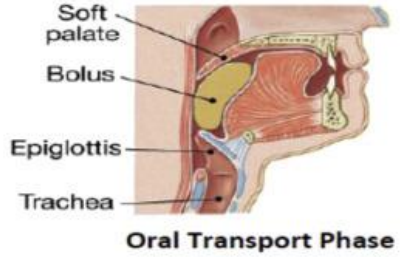


ORAL PHASE PROPER

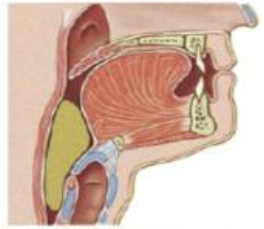
- During this phase, the bolus is moved towards the back of the tongue.
- The contraction of soft palate prevents nasal regurgitation, also prevents premature movement of bolus into the oropharynx.
- Once the bolus is ready to be sent from mouth to oropharynx, it just takes a couple of seconds.
- Tongue plays also a vital role during this phase.
- The intrinsic muscles contracts and reduces its size, while genioglossus muscle elevates the tongue towards the palate.
- The elevation of the mandible plays an essential role here.
- When the mandible is elevated, the suprahyoid muscles raises the hyoid bone.

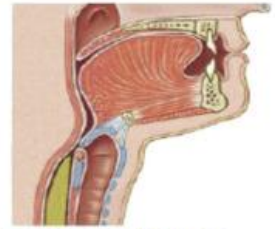


Oral Preparatory Phase



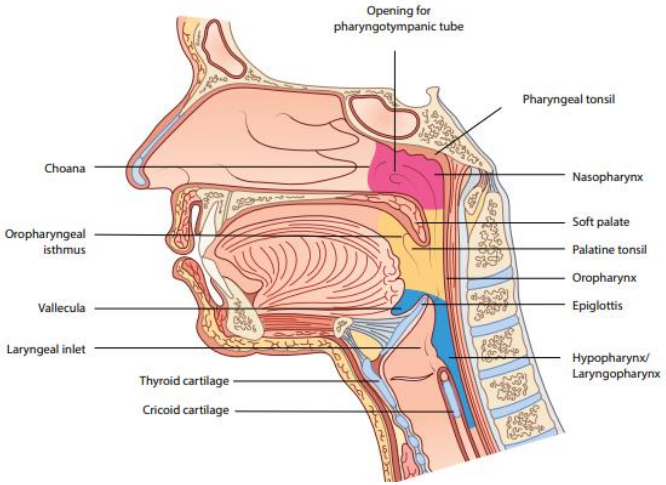
Oral Transport Phase


Pharyngeal Phase


Esophageal Phase

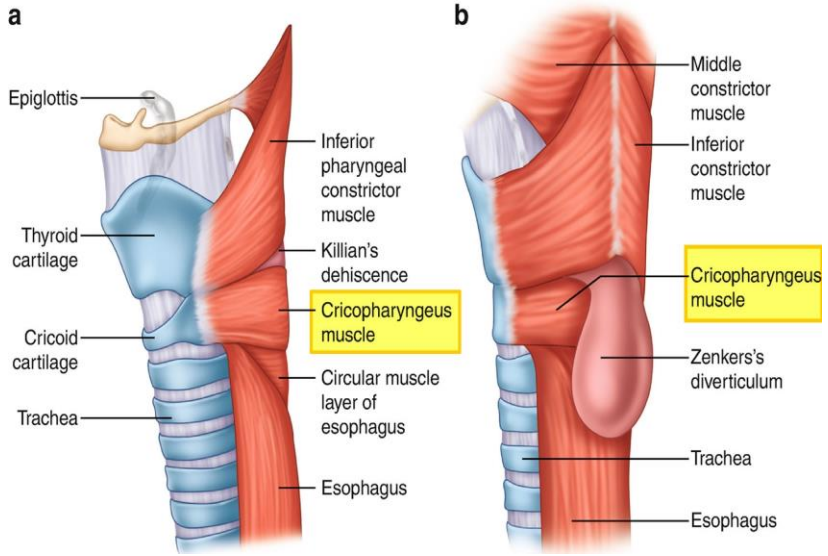
PHARYNX

- Once leaving the oral cavity, food enters the pharynx, a midline tube continuous with the oesophagus below and the nasal cavities above and the larynx which opens on its anterior wall.
- Pharynx is divided into three regions:
    - Nasopharynx.
    - Oropharynx.
    - Laryngopharynx.



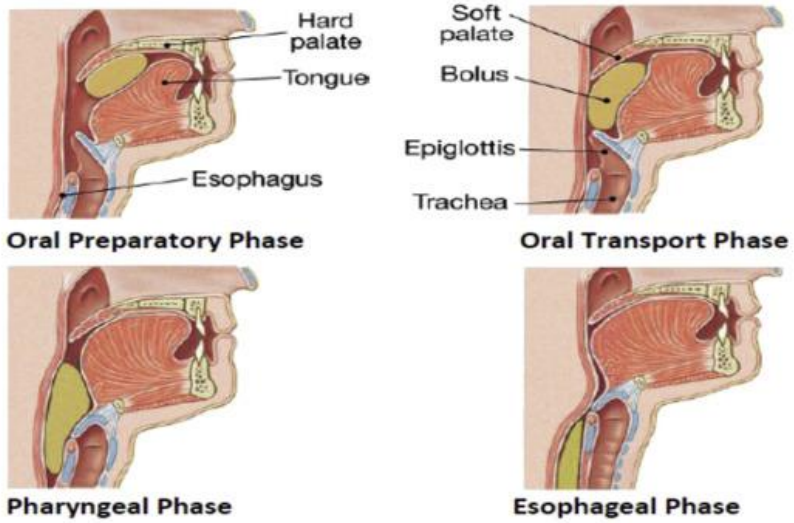
PHARYNGEAL MUSCLES

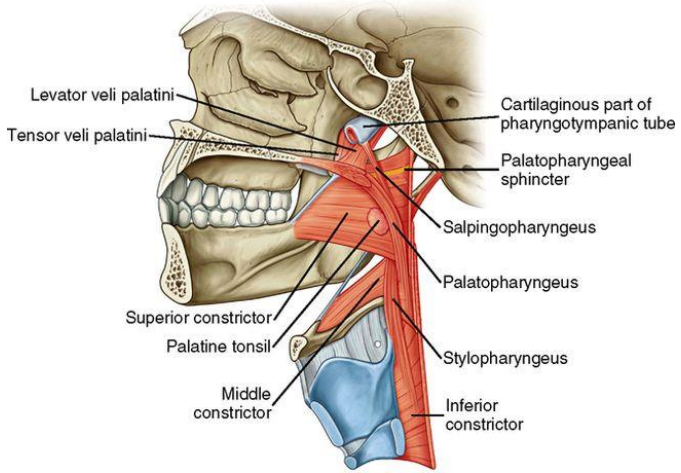
- The **circular muscles** are arranged as the superior, middle and inferior constrictors, with the latter being further subdivided into a **thyropharyngeus** and **cricopharyngeus** parts.
- With the exception of the *cricopharyngeus*, the constrictor muscles are paired and attach to a posterior midline raphe.
- The cricopharyngeus forms a distinct sphincter at the point where the laryngopharynx joins the oesophagus.
- There are two discrete longitudinal muscles on each side, *palatopharyngeus* and *stylopharyngeus*.



PHARYNGEAL PHASE
(PUMPING ACTION OF TONGUE AND HYPOPHARYNGEAL SUCTION)

- This phase of deglutition is reflexive in nature.
- During this phase, the ventilatory and alimentary streams cross each other.
- Dynamic separation of these streams is possible due to the coordination of reflex phase that occurs.
- It just takes a second for the bolus to reach the pharynx and the cricopharyngeal area.
- Contraction of diaphragm is inhibited making simultaneous breathing and swallowing impossible.
- Soft palate is elevated in order to seal off the nasopharynx **(tensor palatini** and **levator palatini)**.
- Vocal cords adduct protecting the airway.
- Once the bolus passes the palatoglossal and palatopharyngeal folds, the act of swallowing becomes reflexive (involuntary).





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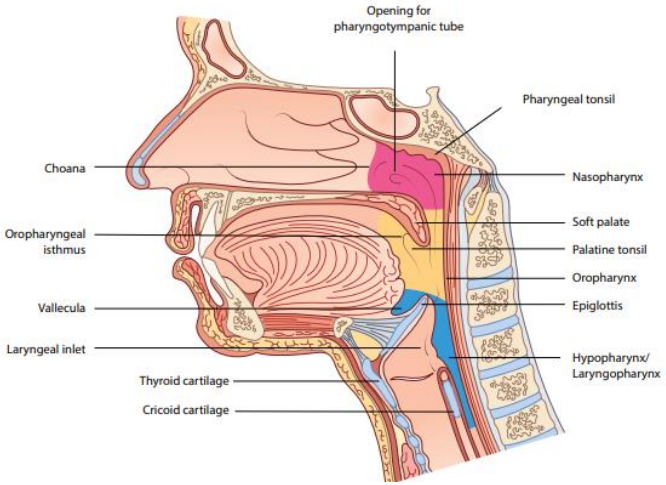
FUNCTIONS OF TRIGGER POINTS IN OROPHARYNX

- Stimulation of trigger points present in the oropharynx starts off the pharyngeal reflexive stage of swallowing.
- Present at the faucial arches and mucosa of the posterior pharyngeal wall innervated by glossopharyngeal nerve.
- Stimulation of these trigger points causes dilatation of pharynx due to relaxation of the constrictors, and elevation of pharynx and larynx due to contraction of longitudinal muscles.
- The pharynx constricts behind the bolus thereby propelling it.
- Contraction of the inferior constrictor moves the bolus towards the oesophagus.



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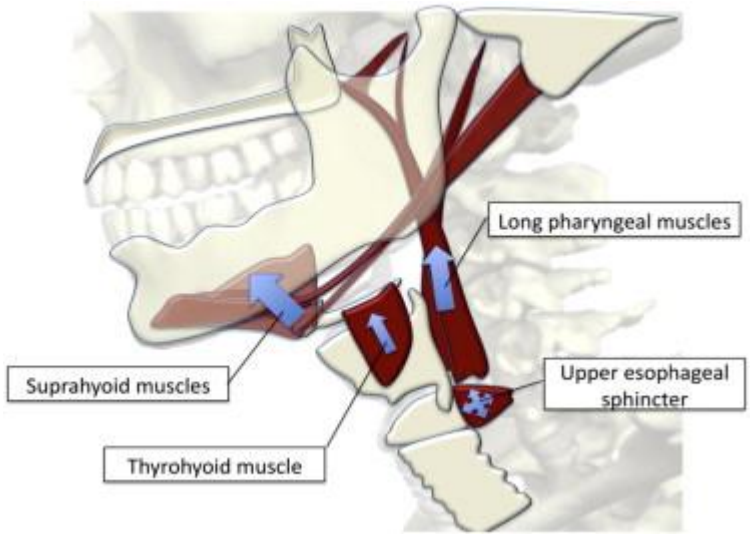
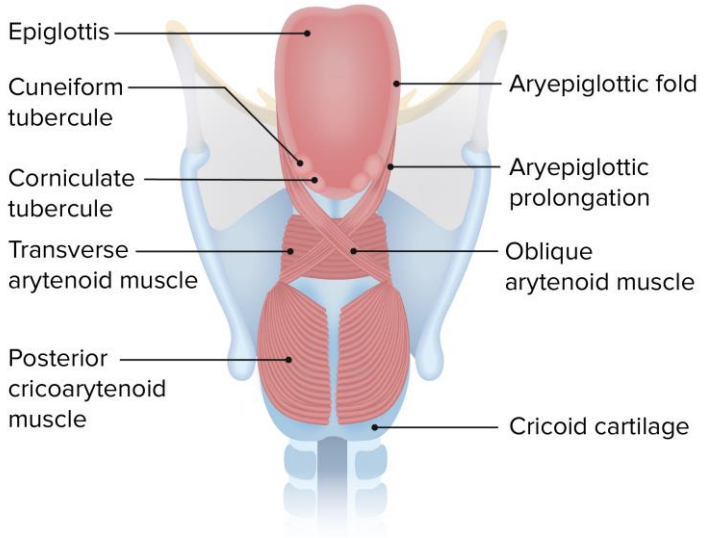
IMPORTANCE OF LARYNGEAL ELEVATION DURING PHARYNGEAL STAGE

- It narrows the laryngeal inlet.
- It ensures better sealing of the laryngeal inlet by the downturned epiglottis.
- Laryngeal elevation also contributes to dilatation of pharynx.
- The laryngeal inlet is closed due to the actions of **interarytenoid**, **aryepiglottic** and **thyroepiglottic** muscles.





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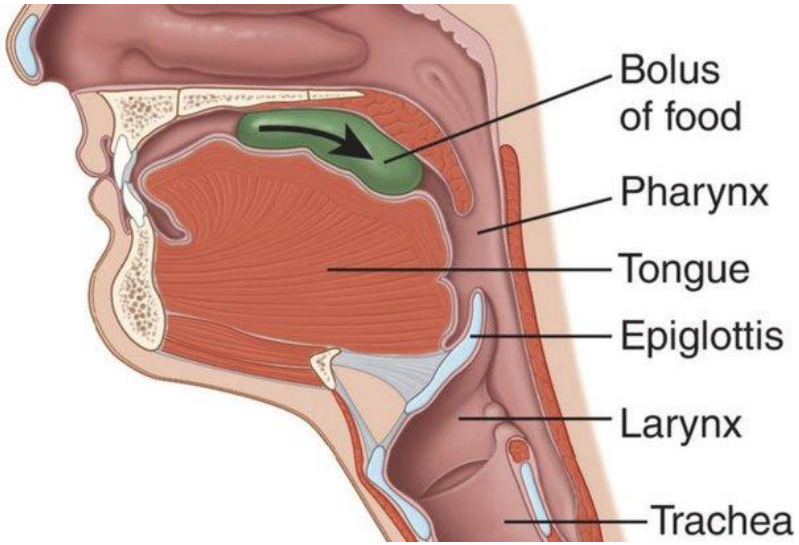
ROLE OF EPIGLOTTIS IN THE PHARYNGEAL PHASE

- The epiglottis is a small, movable **lid** just above the larynx that prevents food and drink from entering the trachea.
- The movement of epiglottis occurs in two stages:
  - The epiglottis moves from vertical to horizontal position.
  - The upper third of epiglottis moves below the horizontal to a slightly lower level to cover the narrowed laryngeal inlet.



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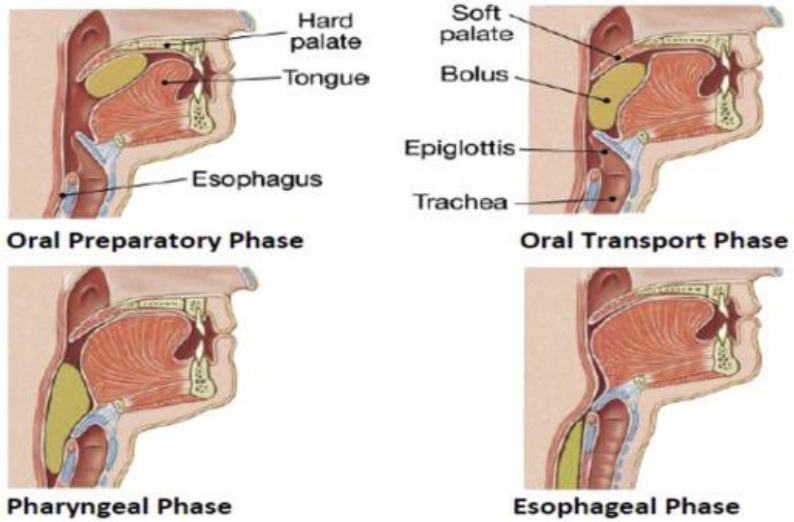
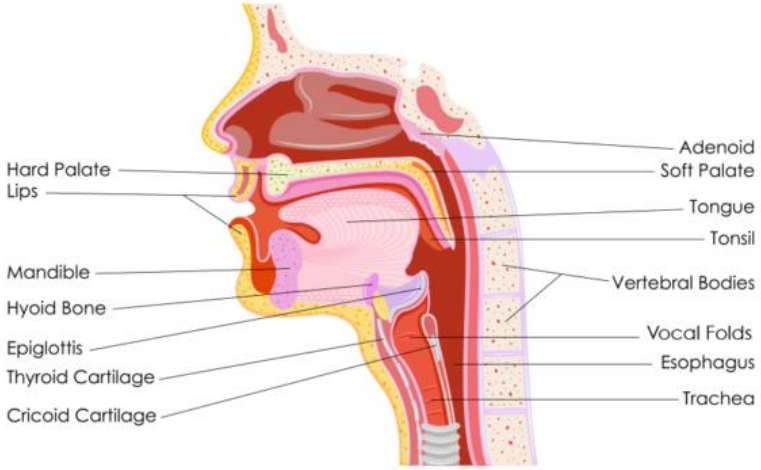
ESOPHAGEAL PHASE

- This is purely involuntary.
- In this phase, cricopharyngeus relaxes and the anterior superior movement of the laryngohyoid complex acts to open the upper oesophageal sphincter.
- The bolus passes through the sphincter and moves along the esophagus by peristalsis.
- The levator and tensor veli palatini relax lowering the soft palate.
- The laryngeal vestibule opens, the hyoid drops and the vocal cords open.
- This opening of the glottis at the very end of oropharyngeal swallow sequence is part of the airway protection mechanism.



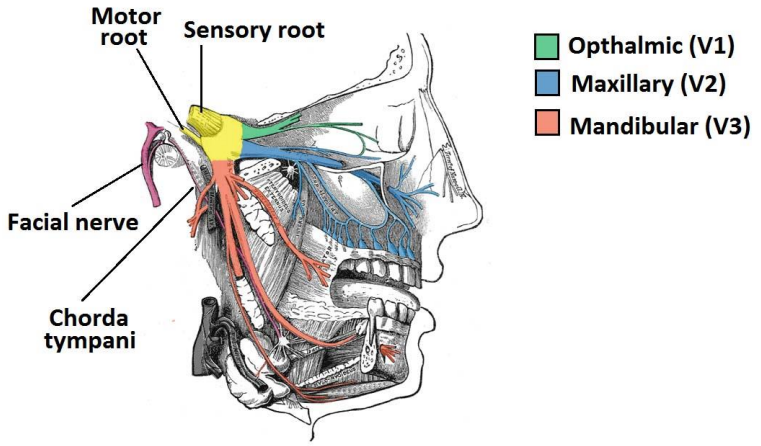
PRESSURE CHANGE

- **A hypopharyngeal suction pump:** by the elevation and anterior movement of the hyoid and larynx, which creates a negative pressure in the laryngopharynx, drawing the bolus towards the oesophagus, aided by a more negative pressure inside the oesophagus.
- The pharyngeal constrictors generate a positive pressure wave behind the bolus.
- Their sequential contraction may facilitate clearance of any pharyngeal wall or piriform sinus residue.



TRIGEMINAL NERVE

- **Sensory:** conveys most sensory modalities (touch, temperature, pressure, and pain), except taste, from the anterior thirds of the tongue, face, mouth, and mandible.
- **Motor:** innervates muscles of mastication.



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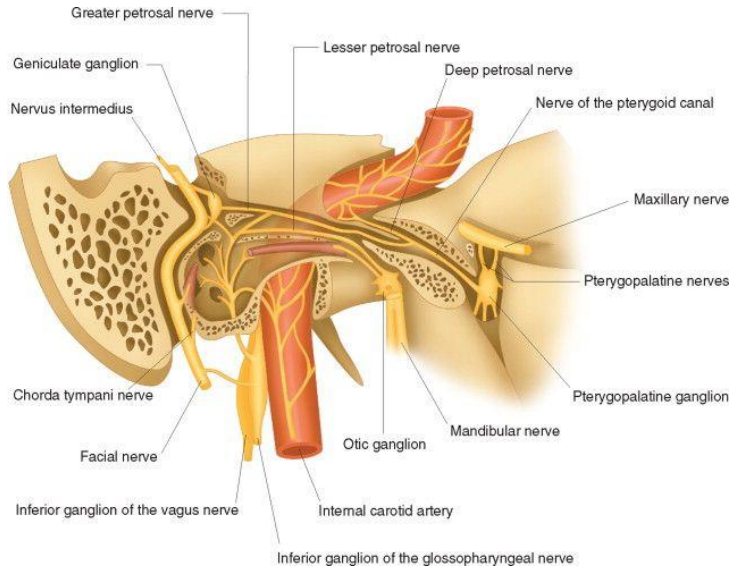
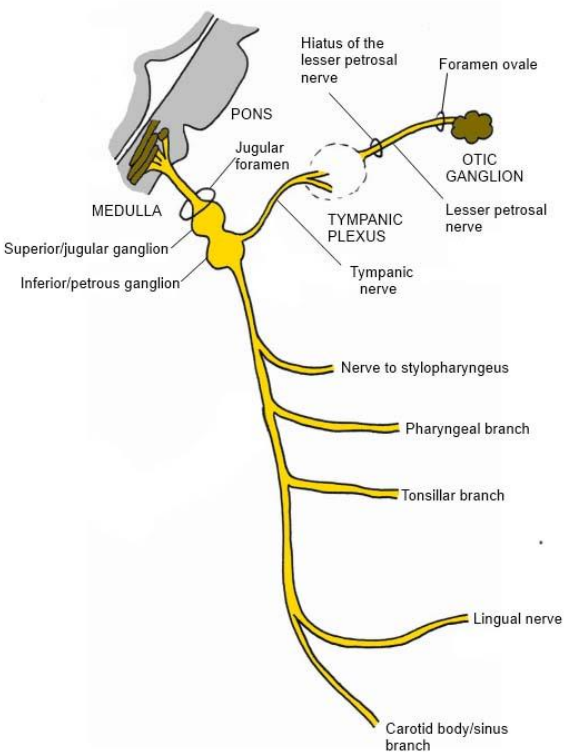
FACIAL NERVE

- **Special sensory:** conveys taste from the anterior two thirds of the tongue and soft palate by way of greater petrosal and chorda tympani, which also stimulates saliva secretion.
- **Mixed-motor:** supplies muscles of facial expression, particularly the lips, which prevent spillage during the oral phase of swallowing.



GLOSSOPHARYNGEAL NERVE

- **General sensory:** mediates all sensation from posterior one third of tongue, oropharyngeal mucosal membranes, palatine tonsils, and faucial pillars.
- **Special sensory:** conveys taste from posterior one third of tongue.
- **Motor:** in conjunction with the vagus nerve innervates the stylopharyngeus, which elevates and pulls anterior the larynx to aid cricopharyngeal relaxation.
- **Secretomotor:** stimulates saliva secretion from parotid gland.



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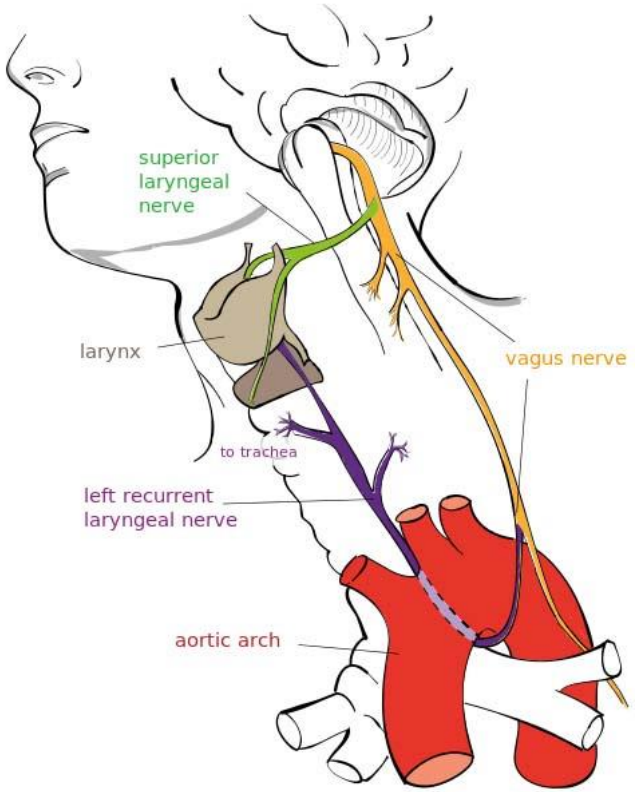
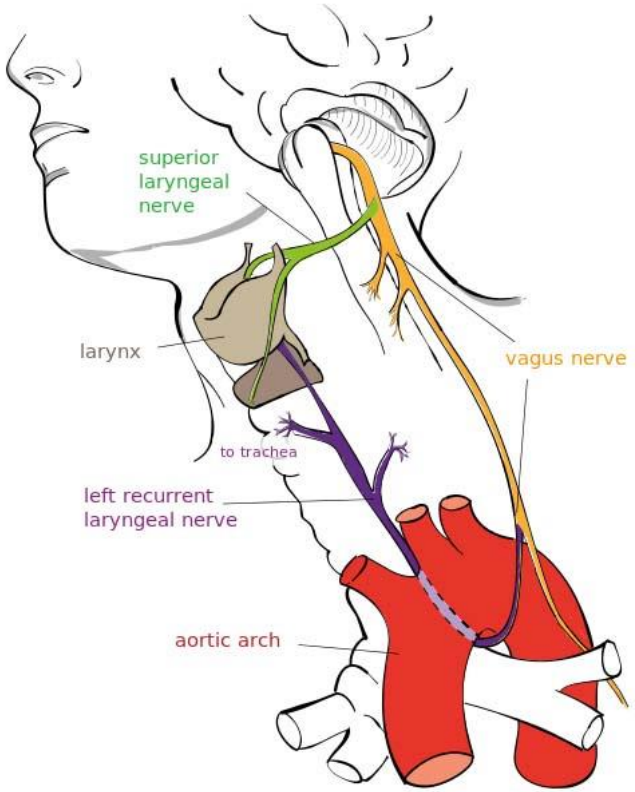
VAGUS NERVE

- **Motor:** responsible for raising the velum as it innervates the glossopalatine and the levator veli palatine muscles.
- Pharyngeal branch innervates the pharyngeal constrictors and intrinsic laryngeal musculature.
- It is also responsible for vocal fold adduction during swallowing and crico-pharyngeal relaxation.
- Muscles involved in the esophageal stage of swallowing and those that control respiration are also innervated by the vagus.



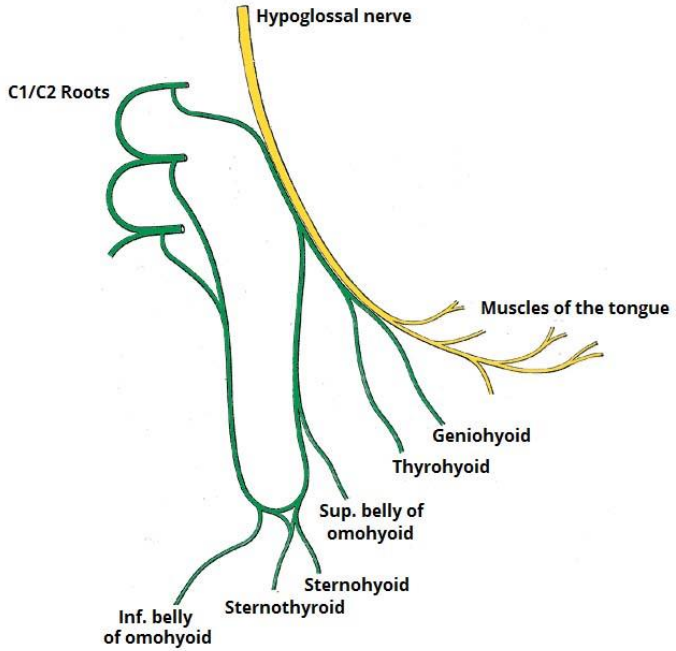
VAGUS NERVE

- **Sensory:** superior and recurrent laryngeal nerves carry information from the velum and the posterior and inferior portions of pharynx, and mediate sensation in the larynx.
- The superior laryngeal nerve has been shown to potentiate the swallow response when combined with cortical stimulation.
- **Two branches of SLN:** the internal, which supplies the mucous membrane of the larynx above the vocal cords, and the external, which supplies the inferior pharyngeal constrictor and the cricothyroid muscles.



HYPOGLOSSAL NERVE

- **Motor:** innervates all intrinsic and extrinsic tongue muscles.
  - Except *palatoglossus* innervated by cranial nerve XI.



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INFANT SWALLOWING

- Newborn feeding is primarily involuntary.
- Dependent on a rooting reflex to latch on to a nipple.
- Suckling requires the generation of intraoral pressure via lip seal around the source and the posterior tongue moving towards the soft palate.
- On average, infants generate two to seven tongue pumps per swallow.
- Jaw movement creates an external pressure on the nipple or teat, encouraging liquid flow into the oral cavity.
- Swallow apnoea is mainly attributed to the larynx tucking under the tongue base and the arytenoids tilting forwards.

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PRESBYPHAGIA

- Presbyphagia is defined as normal age-related changes in swallowing in healthy adults.
- Weaker oral phase movements, including reduced tongue strength.
- The pharyngeal phase is often longer in duration, with prolonged hyolaryngeal excursion.
- Breathing and swallowing coordination may also decrease with age, with over all longer periods of apnoea.

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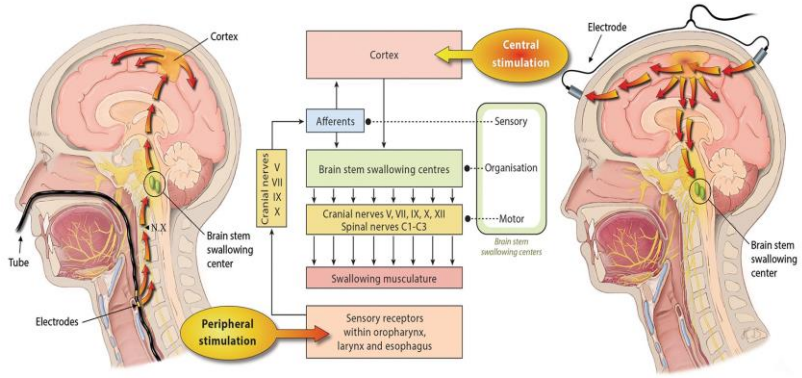
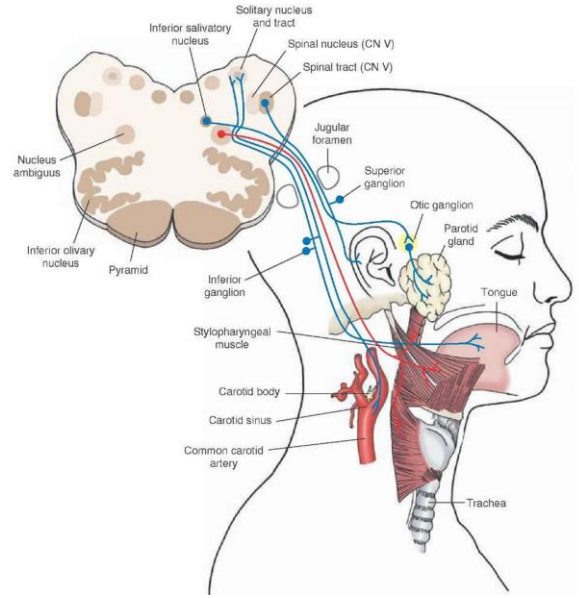
NEURAL CONTROL OF SWALLOWING

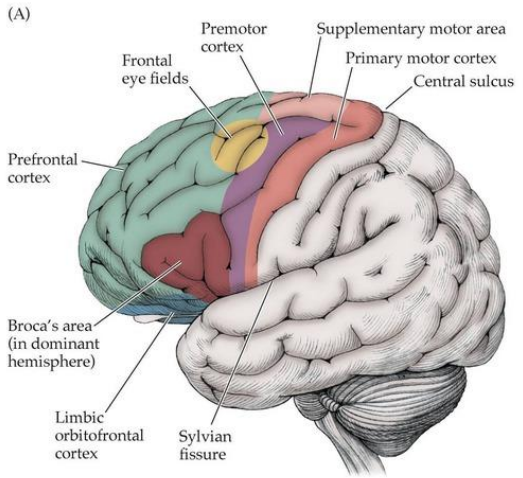
- Two areas of brain are involved:
  - **Cerebral Cortex**
  - **Brainstem**

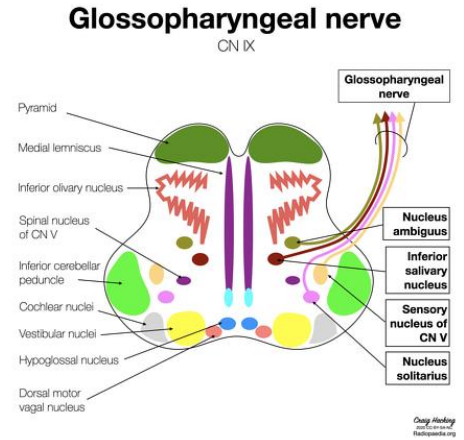




NEURAL CONTROL (INITIATION)

- Initiation of the process of swallowing is voluntary.
- Bilateral prefrontal, frontal and parietal cortices (singular: cortex) are involved.
- Swallowing is initiated when food comes into contact with certain trigger areas like fauces/mucosa of posterior pharyngeal wall.
- Afferent nerve is the **glossopharyngeal nerve**.
- Nucleus tractus solitarius and spinal nucleus of trigeminal nerve play a vital role in this process.
- Efferent involve several cranial nerve nuclei which include **nucleus ambiguous** (muscles of palate, pharynx and larynx), **hypoglossal nucleus** (muscles of the tongue), **motor nuclei** of trigeminal and facial nerves supplying the muscles of face, jaws and lips.





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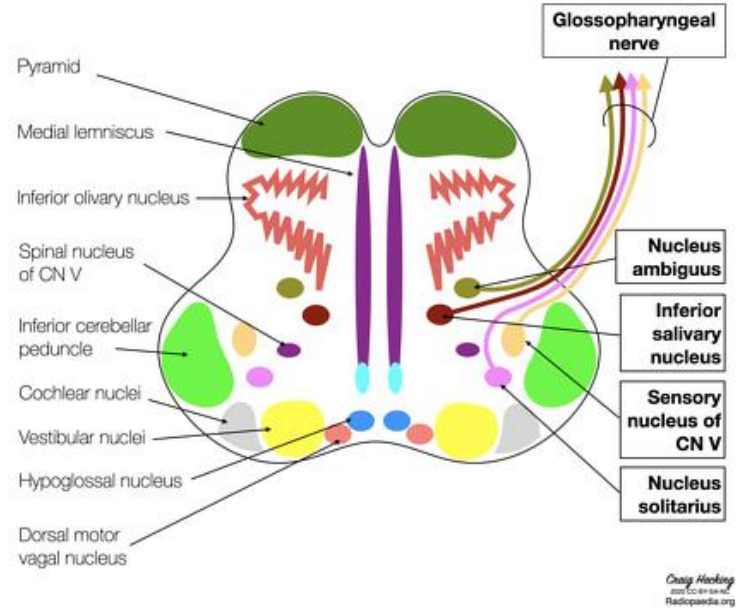
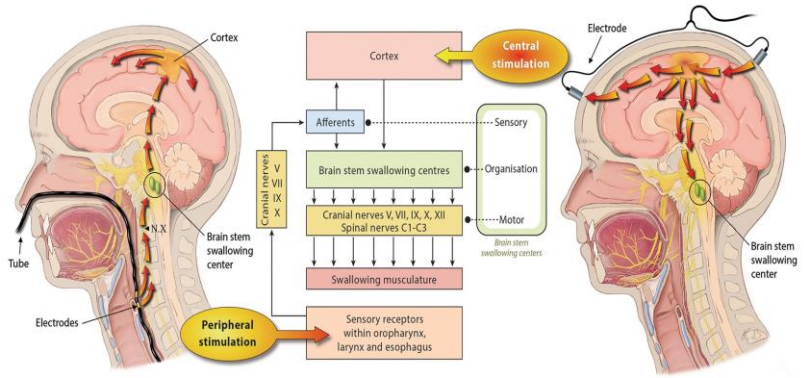
ROLE OF MEDULLA

- There are two groups of neurons in the medulla while lie between the afferent and efferent system.
- First group lie in the dorsal medulla above the **nucleus of the solitary tract**.
- The second group lie in the ventral medulla around **nucleus ambiguous**.
- These groups of neurons are named as lateral and medial medullary swallowing centers.



ROLE OF CENTRAL PATTERN GENERATOR

- Central pattern generator are a set of neurons capable of initiating sequential swallow.
- These neurons act like a **cardiac pacemaker**.
- Since the process of swallowing and breathing are interlinked, there is a certain degree of central coordination taking place.



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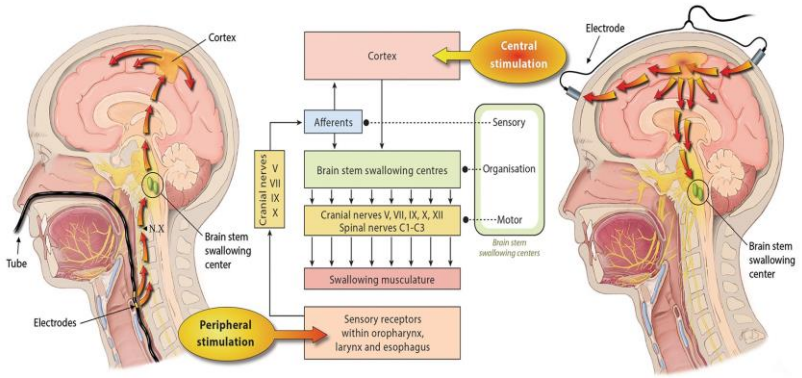
PHASE OF RESPIRATION AND SWALLOWING

- Swallowing occurs during expiratory phase of respiration.
- This helps in clearing food material left in the vestibule.
- Therefore, it should be considered to be a protective phenomenon.
- The rhythm of respiration is reset after a successful swallow.



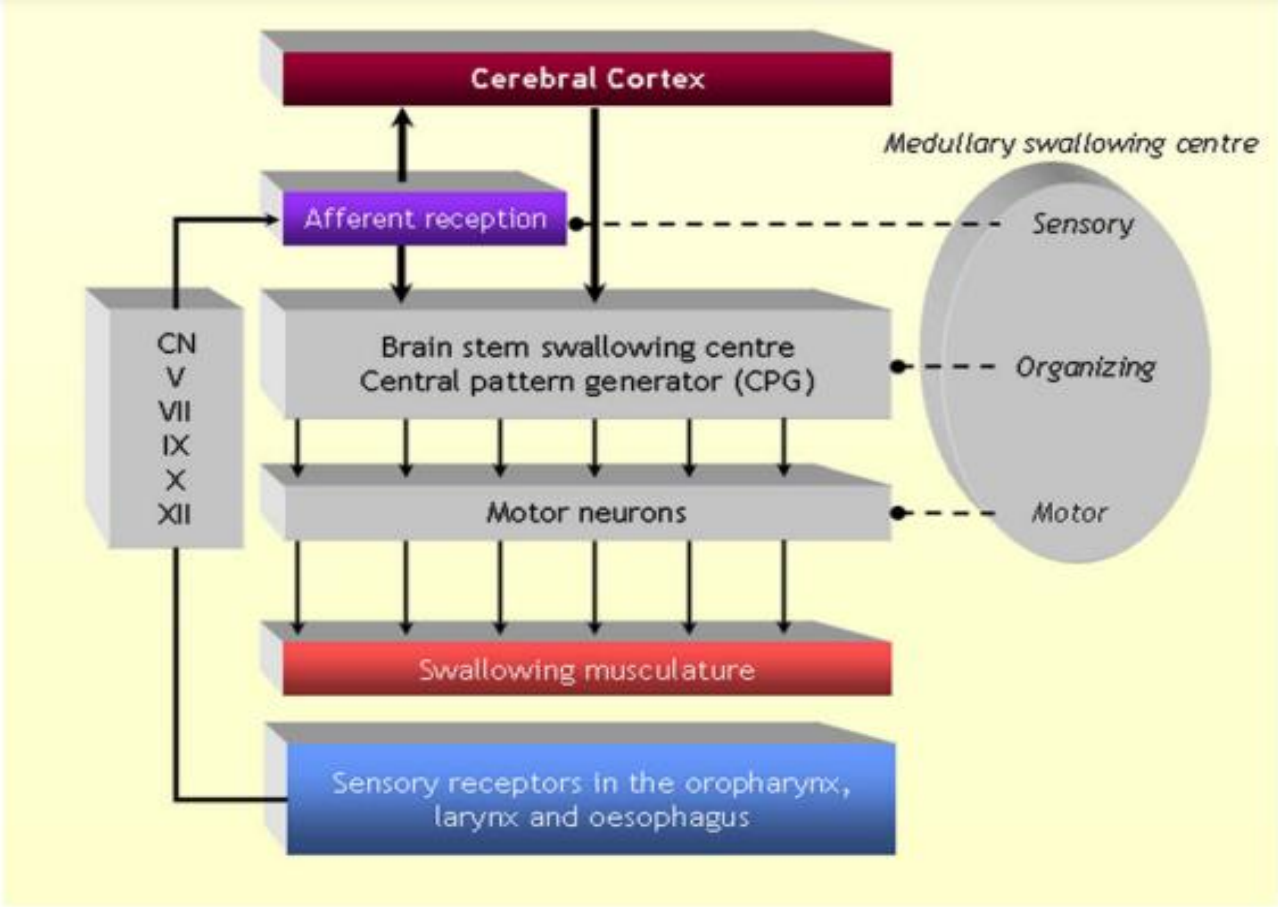
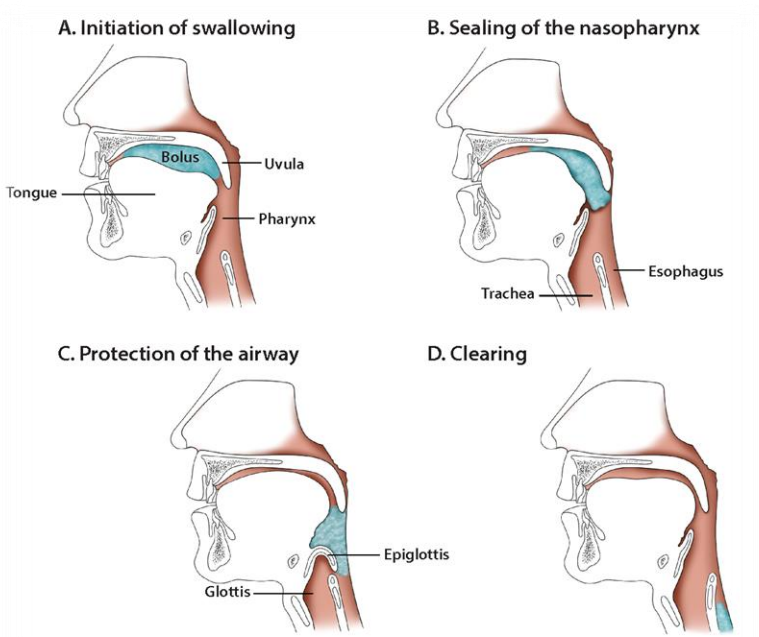


Fig. 3. The complex multidimensional nature of swallowing neurophysiology. Inputs from the periphery and higher brain centers converge onto interneurons in the brainstem swallowing center. The central pattern generator then organizes the sequential excitation of motor neurons controlling swallowing muscles by way of the bulbar nuclei. (*Modified from* Diamant NE. Firing up the swallowing mechanism. Nat Med 1996;2:1190; with permission.)

SWALLOW APNEA

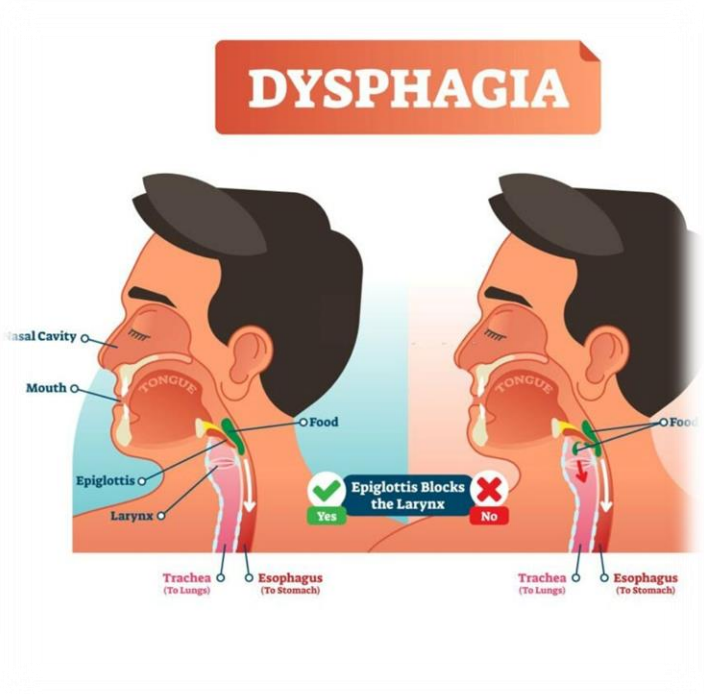
- Ventilation has to be suspended during pharyngeal transit of the bolus.
- This is known as the period of swallow apnoea and is typically less than 1 second in length.
- Corresponding to the duration of the reflex part of the swallow in its pharyngeal phase.



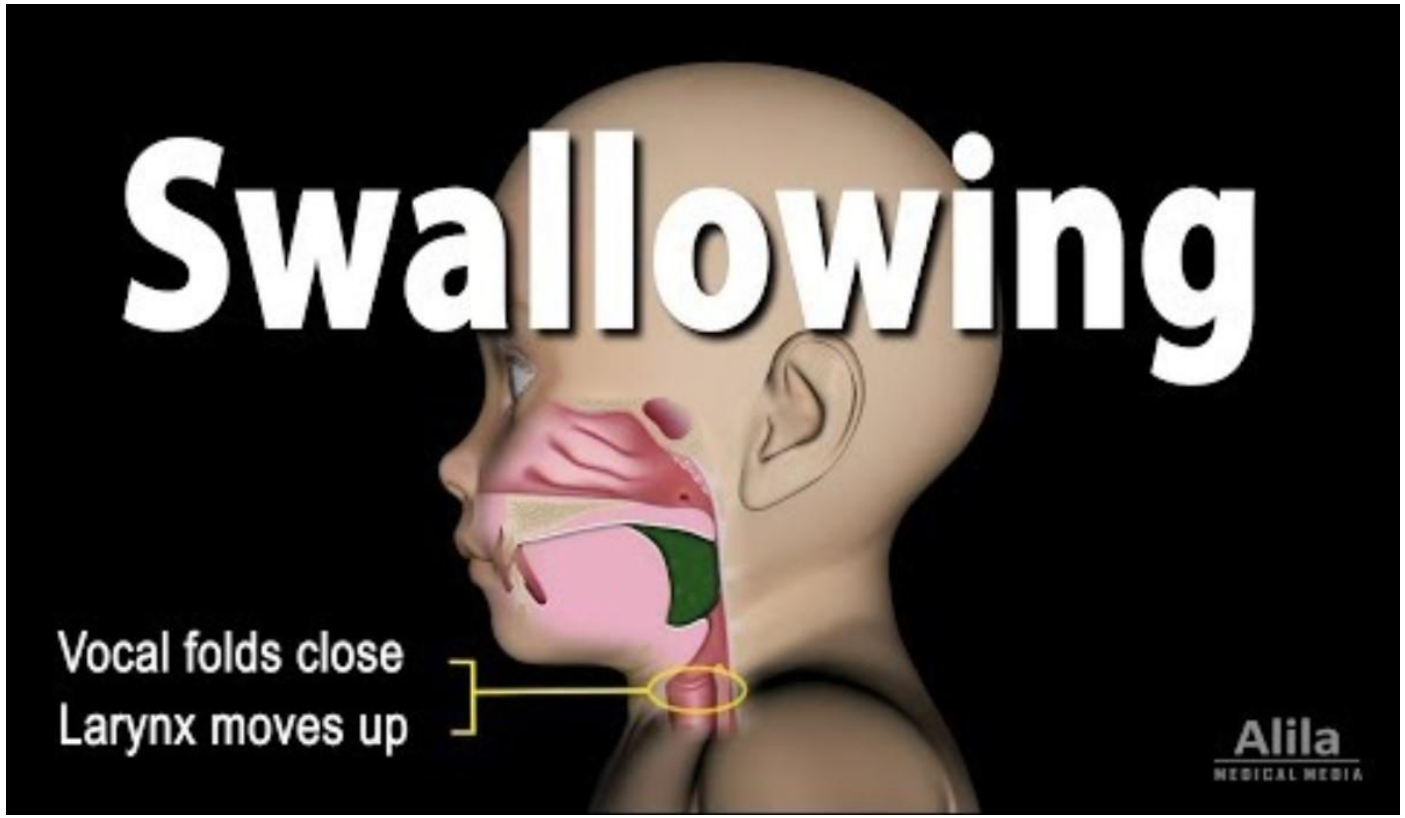
KHALEEL ALYAHYA, PHD, MED

DYSPHAGIA

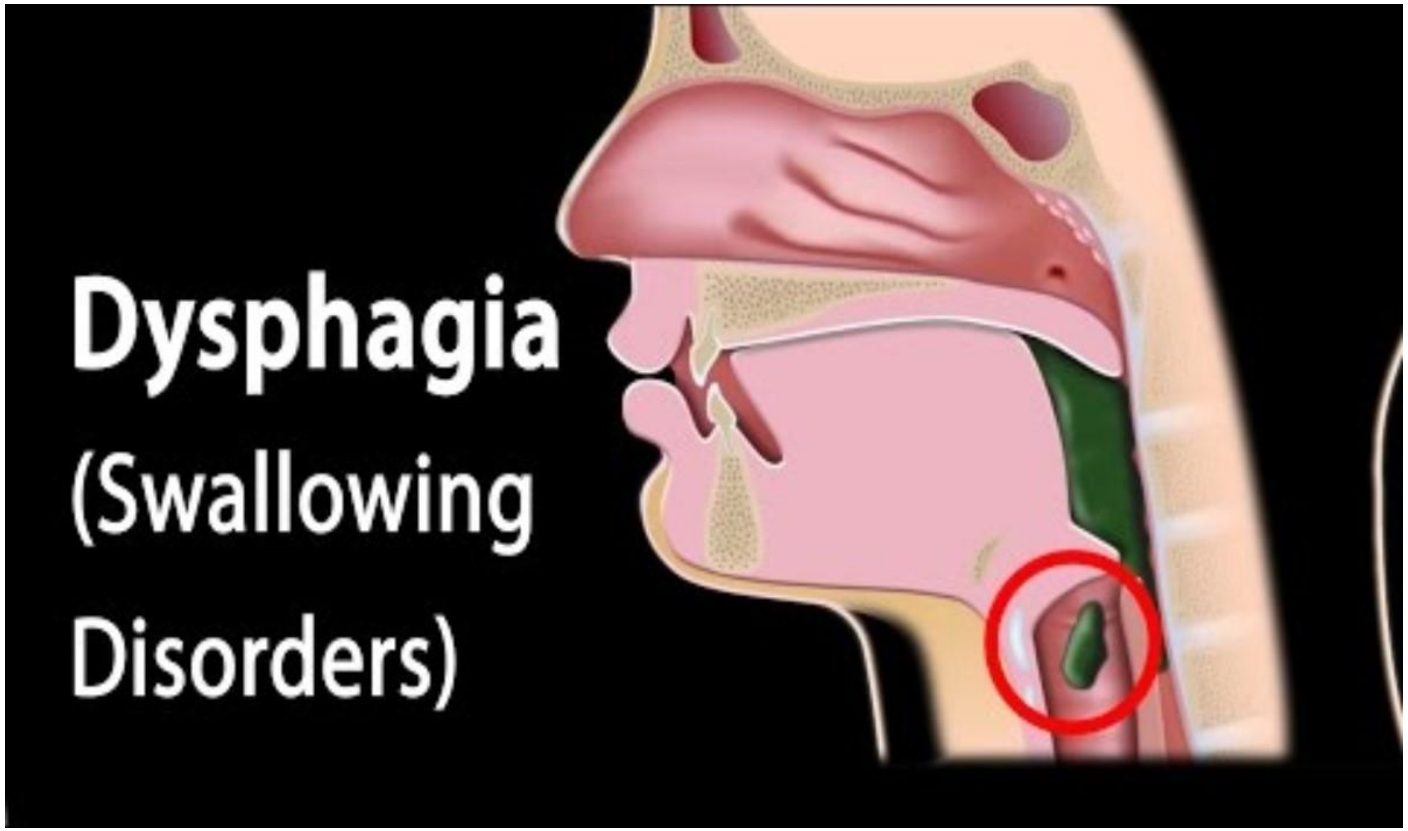
- Dysphagia is a term used to describe difficulty with swallowing solids, liquids or both. It implies impairment of one or more of the phases of swallowing.
- Dysphagia usually arises as a complication of another health condition. It can be divided into oropharyngeal (high) dysphagia and oesophageal (low) dysphagia.
- Dysphagia is common, with epidemiologic studies suggesting that as many as 22% of the population over the age of 50 are affected



VIDEO OF SWALLOWING



VIDEO OF DYSPHAGIA



QUESTIONS?

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