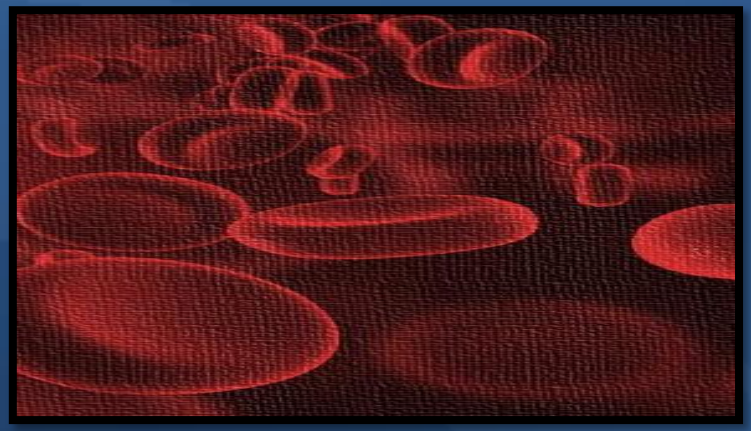
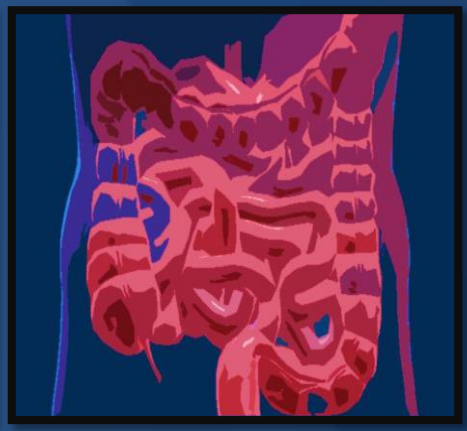
Physiology Team

GASTOINTISTINAL TRACT

# LECTURE 3

## Deglutition & Physiology of Esophageal Motility



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# OBJECTIVES

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

- Swallowing process and its stages:
  1. Oral stage.
  2. Pharyngeal stage.
  3. Esophageal stage.
- Types of esophageal peristalsis.
- Function of lower esophageal sphincter (LES).
- Prevention of esophageal reflux by valve-like mechanism.
- Achalasia.
- Incompetence of lower esophageal sphincter.

# MIND MAP

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## Swallowing (deglutition)

- **Oral phase.**
- **Pharyngeal phase.**
  - Reflex mechanism (nervous role).
- **Esophageal phase.**
  - UES (relaxes 1-2 sec)
  - LES (relaxes 7-10 sec)
    - - Function.
      - Competence.
      - Control.

## Esophageal Peristalsis

- **Primary**
  (control: swallowing center).
- **Secondary**
  (control: swallowing center + ENS).

## Pathological Conditions

- **Achalasia**
  (Problem in Myenteric plexus)
- **Incompetence** of lower esophageal sphincter

# Swallowing (Deglutition):

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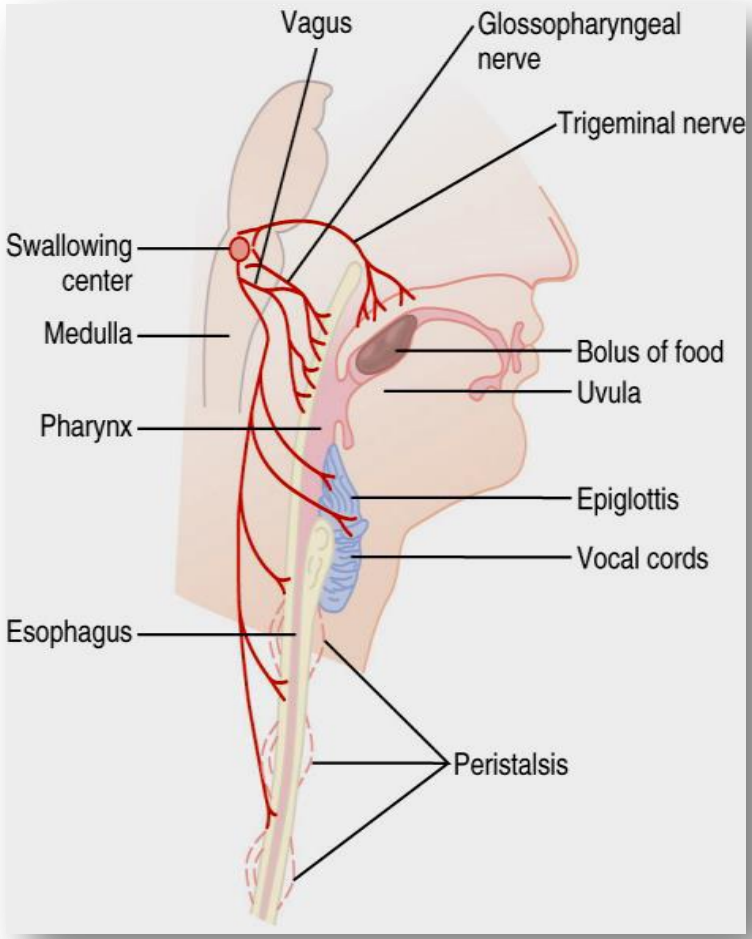
- Swallowing is the ordered sequence of events that propel food from the mouth **to** the stomach.
- Swallowing can be **initiated voluntarily** in the mouth, but thereafter it is almost entirely under **reflex control (involuntary).**
- The reflex portion is controlled by the **swallowing center in the medulla.**
- This reflex **inhibits respiration** and prevents the entrance of food into the airway passages.



# Stages of Swallowing (Deglutition):

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| Voluntary | Involuntary | |
|---|---|---|
| **Oral Stage** | **Pharyngeal Stage** | **Esophageal Stage** |
| This stage involves the voluntary rolling of the bolus posteriorly into the pharynx by the upward and backward pressure applied by the **tongue** against the palate. | The bolus stimulates **sallowing receptor areas** around the pharynx opening and impulses pass to the **swallowing center** and initiate a series of autonomic pharyngeal muscle contractions.<br>(next slide) | The esophagus is a conduit to move food rapidly from the pharynx to the stomach.<br>Physiologically, esophagus is divided into 3 functionally distinct regions:<br>1- Upper esophageal sphincter (UES).<br>2- Esophageal body.<br>3- lower esophageal sphincter(LES). |
| -------<br>Since pharynx is common pathway of resp. & swallowing. | During this stage, the **swallowing center inhibits the respiratory center** of the medulla which stops respiration **during swallowing.** | When bolus of food passes through relaxed UES, the swallowing reflex closes the sphincter so food cannot reflux into the pharynx.<br>Nerve control (after 2 slides). |

## A series of autonomic pharyngeal muscle contractions as follows:

1- The soft palate is pulled upward which **prevents the food from entering the nasal cavities.**
2- The palatopharyngeal folds are pulled medially to approximate each other to 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 cause the epiglottis to swing backward over the opening of the larynx**.
4- The upward movement of the larynx **pulls up and enlarges the opening to the esophagus.**
5- The upper esophageal sphincter (the pharyngoesophageal sphincter) relaxes and **allows food to move freely from the posterior pharynx into the upper esophagus.**
6- Once the larynx is raised and the pharyngoesophageal sphincter relaxes, **the entire muscular wall of the pharynx contracts** (superior, middle, then inferior parts {circular constrictors} ) propelling the food by peristalsis into the esophagus.

# Nervous initiation of the pharyngeal stage:

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**Receptors**

The most sensitive areas for initiating the pharyngeal stage of swallowing are located in a ring around the pharyngeal opening including the tonsillar pillars.

**Sensory nerves**

Sensory impulses are received by the nucleus tractus solitarius (NTS) via the medulla oblongata through the 5th & 9th cranial nerves.

**Center**

The successive stages of swallowing are then automatically initiated by swallowing center in medulla and lower portion of the pons.

**Motor nerves**

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.

# Esophageal Stage (Nerve control):

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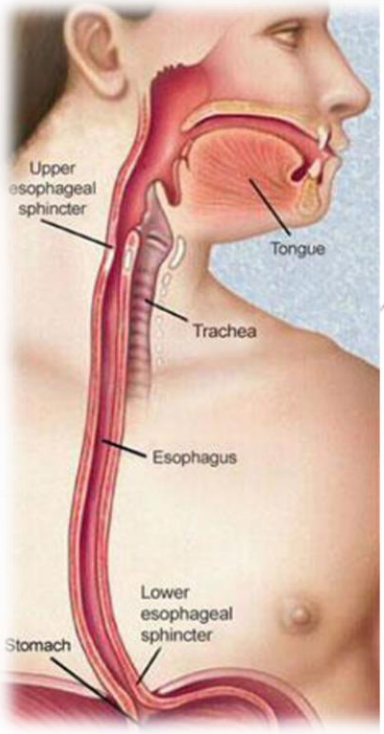
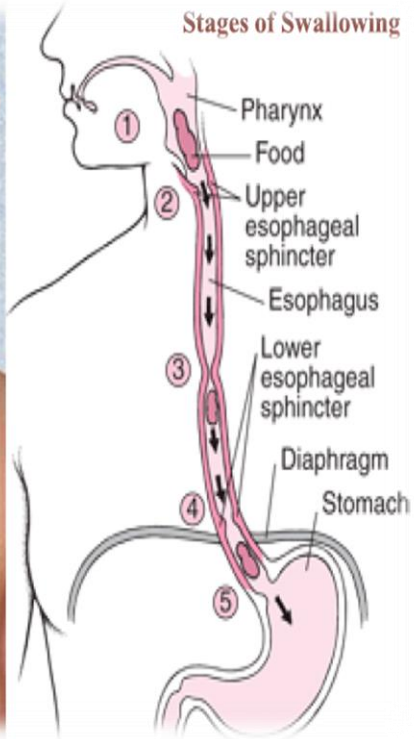
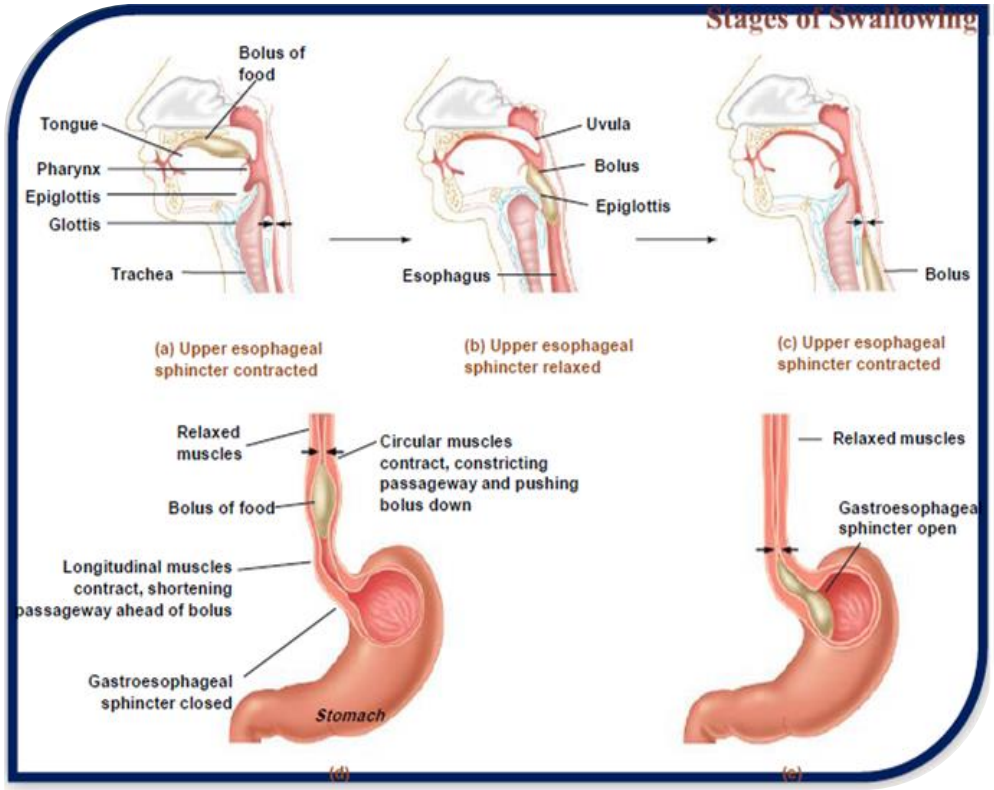
- The musculature of the **upper third** of the esophagus is **skeletal muscle** (peristaltic waves are controlled by impulses from **glossopharyngeal and vagus nerves**).
- The musculature of the **lower two thirds** of the esophagus is **smooth muscle** (controlled by the **vagus through connections with the esophageal myenteric nervous system**).




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

# Types of Esophageal Peristalsis:

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| Primary peristalsis (weaker) | Secondary peristalsis (stronger) |
|---|---|
| Continuation of pharyngeal peristalsis | Occurs in response to distention (activation of receptors above the distended part). |
| Coordinated by **swallowing center** | **Enteric nervous system** (ENS) and **swallowing center** are both involved. |
| Efferent: vagus nerve | It occurs when 1ry peristalsis is weak to propel (large or sticky) food.<br>Efferent: vagus & intrinsic nerves (ENS). |
| Cannot occur after vagotomy (striated muscle) | Can occur after vagotomy (smooth muscle). |

- **Receptive Relaxation of the Stomach:**

When peristaltic waves reaches the stomach, it relaxes to receive the food.

# Esophageal sphincters:

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| The upper esophageal sphincter (UES) | The lower esophageal sphincter (LES) |
|---|---|
| **It relaxes** during swallowing for **about 1 to 2 seconds** allowing the bolus to be forced through **the relaxed UES.** | It is formed by circular muscle located in an area of ~ 3 cm upward of the junction with the stomach. |
| | With initiation of esophageal peristalsis, **The LES opens** mediated by impulses in **vagus nerve**. |
| **UES remains tonically contracted** (if there is no swallowing) to **prevent entry of air** into esophagus. | In absence of esoph. peristalsis, **the sphincter remains tightly closed** to **prevent reflux of gastric contents** into esophagus. |

## Functions of LES:

- The principle function of the LES is to prevent reflux of stomach contents into the esophagus.
- It normally remains tonically constricted (closed) → means there is a pressure.
- When a peristaltic wave of swallowing passes down the esophagus, **it relaxes** the LES (**for 7-10 sec.**) and allows easy propulsion of the swallowed food into the stomach.

# Esophageal sphincters (cont.):

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It is necessary to have a barrier (sphincter) at the gastroesophageal junction (why?)

- Pressure in the esophagus is **the same** as the **intrathoracic pressure** i.e. mostly **–ve** (**except** for a short intra-abdominal segment).
- So that pressure in the stomach is **always higher** than the esophagus.

## Competence and the anti-reflux functions of the LES is due to:-

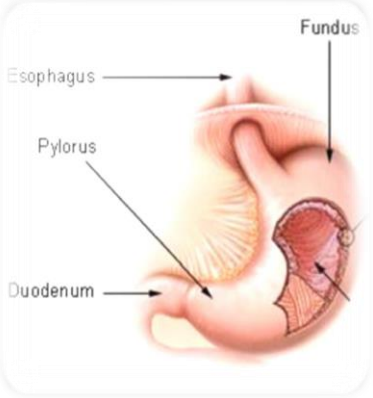
**1-** Its resting pressure (tonically contracted by vagal impulses) (15-30 mmHg).

**2-** Flutter-valve closure of the distal end of the esophagus is exposed to +ve intra-abdominal pressure.

- This prevents the high pressure in the stomach from forcing its contents into the esophagus.

**3-** Contraction of the crura of the diaphragm that wrap around the esophagus at the level of LES

- It helps to increase the pressure in the LES with each inspiration.



# Control of LES Function:

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**Contraction of the circular musculature of the sphincter is regulated by:**

1. **Nerves (extrinsic & intrinsic).**
2. **Hormones.**
3. **Neuromodulators.**

| | Between Swallows | During Swallowing |
|---|---|---|
| **Nerves** | 1. Tonic **vagal** **cholinergic** impulses (**stimulatory**) maintain contraction to keep the sphincter closed.<br>2. Stimulation of **sympathetic nerves** to the sphincter also causes the LES to contract. | Efferent impulses in the **vagus** are **inhibitory** causing the sphincter to relax. |
| **Neuro-modulators** | Acetylcholine | • NO: Nitric oxide.<br>• VIP: Vasoactive intestinal peptide. |
| **Hormones** | The hormone **gastrin**, released from the stomach by food, contracts LES. | Secretin and cholecystokinine (**CCK**) released from the upper intestine relax the LES. |

# Pathological Conditions:

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| 1- Achalasia (contracted all the time) | 2- Incompetence of the LES (relaxed all the time) |
|---|---|
| Food transmission from the esophagus into the stomach is impeded or **prevented**. | Incompetence cause **esophageal reflux** and result in chronic exposure of esophageal mucosa to acid. |
| • It's a condition due to **high resting pressure** of the LES.<br>• It's due to pathology of or absence of the myenteric plexus containing VIP & NO in the lower third of esophagus.<br>• 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 (vagal Ach & sympathetic take the upper hand & LES remains tonically contracted). | • The esophageal mucosa, except in the lower eighth of esophagus, is not capable of resisting for long the digestive actions of gastric secretions. |
| • Fatal if not diagnosed; food accumulation in esophagus → rupture. | • It can lead to reflux esophagitis, heart burn, esophageal ulcer and dysplastic changes that may become cancerous. |

**Swallowing can be divided into:**

- ***Voluntary stage of swallowing:***
  - **Bolus → voluntarily squeezed or rolled posteriorly against the palate.**
  - **Swallowing cannot be stopped.**

- ***Involuntary Pharyngeal stage of swallowing:***
  - **Bolus reaches posterior mouth & pharynx → stimulates receptors → initiate series of automatic pharyngeal muscle contraction.**

- ***Involuntary Esophageal stage of swallowing.***

***1- Pharyngeal stage of swallowing:*** **The pharyngeal stage of swallowing is a reflex act initiated by the voluntary movement of food into the back of the mouth. This will initiate series of automatic pharyngeal muscle contraction:**

- Soft palate is pulled upward and prevents the reflux of food to nasal cavity.
- Palatopharyngeal folds are pulled medially to approximate each other – form a sagittal slit.
- Vocal cords are approximated.
- Larynx is pulled upward & anterior by neck muscles.
- Epiglottis swing backward over the opening of larynx.
- Upward movement of larynx & enlargement the opening of esophagus.
- Upper 3-4cm of esophagus relaxes.
- Muscular wall of pharynx contracts to push the food downward (propulsive contraction).

***2- Esophageal stage of swallowing:*** **Conducts food rapidly to the stomach. Two types of peristaltic movements:**

**A) Primary peristalsis waves: Continuation of a peristaltic wave.**

– Begins in pharynx & spreads into esophagus, passes in 8-10 sec.

**B) Secondary peristaltic waves: begins if the primary wave failed to push the food down.**

– Results from the distention of esophagus.

– Mediated by the enteric nervous system.

# Lower Esophageal Sphincter:

Males' Slide

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- Above the junction of esophagus with stomach by 3 cm.
- Remains tonically constricted.
- Lower esophageal sphincter relaxes as a result of:
  1) Vagus nerve fibers (peptidergic fibers) stimulation.
  2) Release of the neurotransmitter (nitric oxide NO or vasoactive intestinal peptide VIP)
  3) Secretin and cholecystokinine (CCK): released from the upper small intestine, relax the LES.
- Peristaltic swallowing wave passes down through esophagus → receptive relaxation of gastro-esophageal sphincter and orad portion of stomach (decrease in pressure) → allow food go easily into stomach. Then the sphincter contracts and returns to its high resting tone.

# SUMMARY

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- The reflex stages of swallowing are automatically initiated by **swallowing center** in **medulla** and **lower portion of the pons**.
- Normally, the upper & lower esophageal sphincters are always closed BUT opened (relaxed) during swallowing.
- If the LES is contracted all the time → achalasia WHILE if it is relaxed all the time → incompetence of the LES.
- Peristaltic waves in the **upper third** of esophagus (striated muscle) are controlled by impulses from **9th & 10th cranial nerves** while the **lower 2\3** are by **10th & myenteric nervous system** (smooth muscle).
- Regulation of LES is by neurohormonal & neuromodulator controls.
- **Vagal** control of LES between swallows is **stimulatory** using **Ach** (contraction) WHILE during swallowing is **inhibitory** using **NO** or **VIP** (relaxation).

# QUESTIONS

Thanks to Eman ALBedaie

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**Q1:What is the hormone that is released from upper intestine and caused relaxation in LES:**

a- Gastrin. b-Cholecystokinin (CCK). c- Glucagone.

**Q2: The function of valve-like mechanism of LES is:**

a- To expose the upper esophagus to +ve pressure to be near from stomach pressure which is -ve.

b- To expose the lower esophagus to +ve pressure to be near from stomach pressure which is +ve.

C- To expose the lower esophagus to -ve pressure to be like intrathoracic pressure which is –ve.

**Q3: In pharyngeal stage, which one of the following are both sensory & motor nerves:**

a- 5th & 9th cranial nerves. b- 9th & 10th cranial nerves. c- Enteric nervous system.

**Q4: Which stage of swallowing is voluntary :**

a- Oral b- pharyngeal c- esophageal

**Q5: During the pharyngeal stage, the nasal cavities closed by ……. , and the opening of larynx by ……. :**

a- Epiglottis , Soft palate

b- Soft palate , Epiglottis

c- Soft palate , vocal cords

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

Slides Important Females' Notes Explanation Males' Notes

# QUESTIONS

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**Q6 : The respiratory center is inhibited during :**

a- Oral b- Pharyngeal c- Esophageal

**Q7 : The musculature of the upper 1/3 of the esophagus is……. And controlled by :**

a- skeletal , Glossopharyngeal and Vagus
b- smooth , Glossopharyngeal and Vagus
c- skeletal , Glossopharyngeal and myntric N.S

**Q8 : The pressure in the stomach is always :**

a- less than the esophagus
b- higher than the esophagus
c- equal to the esophagus

**Q9 : The resting pressure of the LES is :**

a- 5-10 mmHg
b- 20-25 mmHg
c- 15-30 mmHg

**Q10 : The Achalasia is :**

a- High resting pressure of the LES
b- Low resting pressure of the LES
c- Non of the above

**Q11 : The vagus N causes relaxation of the LES by releasing :**

a- VIP
b- NO
c- a+b

**6- B**
**7-A**
**8-B**
**9-C**
**10-A**
**11-C**

# THE END

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**If there are any Problems or Suggestions,**
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THANK YOU

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