The digestive system

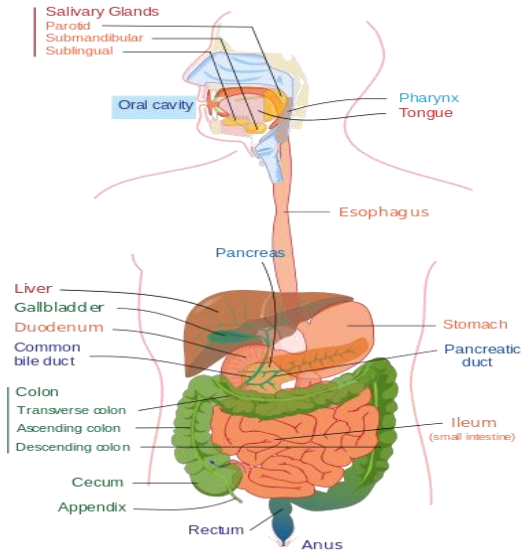
a) Alimentary canal:-

- It runs through the body from the mouth to the anus.
- It includes the mouth, pharynx, esophagus, stomach, small intestine and large intestine.
- The different parts of the GIT are separated by special muscles named sphincters that control the passage of food contents from one part to another one. For example;
  - Upper esophageal sphincter separates the pharynx from the esophagus.
  - Lower esophageal sphincter separates the esophagus from the stomach.
  - Pyloric sphincter separates the stomach from the duodenum.
  - Ileocecal (ileocolic) sphincter separates the ileum from the cecum (beginning of ascending colon).

b) Digestive glands:-

Which secrete its digestive enzymes into the alimentary canal, it includes:

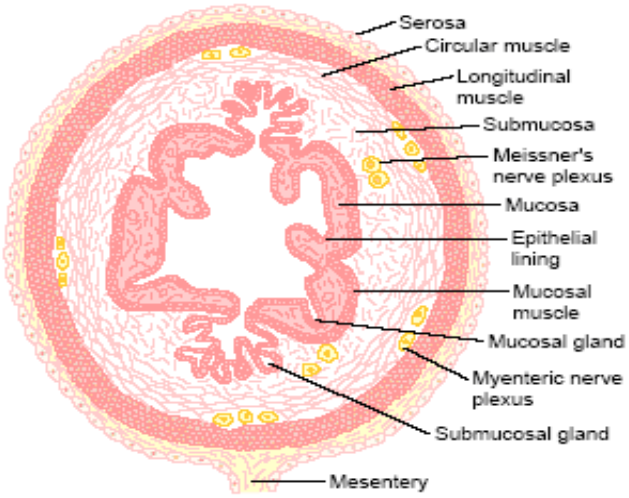
- Salivary glands.
- Gastric glands.
- Intestinal glands.
- Pancreas.
- Liver.



The wall of the alimentary canal is formed of 4 layers:

1- Mucosa
2- Submucosa with submucosal (**Meissener's) nerve plexus**

3- Muscular layer with myenteric (**Auerbach's) nerve plexus in between**.
4- Serosal or adventitious coat.

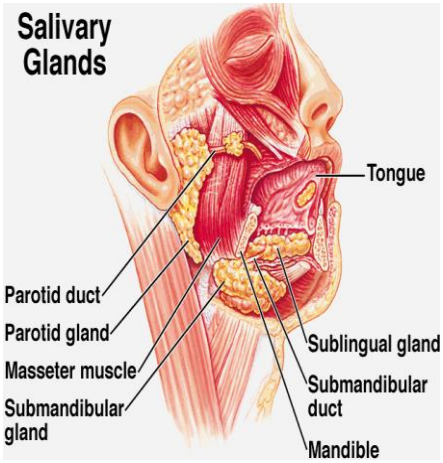


General functions of the digestive system include:

a) Motility ***b) Secretion***
c) Digestion. ***d) Absorption.***
e) Excretion.

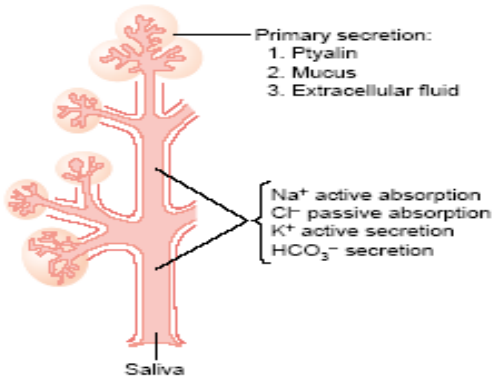
Salivary secretion (Saliva)

- ***The mouth contains 3 major pairs of salivary glands connected to oral cavity by ducts named;***
  - Parotid gland.
  - Submandibular (sub maxillary) gland.
  - Sublingual gland.



- ***There are two types of secretory cells:***
  - Serous cells: which secrete serous (thin) saliva rich in salivary amylase enzyme for starch digestion
  - Mucous cells: which secrete viscid (thick) saliva rich in mucin, which is a mucoprotein for lubrication and protection.
    - The parotid gland acini are serous.
    - The sublingual gland acini are mucous.
    - The submandibular gland acini are mixed.
- ***Volume:*** daily salivary secretion ranges from 700 – 1500 ml.
- ***PH of salivary secretion:*** Is between 6 – 7.4
- ***Composition of saliva:***
  1. Water: 99 – 99.5 %.
  2. Electrolytes (inorganic ions) as Na^+, K^+, Cl^-, HCO_3^- and phosphate.
  3. Organic substances:
     a. Digestive enzymes: Salivary amylase (alpha amylase; ptyalin) and lingual lipase enzyme (secreted by the buccal glands).
     b. Mucin: For lubrication and protection.
     c. Proteolytic enzymes (lysozymes), thiocyanates and IgA.
- ***Mechanism of salivary secretion:***
  - The acini secrete a primary secretion which contains water, ptyalin, mucin and electrolytes (ions) in concentrations similar to that of plasma i.e. iso-osmotic. This secretion flows out of the acini into collecting ducts.
  - Within the duct, the composition of the secretion is modified under the effect of aldosterone
    1. First, Na^+ is reabsorbed in exchange to K^+ secretion.
    2. Second, HCO_3^- is actively secreted in exchange to Cl^- reabsorption

resulting in hypo-osmotic salivary secretion rich in K^+ (30 mEq/L) and HCO_3^- (50 - 70 mEq/L) i.e. 7 times their plasma concentration while poor in Na^+ and Cl^- (15 mEq/L) i.e. $^1/_7$ their plasma concentration.



The ionic composition of saliva is affected by:

1. Aldosterone hormone: Increased aldosterone secretion increases the rate of NaCl absorption while increases K^+ secretion thus ↓ NaCl concentration in saliva down to zero and ↑ K^+ concentration to more than 7 times its plasma concentration.
2. Rate of salivary secretion: Increased the rate of salivary secretion gives no chance for modification of salivary ionic composition thus ↑↑ NaCl concentration in saliva and ↓↓ $KHCO_3$ concentration.

- The ducts actively secrete iodide (salivary iodide concentration can reach 10 times that of the plasma).

Functions of saliva:

1. **Digestion:** Salivary secretion contains
   - Alpha amylase (ptyalin) which initiates digestion of starch by the splitting of starch producing smaller fragments (Maltose). The optimum pH for its activity is 6.9 and it continues to digest starch in the stomach until its inactivation by gastric acidity.
   - Lingual lipase enzyme which starts digestion of less than 10% of ingested triglycerides splitting them into fatty acids and glycerol.
2. **Lubrication:**
   - Moistens the mouth and aids speech.
   - Contains mucin which lubricates food and assists swallowing.
3. **Oral hygiene:** Oral cavity is almost loaded with many pathogens. However, salivary secretion plays an important role in keeping healthy oral tissue through:
   a. Washing away the pathogenic bacteria and the food debris thus keeps the mouth relatively clean.
   b. Containing thiocyanates, lysozymes and IgA which have bactericidal activity.
4. **Buffering action:** It contain bicarbonate and mucin that act as buffers that helps to
   - Maintain oral PH around 7 thus reduces loss of Ca^{++} from teeth into oral fluid. Shifting of PH to acidic side increases the solubility of Ca^{++} leading to its loss from the teeth enamel resulting in dental caries.
   - Neutralize the gastric acidity thus relieves the heartburn resulting from reflux esophagitis.
5. **Maintenance of water balance:** as decreased salivary secretion by dehydration leads to thirst sensation which drives the person to drink.

6. **Stimulates taste sensation:** Saliva acts as solvent for the molecules that stimulate the taste buds thus facilitates taste sensation.
7. **Contains** growth factors and hormones (as somatostatin, glucagen, rennin and bradykinin).
8. **Saliva helps heat loss** through evaporation in panting animals as dogs

Innervation of salivary glands:-

1. **Parasympathetic supply:**
   - **Submandibular and sublingual glands** are supplied by the chorda tympani branch of the facial nerve (**VII**). The preganglionic fibers arise from superior salivary nucleus (SSN) in the lower pons and relay in submandibular ganglion.
   - **Parotid gland** is supplied by the autonomic fibers of the glossopharyngeal nerve (**IX**). The preganglionic fibers arise from inferior salivary nucleus (ISN) in the upper medulla and relay in otic ganglion.
   - **Functions:**
     - Stimulates true salivary secretion which is large in volume, watery, rich in salivary amylase, Na^+, Cl^-, and $HCO3^-$.
     - Vasodilatation which increases blood flow to salivary glands.
2. **Sympathetic supply:**
   - From the L.H.Cs of the upper two thoracic segments and relay in superior cervical ganglion.
   - **Functions:**
     1. Stimulation of β-adrenergic receptors leading to:
        - Trophic salivary secretion which is small in volume, viscid (thick), poor in electrolytes and rich **in mucin**.
        - Contraction of myoepithelial cells around the acini to squeeze saliva.
        - Vasodilatation.
     2. Stimulation of alpha-adrenergic receptors produces vasoconstriction of the blood vessels which may explain the decreased salivary secretion in stressful emotional conditions.

Control of salivary secretion:

Secretion of saliva is under nervous control only which occurs through conditioned (acquired) and unconditioned (inborn) reflexes:

	Unconditioned (inborn) reflex	Conditioned (acquired) reflex
Need of cerebral cortex or training	Do not need cerebral cortex or training.	Need cerebral cortex and training.
Stimulus	Mechanical as chewing gum or chemical stimuli due to presence of food in the mouth	Seeing, smelling, hearing the preparation of food or even thinking of food.
Receptor	Mechanoreceptors in the mouth, pain and temperature receptors.	Visual, smell or auditory receptors (special sense).
Afferent	Chorda tympani of facial nerve from anterior $^2/_3$ of tongue, glossopharyngeal n. from posterior $^1/_3$ and vagus n from the inferior surface of the tongue.	Optic, olfactory or cochlear nerves.
Center	Superior and inferior salivary nuclei in lower pons and upper medulla.	Cerebral cortex which send impulses to the superior and inferior salivary nuclei.
Efferent	Facial (chorda tympani) and glossopharyngeal nerves or sympathetic nerves.	
Effector organ	Salivary glands.	
Response	Increased salivary secretion (true with parasympathetic and trophic with sympathetic supply).	

N.B:-

* Tactile and thermal stimuli lead to reflex salivary secretion.
* Acidic food as lemon is the most powerful stimulus for salivary secretion.
* Salivary secretion is an active process.
* Afferent impulses from lower esophagus, stomach and small intestine are carried along vagus nerve to cause reflex increase in salivary secretion in case of gastrointestinal irritation or nausea.

Mastication (chewing):-

A) <u>The chewing process is mainly caused by the chewing reflex that begins by</u> presence of bolus of food in the mouth in contact with the oral mucosa causing reflex inhibition of the muscles of mastication so the lower jaw drops down. The drop of the jaw stimulates the stretch reflex of the jaw muscles leading to rebound contraction which allow the jaw to move up and closure of the teeth that compress the bolus against the oral mucosal linings and another cycle begins.

B) <u>The chewing process It is the first step in the breakdown of complex foodstuffs and serves several functions;</u>

– **Grinding** of food into small particles thus helping digestion by

- Increasing its total **surface area** which is exposed to the digestive enzymes.
- Softening the food and transforming it into a size easily to be swallowed.
- Preventing excoriation (injury) of GIT.

– Allow the food to stimulate salivary secretion which soften, lubricates and digest foods.
– Allow the food to stimulate the taste and smell receptors that gives satiety sensation.

Swallowing (Deglutition):-

After chewing and mixing the food with saliva, it is propelled by swallowing through the pharynx and esophagus into the stomach.

<u>The process of swallowing is divided into 3 stage:-</u>

A) Buccal stage (pressing the bolus of food into the pharynx):

When the bolus of food becomes ready for swallowing, it is rolled over the back of the tongue by voluntary elevation and retraction of the tongue against the hard palate then it is forced into the pharynx by contraction of mylohyoid muscle (a skeletal muscle in the back of the throat). This is the only step that occurs voluntarily. The remaining steps occur reflexly.

B) Pharyngeal stage (propelling the bolus of food into the esophagus):

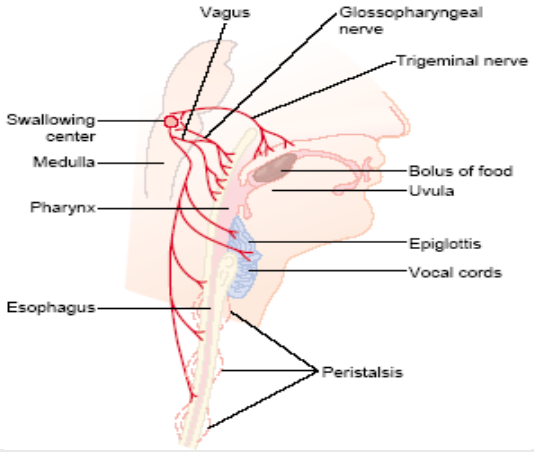
As the bolus of food enters the posterior mouth and pharynx, **swallowing reflex** is initiated.

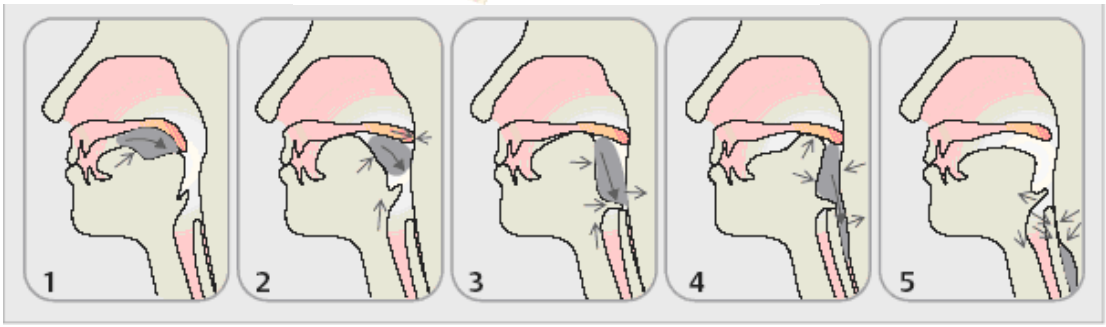
Initiation of several actions that are basically involve propelling the bolus into the esophagus and at the same time closing all alternative routes of escape.

1. The tongue is maintained elevated against the hard palate by continued contraction of mylohyoid muscle to prevent reflux of food into the mouth.
2. The soft palate is elevated to close the posterior nares (nasal opening) to prevent reflux of food into the nasal cavities.
3. The food is inhibited from entering into the larynx and trachea by:
   - Closure of the glottis (superior laryngeal opening) through elevation of the larynx to be covered by epiglottis.
   - Inhibition of respiration for less than 2 sec. (deglutition apnea).
   - Approximation of the vocal cords.
4. The palatopharyngeal folds on either side of the pharynx are approximated forming a sagittal slit through which the masticated food to pass easily into the posterior pharynx.

5. **The pharyngeal peristaltic** wave starts at the superior pharyngeal muscles then spreads downwards along the middle and inferior muscle pushing the food to the esophagus. The peristaltic wave increases the pressure at the pharyngeal side of the pharngo-esophageal junction to about 100 mmHg.
6. As the bolus reaches the upper esophageal sphincter, it relaxes under the effect of high pressure and the bolus passes through it then it is closed again, with opening of the glottis and respiration starts once more.

N.B. The upper esophageal sphincter is normally strongly contacted (closed) between swallows to prevent entry of air to esophagus or stomach during inspiration.



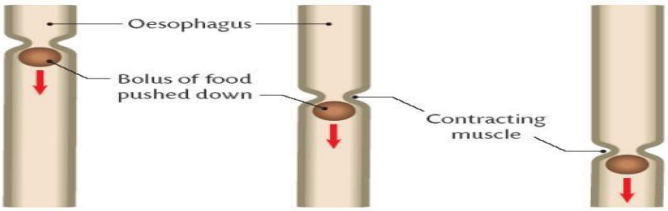


C) Esophageal stage (propelling the bolus of food to the stomach):

- The esophagus is a muscular tube between the pharynx and stomach.
- Its upper third is formed of **striated muscle** fibers, and its lower third is formed of **smooth muscle** fibers while its middle third is mixed.
- Its role in digestion is to convey bolus of food from the pharynx to the stomach.
- If the bolus of food is liquid, it travels along the esophagus by gravity but if it is semisolid, it travels by peristalsis.
- The esophageal peristaltic waves may be:

1. **Primary peristalsis:** It is the continuation of the pharyngeal peristaltic wave in the form of a wave of contraction preceded by a wave of relaxation, to push the bolus of food to the stomach. The peristaltic wave travels at the rate of 2-4 cm/sec. and completely traverses the esophagus in 10 seconds.
2. **Secondary peristalsis:** It occurs if the bolus is not delivered in "one pass" to propel the remnants of food that distend the esophageal wall thus, all esophageal content reach the stomach.

- The lower esophageal (gastro-esophageal) sphincter, which is a lower part of esophagus 2- 5 cm above the gastro-esophageal junction is relaxed (receptive relaxation) thus the food reaches the stomach.



N.B. The lower esophageal sphincter (LES) is normally contracted (closed) to prevent regurgitation of the acidic gastric contents into the lower esophagus.

Abnormalities of swallowing:-

1- **Dysphagia:** Means difficulty of swallowing which is due to lesion in the reflex arc of swallowing as a result of
   - Nervous factors as poliomyelitis.
   - Muscular weakness as myasthenia gravis.

2- **Achalasia:** Uncoordinated esophageal contractions due to absence of myenteric plexus of the esophagus through which the vagus normally exerts its motor effects “in which the LES fails to relax in front of the peristaltic wave during swallowing and the food has difficulty to enter the stomach and tends to accumulate above the sphincter causing dilation of the lower part of esophagus”.