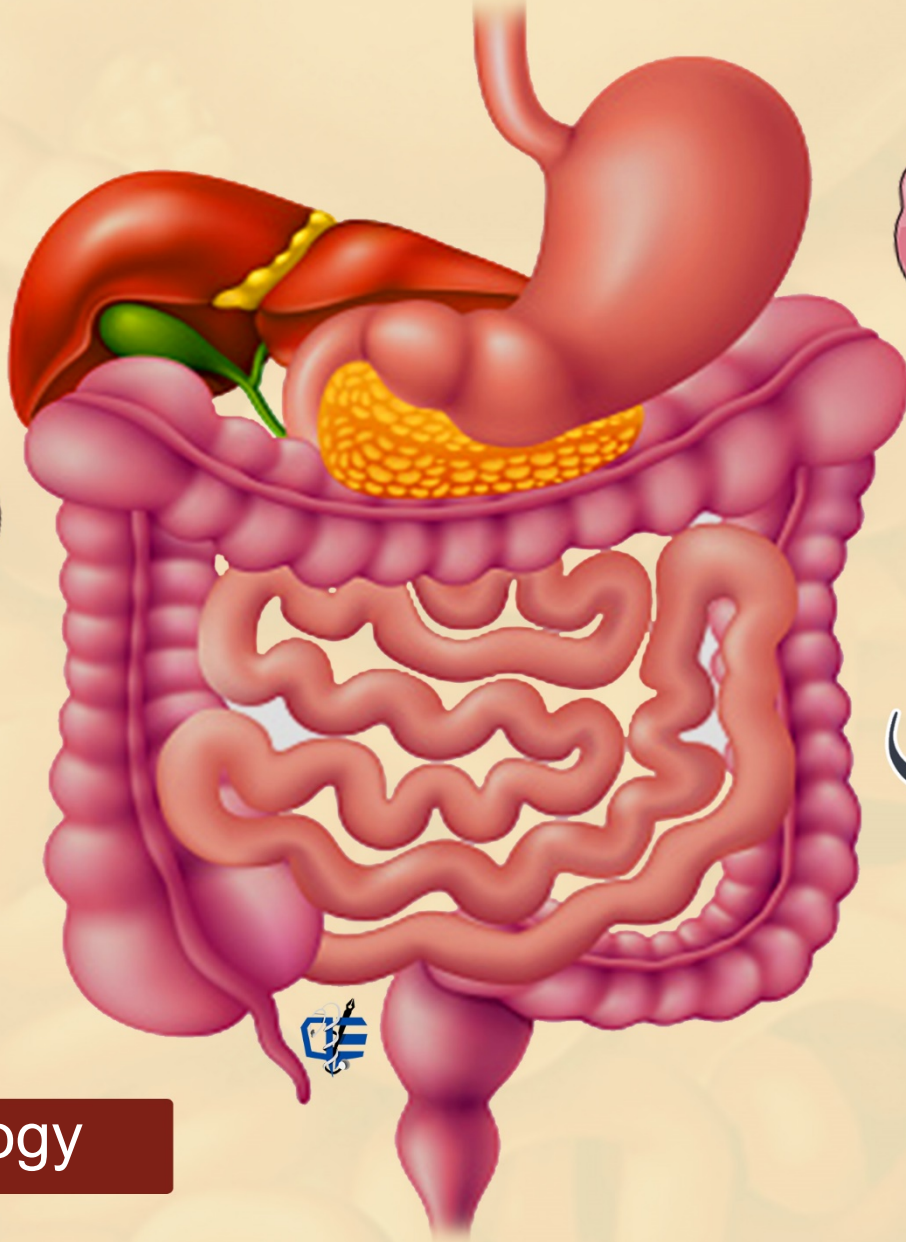


# GastroIntestinal System



physiology

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# Gastrointestinal Motilities

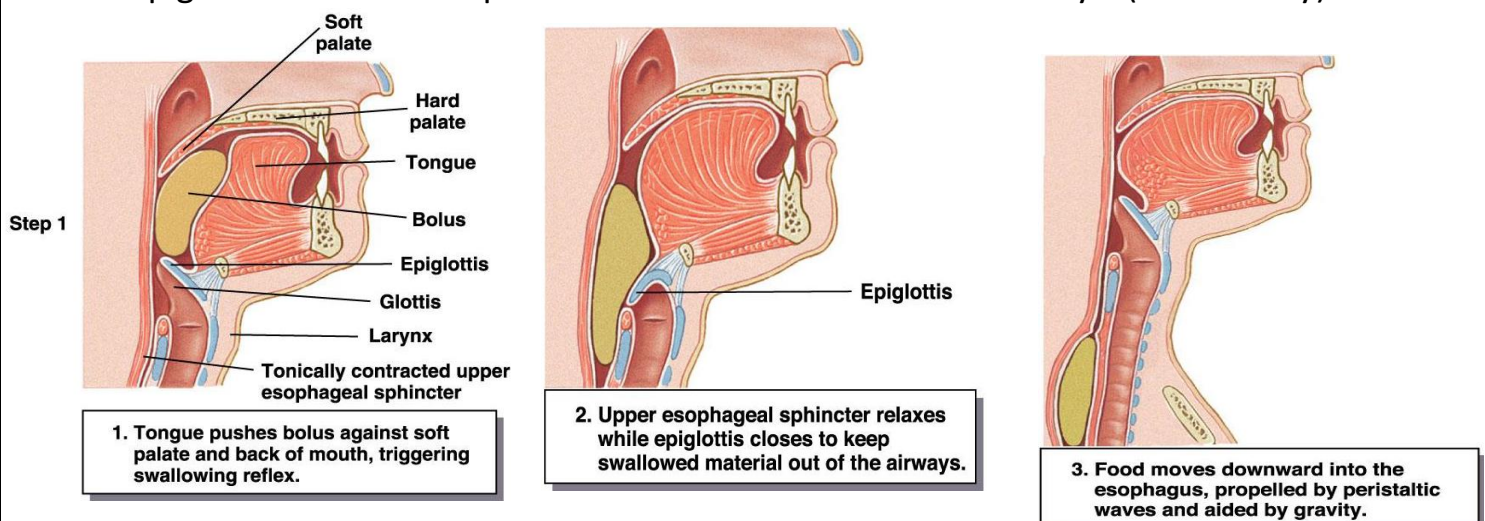
There are many processes that take place in our GI tract every time you eat some thing or drink something.

## 1. Mastication (chewing):

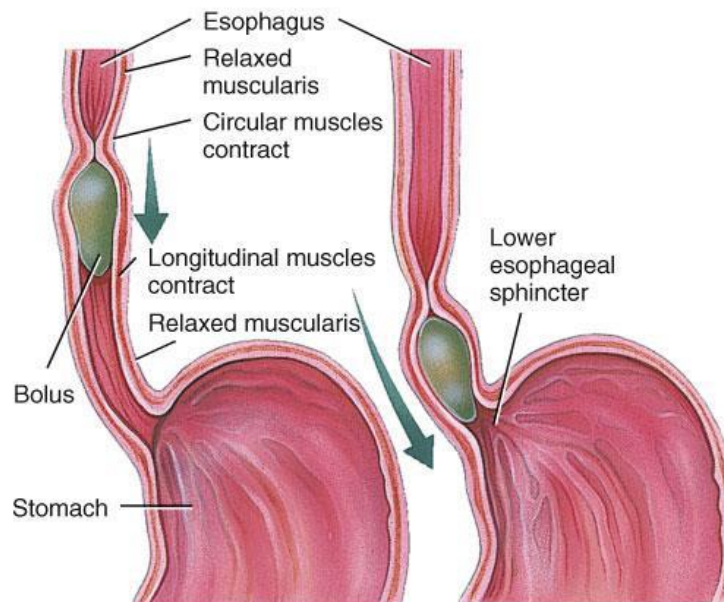
- First thing you do after eating a nice slice of pizza. You start grinding this food between your upper and lower jaw with the help of your mastication muscle.
  - This process is **voluntary** with **some involuntary** action taking place (**chewing reflex**).
  - “The initiation of chewing reflex appears by muscle stretching caused by drop of the lower jaw (due to the presence of food bolus in the mouth). This will result in a rebound of the lower jaw by activation of stretch reflex”.
  - “Mixing is also promoted by the movements of the tongue”.
  - So, the purpose of mastication is **mixing of food with saliva and grinding**.
- Why do we chew the food?
- ✓ To get smaller particles.
  - ✓ Mixing of food with saliva
  - ✓ For easier swallowing due to lubrication effect of saliva.

## 2. Swallowing (deglutition)

- Start as a **voluntary** action but **continues as involuntary**.
- It is divided into two stages:
- ✓ Pharyngeal stage
  - ✓ Esophageal stage
- Firstly, starting with the **pharyngeal stage**  
Happen through many steps:
    - ✓ Tongue pushes bolus against soft palate and back of mouth into the pharynx, triggering swallowing. (voluntary)
    - ✓ Upper esophageal sphincter relaxes and esophageal opening is enlarged while epiglottis closes to keep swallowed material out of the airways. (involuntary)



- ✓ Remember that **the nasal and oral cavities are closed by the soft palate and tongue**, respectively. (no respiration happens).
- ✓ In the pharynx you can have both voluntary and involuntary action.
  - Involuntary: when the bolus is in the pharynx you have no control over the pharynx.
  - Voluntary: when your pharynx is empty, but you can still get a contraction if you want.
- Secondly **the esophageal phase**:
  - ✓ Food moves downward along esophagus to the stomach, propelled by **peristaltic waves** and aided by **gravity**.
  - ✓ Peristaltic contraction: means contraction up (before the bolus) and relaxation down (after the bolus) so it slips easily forward. (the law of GI tract)  
 Why? Because of the enteric nervous system axons are arranged in a way that the activator axons are pointed upward and the inhibitory axons are pointed downward, so when this neurons are activated they initiate contraction above the bolus and relaxation below it.



Anterior view of frontal sections peristalsis in esophagus

## 24.10

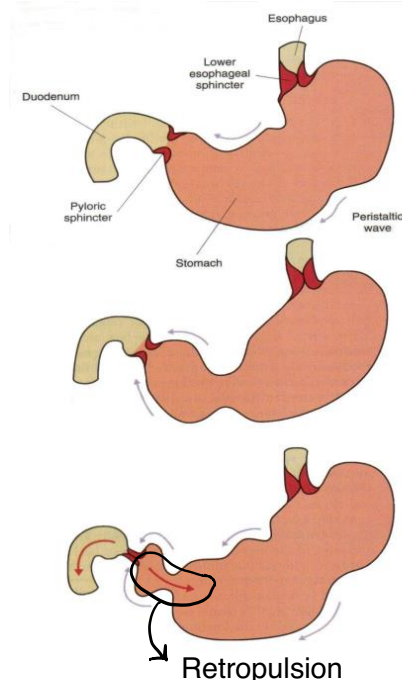
- ✓ There are two type of peristaltic contractions:
  - a- Primary peristaltic contractions: continuation of the contractions initiated in the pharynx which conduct bolus through the esophagus.
  - b- Secondary peristaltic contraction: a second wave of contraction initiated in any part of the esophagus in response to retained food in esophagus or after the failure of the first peristaltic contraction to move bolus of food along esophagus. "Represented by intrinsic (within myenteric plexus) and extrinsic (through afferent and efferent vagus fibers)"
- ✓ At the end of esophagus there is a sphincter (lower esophageal sphincter), relaxation of this sphincter is mediated by ENS (inhibitory neurons) which decreases the tonic contraction of the sphincter causing it to dilate.

✓ Notes:

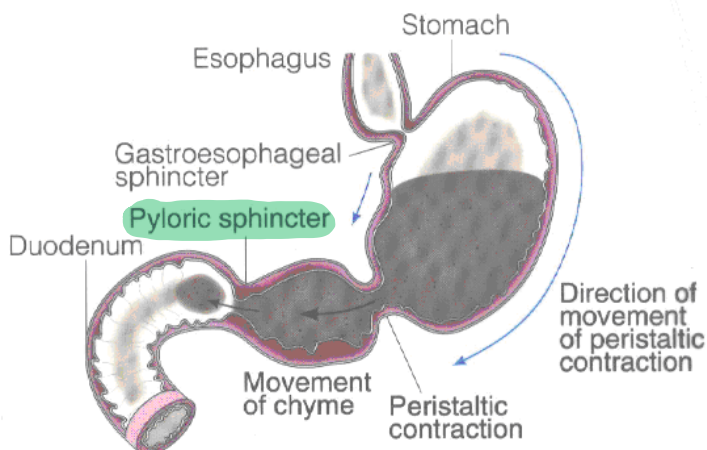
- Failure of the sphincter to relax may result in a pathological condition known as **achalasia**. In which the ability of myenteric plexus to cause relaxation of the sphincter has failed. ( may cause aspiration of food).
- Gastro-esophageal sphincter is equipped also by valve like closure at the distal opening of the esophagus to prevent reflux of food from the stomach. The failure of this system may result in esophageal reflux (Return of gastric content toward esophagus).
- Some people have difficulties in swallowing due to **less representation of ENS** at the level of esophagus resulting in weak contraction of the esophagus, is condition is called **dysphagia**.

### 3. Gastric motilities

- “The most important function of the stomach is storage of food”
- The stomach when it’s empty it has a low capacity equal (50-100)ml (in relaxation state) but once you have eaten you are filling your stomach with food and thus the capacity increase up to 4-5L.
- “This dilation begins with **receptive relaxation** and the intervention of vago-vagal reflex that decreases the muscular tone of the stomach>>relaxation”.
- Relaxation of the stomach caused by receptive reflex (is a reflex in which the gastric fundus dilates when food passes down the pharynx and the esophagus).
- Peristaltic contraction in the stomach:
  - ✓ Start at **the mid portion** of the stomach and move toward the antrum and repeated many times. The frequency is determined by the frequency of basic electrical rhythm (BER) of gastric smooth muscle.
  - ✓ As they approach the antrum, they are forming **constrictive rings**.
  - ✓ At the antrum, when the peristaltic constrictive wave reaches the pylorus, it causes **constriction of the pyloric sphincter** (more closed) which impedes emptying of chyme into the duodenum. (chyme: stomach secretions mixed with food)



Gastric Emptying and Mixing as a Result of Antral Peristaltic Contractions



- ✓ Only **small amount** of chyme (must be fluid consistency/no solids) can pass into the duodenum because of **the small opening of the pylorus** and **the constriction of pyloric sphincter**, but most of the content (fluid/ food) is tossed back to the stomach. This process of tossing back the antral content is known as **retropulsion**.
- ✓ “The process that results in passage of chyme into duodenum is known as **gastric emptying**. The whole activity that results in gastric emptying is known as pyloric pump” (pyloric pump = gastric emptying+ retropulsion).
- ✓ The functions of this contraction are:
  - Mixing food
  - Grinding food (mechanical digestion)
  - Toss the content of the antrum back toward the body and forth (**retropulsion**)
- ✓ If someone swallowed a solid particle like metal coins, etc. This particle will not be in the stomach forever. After approximately 6 hours, the contraction of the stomach become very intense and force the release of this particle toward the duodenum if that solid particle can Pass through the Pyloric sphincter .
- “Pylorus as functional structure: Pylorus is a small opening between stomach and duodenum guarded by smooth muscle cells that form the pyloric sphincter. The muscle cells of this sphincter are in tonic contractions. This structure gives access only to fluids to pass into duodenum and prevents the passage of food particles until they are grind and mixed well with secretions by forming chyme with fluid consistency”.
- **Hunger contractions**
  - ✓ These intense contractions are initiated when the stomach is empty.
  - ✓ There is no information about the mechanism of action or how they are activated.
  - ✓ They believe that these contractions are related to the level of blood sugar (They are increased by decreasing glucose level in blood).
- **Control of gastric motility**
  - ✓ We have power control over the activity of stomach, but don't forget over all movements along GI system, **the main control is achieved by electrical activity and neural control**.
  - ✓ We have to a **lesser** extent the effect of hormones over motor activities, while in **secretion** we have **more powerful** control for **hormones**, we can also have some control by neurons.
  - ✓ Neural controls
    - Once you have **filling of the stomach** you have **activated the ENS and ANS** and cause increase activity of the stomach by local reflexes. “initiates myenteric reflexes that causes an increase in the activity of pyloric pump and inhibits the tone of pyloric sphincter”.
    - One you have **empty the content into duodenum**, you have **distention of duodenum** which activate inhibitory reflexes of stomach these reflexes are called **enterogastric reflexes to inhibit gastric activities**.

- ✓ Hormonal controls
  - We have some hormones released from the lower part of the stomach like **gastrin, cholecystinin (CCK), gastric inhibitory peptide (GIP), secretin**.
  - Gastrin can have some mild role in stimulation of peristaltic activities of the stomach, which enhance pyloric pump.
  - On the other hand, CCK, secretin and GIP from its name, has an inhibitory effect on gastric activities.

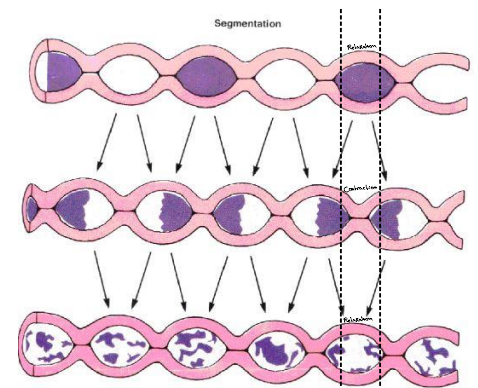
Note : this topic will be repeated again in details in next lectures.

#### 4. Motility in small intestine

- Site of most digestion and absorption: **duodenum and jejunum**
- Types of movement in small intestine :

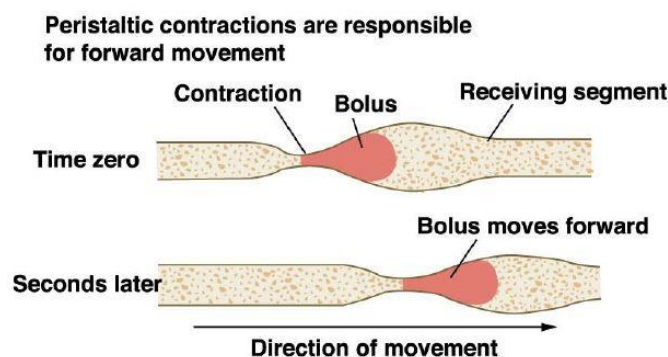
##### a- Segmentation (mixing) - digestive state

- Involves contraction and relaxation of the circular muscles in the small and large intestine which are giving this segmented appearance.
- The main purpose of segmentation contraction is to **mix chyme with enzymes and secretions** released from the intestine and pancreas.
- “The rate of contractile activity is determined by the rate of slow waves (the electrical activity of smooth muscle cells or BER) in that segment of the intestine. The maximum frequency of contractions is about 12/minute in the upper part of intestine (duodenum and jejunum) and 8/minute in the terminal ileum”.
- It’s rhythmic contraction controlled by electrical control.



##### b- Peristalsis (propulsive)-inter-digestive

- As we said before peristalsis is about contraction up and relaxation below mainly by **circular muscles (rhythmical contraction, it is controlled by ENS)**.
- In addition to that you can have activity of **longitudinal muscles** to get shortening and elongation of the that segment in between, this shortening and elongation results in chyme movements downward along the GI (in analward direction).
- The first part (up-down) is controlled by ENS. The second part (shortening-elongation) is a **rhythmical contraction controlled by electrical control**.
- “The main effect of this type of contraction is to propel chyme in caudal direction, they also have some effects on mixing food and spreading chyme along the intestine which help in the absorption of food”.



### c- Migrating motor complex

- Once you have empty all the content of the small intestine, a special type of contraction is initiated at the distal part of the stomach (antrum) and continues along the entire small intestine
- It is like a constricted ring traveling along the whole small intestine from the stomach until the ileocecal part.
- The function of these contractions is to sweep the intestinal content in the time between meals.
- These contractions are initiated by hormone called Motilin. (Note : Motilin concentration increase between meals).
- “The contractions that forming MMC appear in 3 phases:  
**First phase:** slow waves (as electrical activity) without contraction are present.  
**Second phase:** not all slow waves are followed by contractions (one slow wave is followed by contraction and 1-5 slow waves are not followed).  
**Third phase** lasts for 5-15 minutes all slow waves are followed by contractions.”

### d- Peristaltic rush (power propulsion)

- Once there is a high toxin level or pathogens in the intestine, this cause the irritation of the mucosa which will lead to powerful peristaltic contraction (peristaltic rush ) and transit time (the time needed to reach from point A to point B) become shorter causing low level of absorption and this will result in emptying the content of the intestine with high amount of fluid, this finally lead to watery diarrhea.
- This is a protective mechanism against toxins and pathogens, so when a patient Came to you with diarrhea don't immediately give him anti-diarrheal drugs instead give him only fluid for replacement.

### • Control of intestinal movement

- ✓ Main control for movement: Electrical activity of muscle & Neural control: ENS, ANS
- ✓ Other effectors (not main control): Hormonal control & Gastrin, CCK, Serotonin enhance intestinal motility & Secretin and Glucagon inhibit intestinal motility.

### • Summary of motilities of small intestine

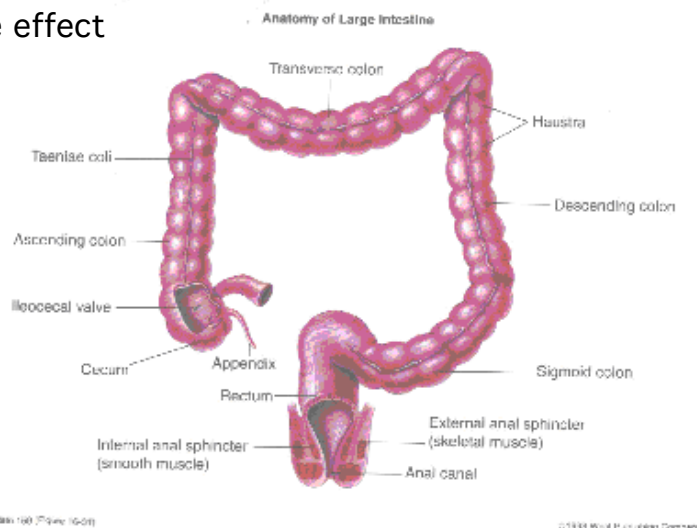
- ✓ **Segmentation contraction:** characterize the digestive or fed state and have mixing effects
- ✓ **Peristaltic contractions:** mainly Propulsive effect
- ✓ **Migrating motor complex** characterizes the inter-digestive state, ended with ingestion of food
- ✓ **Peristaltic rush** is a response to harmful agents

## 5. Motility of the colon

two type of contraction:

### 1- Haustration contractions:

- It is somehow similar to segmented contraction in the intestine, This segmented appearance is due to the highest activity of circular layer.
- At the colon the longitudinal layer of muscles are grouped together to form three strips along the colon, forming what we call **taeniae coli**.
- the activity of circular layer, longitudinal muscle strips are also involved to cause haustral appearance in the colon
- these contractions have also propulsive effect
- Although, they have **slow effect** on the content of cecum and ascending colon, they are the main responsible in moving fecal materials into the transverse colon.
- Due to slow contraction, it needs about 9 hour to move the fecal material from cecum to the transverse colon.
- **This type of contraction happens all day, with different intensities and keep switching between relaxation and contraction.**
- it has propulsive effect



### 2- Mass contractions:

- More absorption of water happens in the transverse colon, making the fecal material more solid.
- Once we have the feces at this solid consistency, we need more powerful contraction at the level of transverse colon to push this solid fecal material furthermore downward.
- This contraction is **mass contraction**:  
Simply it is contraction up and relaxation below and shortening in the middle but much powerful contraction. which result in evacuation the content to lower part until it reaches rectum.
- **These contractions happen once, twice or three times a day.**
- **These contractions are initiated after meals by gastrocolic reflexes.**
- the enteric nervous system is activated

**Note :** once you eat, you have distention of stomach causing reflexes carried by vagus nerve to activate the upper part of the colon and to initiate mass contraction. By initiation of these mass contractions you are moving the content in direction of anal canal and we can start the process of defecation.



- **DEFECATION**

- ✓ A process that involves the discharge of faeces from the body.
- ✓ As we know , we have two types of movements in colon:  
Mass contraction and Haustration contraction
- ✓ After multiple mass contractions, the faeces now reach the sigmoid part of large intestine, and here there are two different types of reflexes preceding defecation process:
  - 1) Intrinsic reflex (aka intrinsic myenteric reflex): The intrinsic reflex is initiated by the distension of the rectum, by the activation of myenteric plexus (ENS), leading to more contractions in the descending colon, sigmoid and rectum. This will force faeces to move toward the anus. This reflex is weak and will not cause defecation.
  - 2) Extrinsic reflex (aka para-sympathetic defecation reflex): This reflex amplifies and enhances the function of intrinsic reflex. Extrinsic reflex involves the sacral segments of the spinal cord. When the nerve endings (sensory parasympathetic fibers) in the rectum are stimulated by the distension that results from the accumulation of faeces, signals are transmitted first into the spinal cord and are then reflexed back to the descending colon, sigmoid, rectum, and anus through parasympathetic nerve fibers (motor fibers). These parasympathetic signals greatly intensify the peristaltic waves and relax the internal anal sphincter, thus converting the intrinsic myenteric defecation reflex, which is weak, into a powerful process of defecation that is effective in emptying the large bowel.
- ✓ Note: all these reflexes are involuntary
- ✓ After all these reflexes, the defecation in normal people occurs only as a voluntary act by relaxing the external sphincter muscle (which is a striated muscle and under voluntary control) and increasing the abdominal pressure, through closing the glottis and contracting the abdominal wall, which causes the pelvic floor to be pulled downward on the anal ring and to be relaxed to evacuate faeces.
- ✓ Pathological problems related to colon movement:
  - 1) Constipation: (hypo-motility of colon) due to less migration of neuron toward the colon, which results in the enlargement of colon (mega-colon).
  - 2) Diarrhea: (hyper-motility of GIT), mucus diarrhea is more associated with hyper-motility of colon, however the watery diarrhea is more associated with small intestine hyper-motility.
  - 3) the hypo-motility might be caused by the effect of anesthetic drugs after procedure.

**The end**