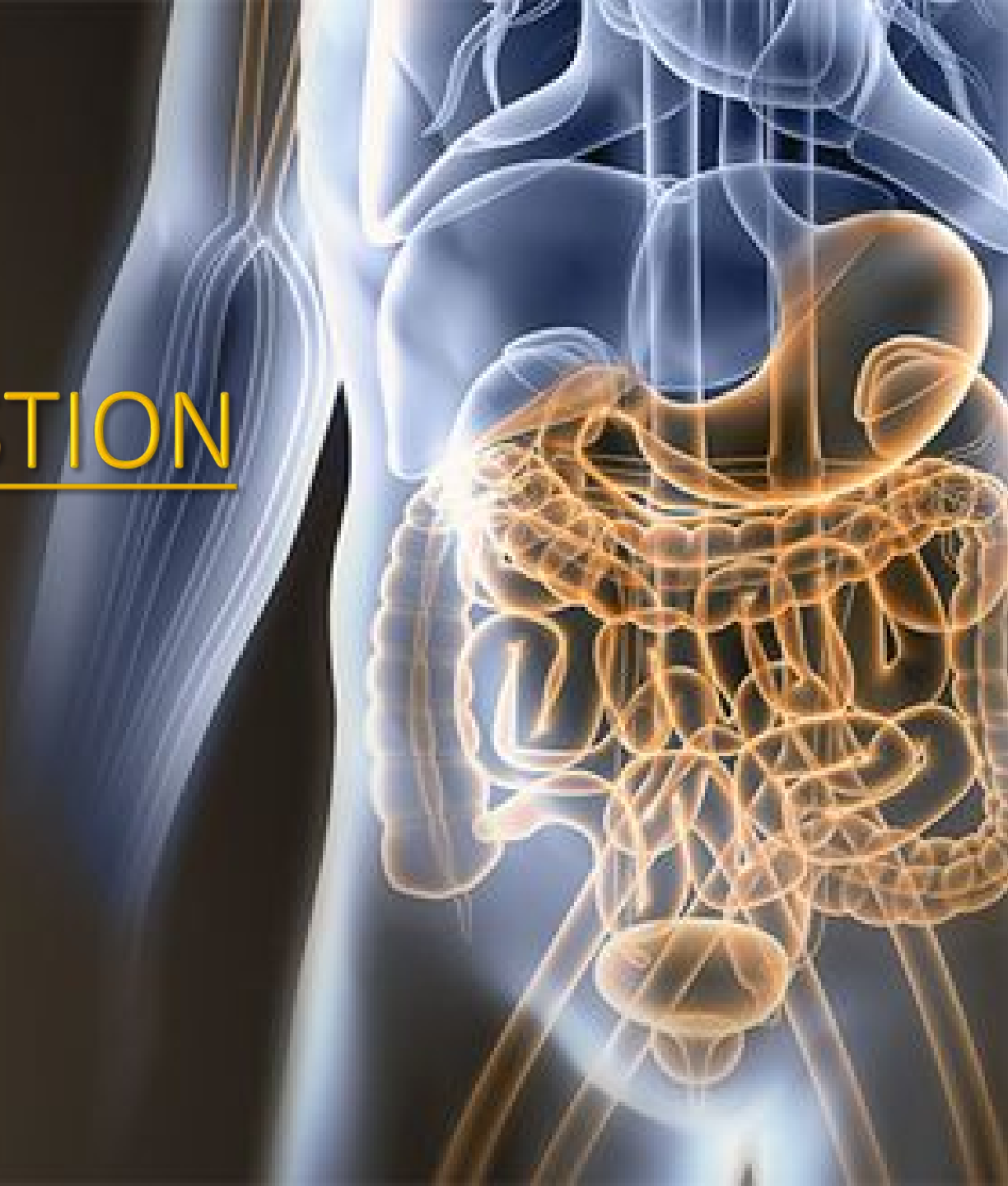
PHYSIOLOGY OF DIGESTION

MECHANICAL DIGESTION

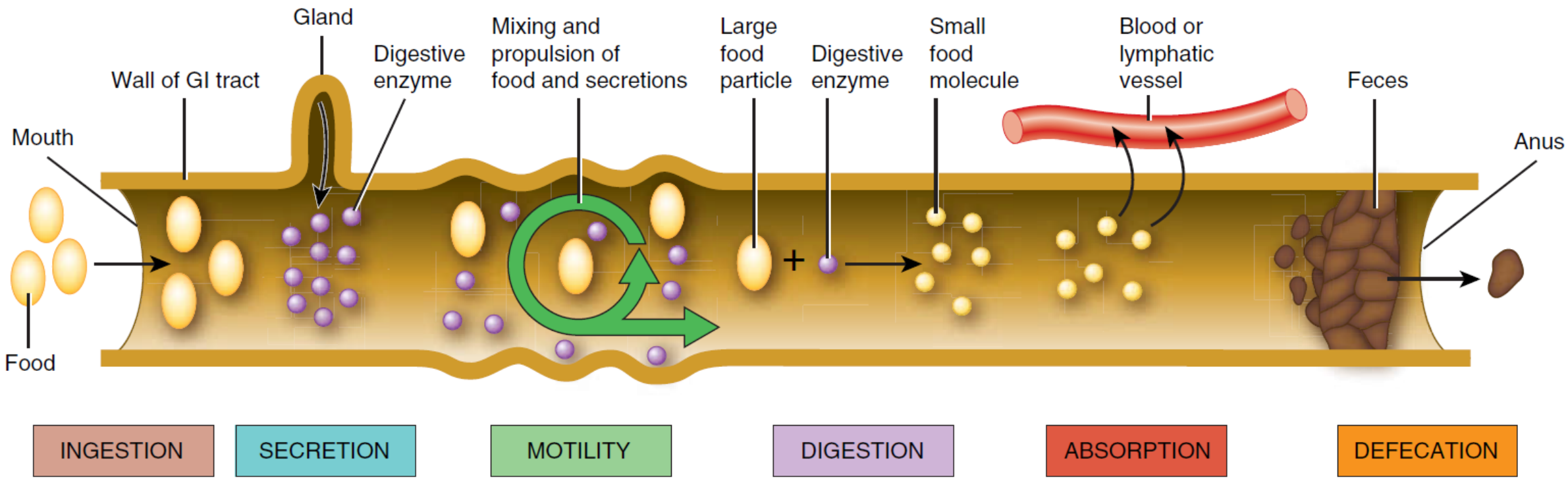
SEMESTER – IV
ZOO CC409
UNIT-1

RAJEEV RANJAN
ASSISTANT PROFESSOR
DEPARTMENT OF ZOOLOGY
PATNA WOMEN'S COLLEGE



INTRODUCTION

- The gastrointestinal tract is basically a muscular tube that contains and processes food as it moves from the **mouth** to the **anus**.
- The food material is complex and composed of carbohydrate, proteins, fats and other substances. These complex materials are hydrolysed into simpler materials, with the help of enzymes for absorption by the intestinal wall. Overall, the digestive system performs **six** basic processes:
- **Ingestion:** This process involves taking foods and liquids into the mouth (eating).
- **Secretion:** Each day, cells within the walls of the GI tract and accessory digestive organs secrete a total of about 7 liters of water, acid, buffers, and enzymes into the lumen (interior space) of the tract.
- **Motility:** Alternating contractions and relaxations of **smooth muscle** in the walls of the GI tract mix food and secretions and move them toward the anus. This capability of the GI tract to mix and move material along its length is called **motility.**
- **Digestion: Digestion** is the process of breaking down ingested food into small molecules that can be used by body cells.
- **Absorption:** The movement of the products of digestion from the lumen of the GI tract into blood or lymph is called **absorption.**
- **Defecation:** Wastes, indigestible substances, bacteria, cells sloughed from the lining of the GI tract, and digested materials that were not absorbed in their journey through the digestive tract leave the body through the anus in a process called **defecation.**



The digestive system performs six basic processes: ingestion, secretion, motility, digestion, absorption, and defecation.

Physiology of Digestion

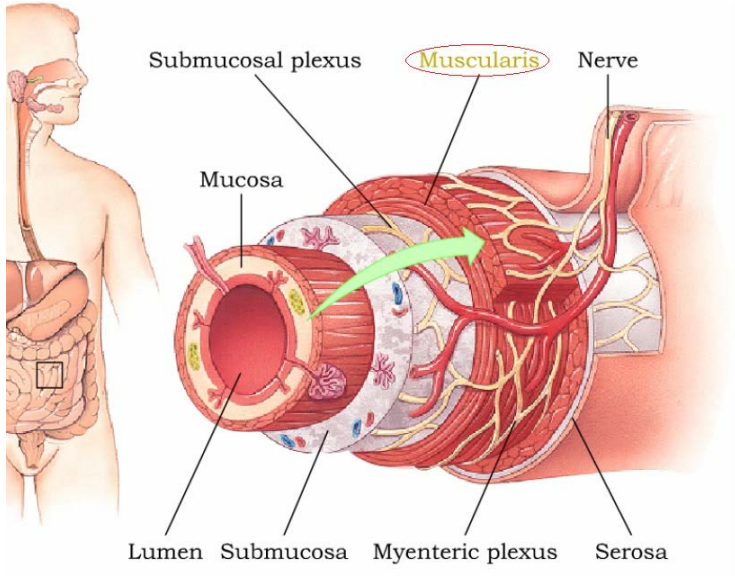
- **Digestion** is the process of breaking down ingested food into small molecules that can be used by body cells. Digestion of food occurs in three phases and all these phases takes place in coordination with each other. Three components of physiology of digestion are:
  - Mechanical digestion
  - Chemical digestion
  - Hormonal control of digestive activities

- In **mechanical digestion** the teeth cut and grind food before it is swallowed, and then smooth muscles of the stomach and small intestine churn the food to further assist the process. As a result, food molecules become dissolved and thoroughly mixed with digestive enzymes.
- In **chemical digestion** the large carbohydrate, lipid, protein, and nucleic acid molecules in food are split into smaller molecules by hydrolysis. Digestive enzymes produced by the salivary glands, tongue, stomach, pancreas, and small intestine catalyse these catabolic reactions.
- Physiology of digestion is under strict action of **hormones** and different **enzymes**.

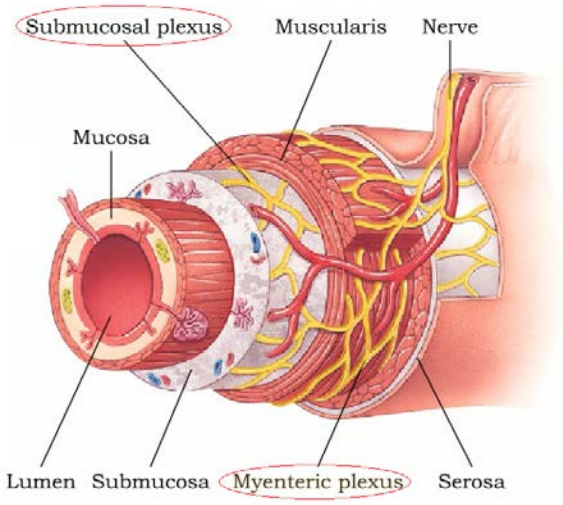
Mechanical digestion

- Mechanical digestive functions consist of both voluntary and involuntary muscle contractions and relaxation including:
  - Chewing and swallowing food.
  - Mixing and moving food throughout the GI tract.
  - Elimination of feces.

- The propulsive and mixing movement of the smooth muscles in the digestive system are regulated by:
  - Hormonal feedback loops
  - Neural feedback loops



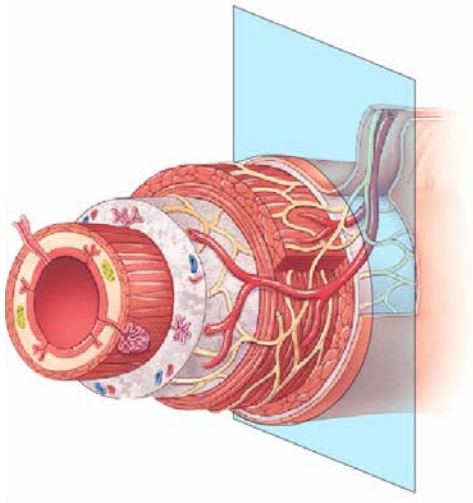
Hormonal feedback loops

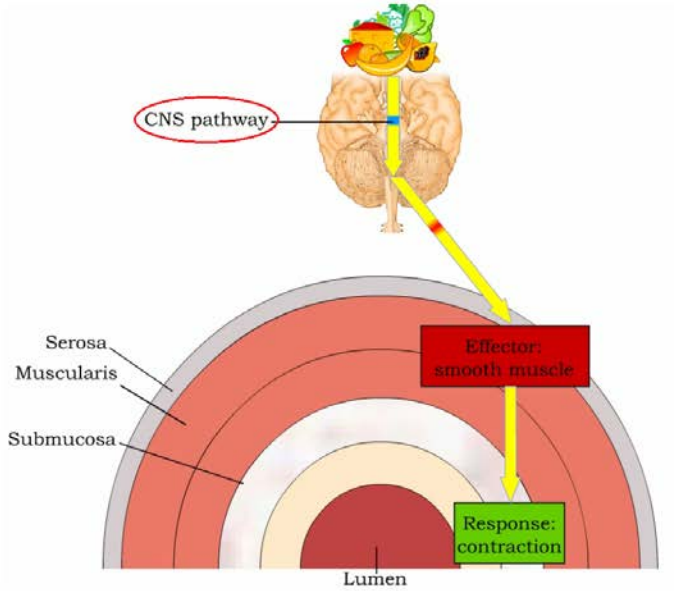


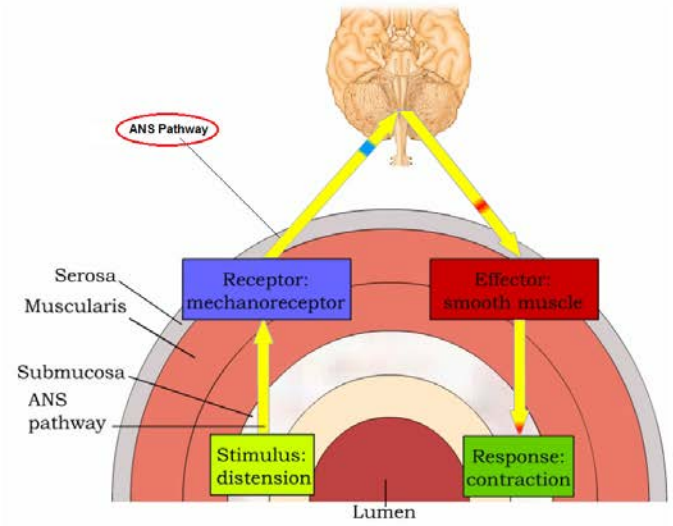
Neural feedback loops

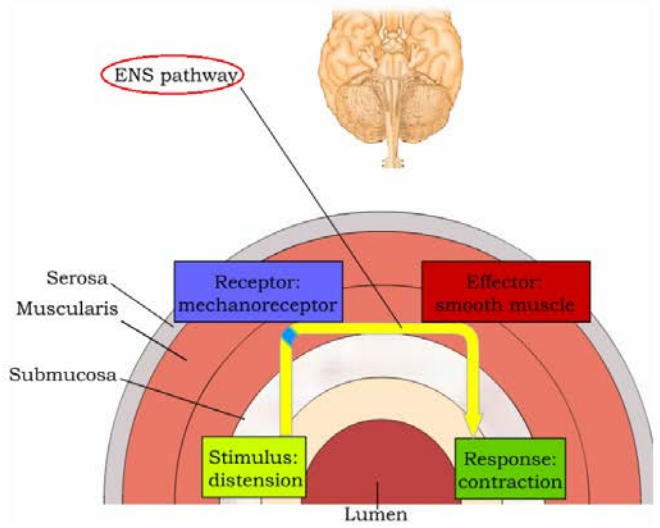
Neural regulation of mechanical digestion

- Neural control of the mechanical movements in the GI tract that comes from the:
  - CNS
  - ANS(long) reflexes
  - ENS(local) reflexes.









(a) CNS controlled voluntary movements

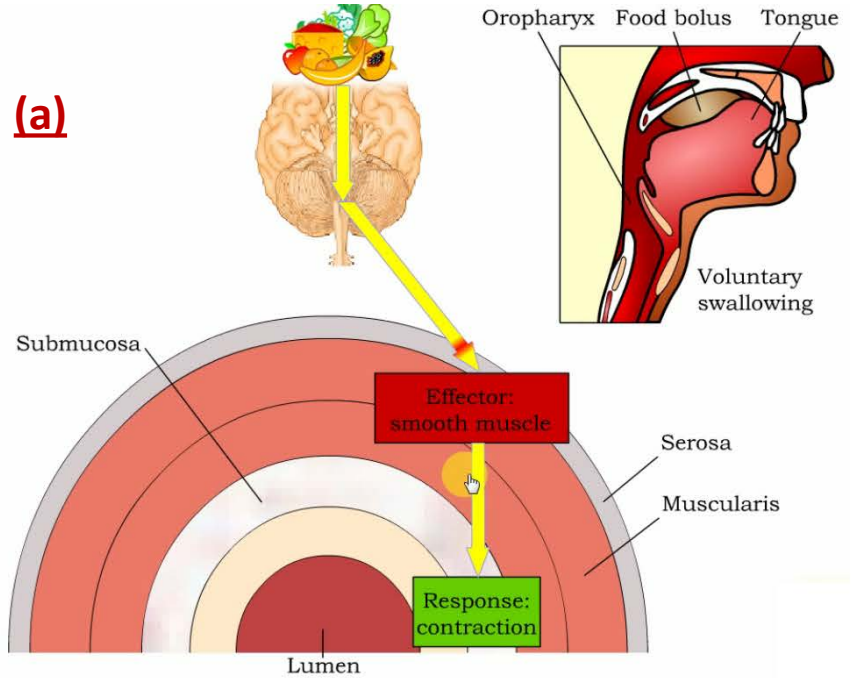
- The CNS controls voluntary swallowing movements.
- The presence of food is the stimulus for voluntary digestive movements

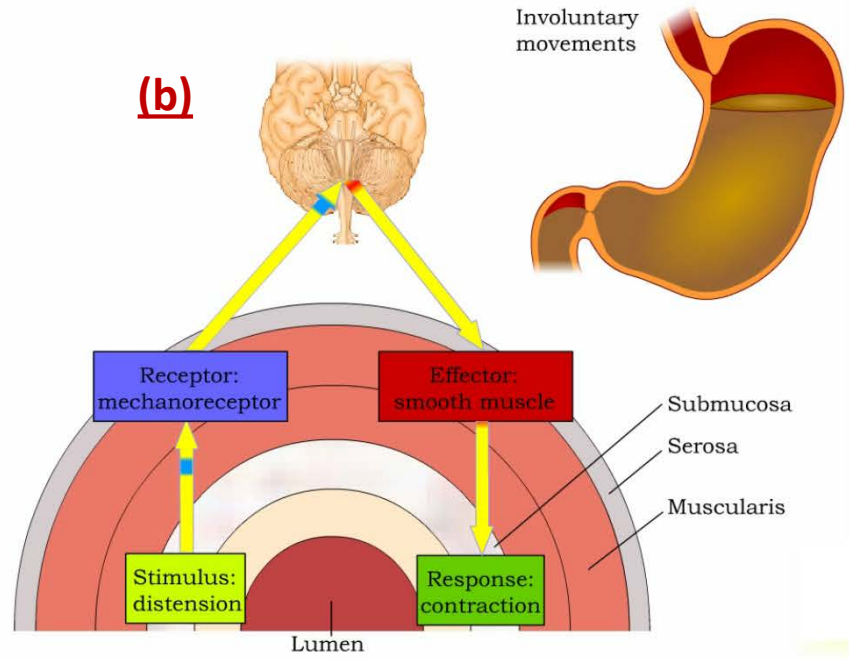
(b) ANS controlled involuntary movements

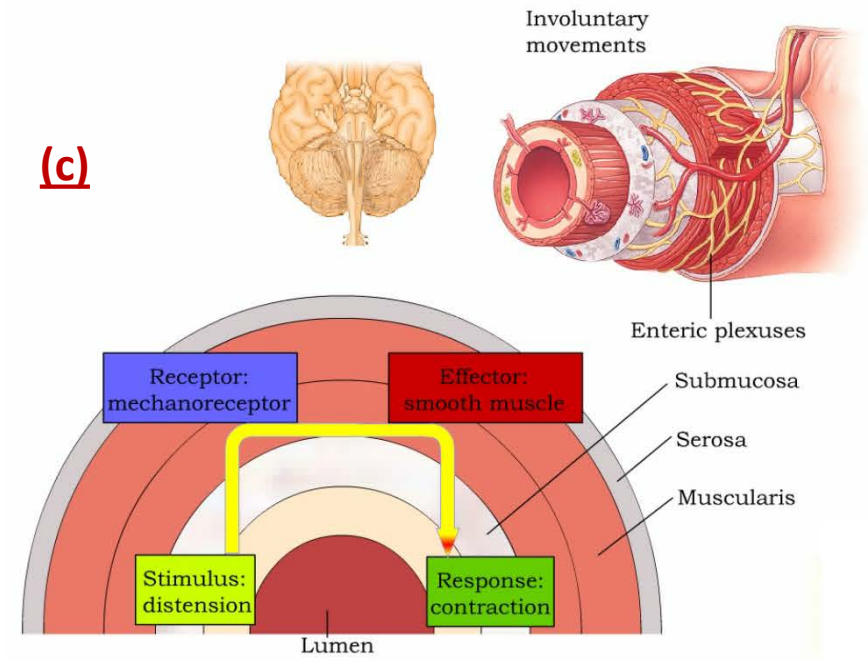
- ANS (long) neural reflexes include a CNS control centre in the spinal cord or brain.
- ANS neurons regulate involuntary smooth muscular movements.
- The stimulus for many involuntary digestive movements is distension.
- The response is either increased or decreased contraction of the muscularis.

(c) ENS controlled involuntary movements

- ENS (or local) reflexes utilize the plexuses embedded in the wall of the GI tract.
- ENS reflexes also control involuntary movements of the muscularis.

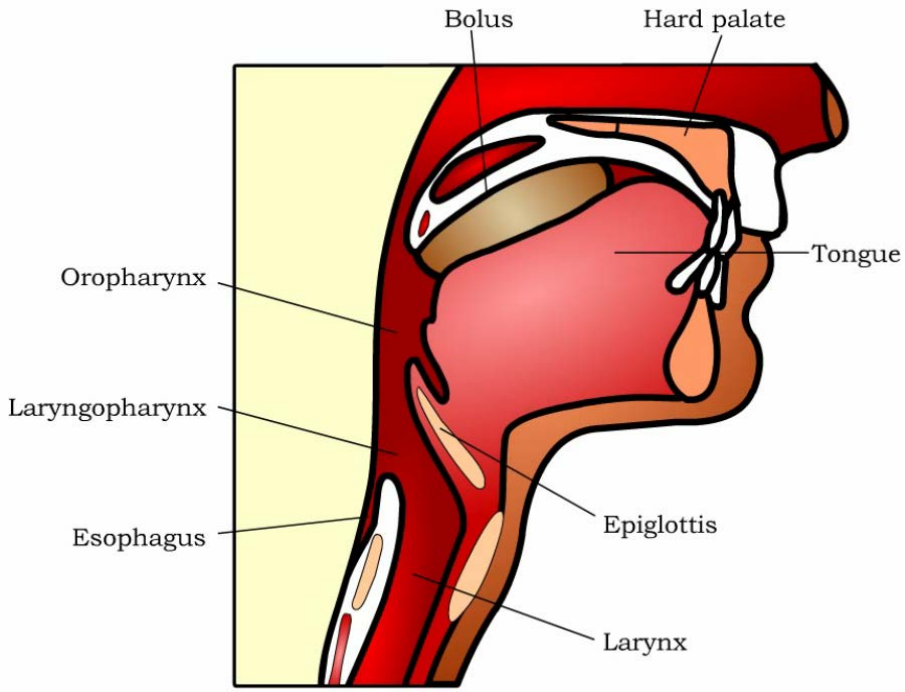

(a)
Oropharyx
Food bolus
Tongue
Voluntary swallowing
Submucosa
Effector: smooth muscle
Serosa
Muscularis
Response: contraction
Lumen


(b)
Involuntary movements
Receptor: mechanoreceptor
Effector: smooth muscle
Submucosa
Serosa
Muscularis
Stimulus: distension
Response: contraction
Lumen


(c)
Involuntary movements
Enteric plexuses
Receptor: mechanoreceptor
Effector: smooth muscle
Submucosa
Serosa
Muscularis
Stimulus: distension
Response: contraction
Lumen

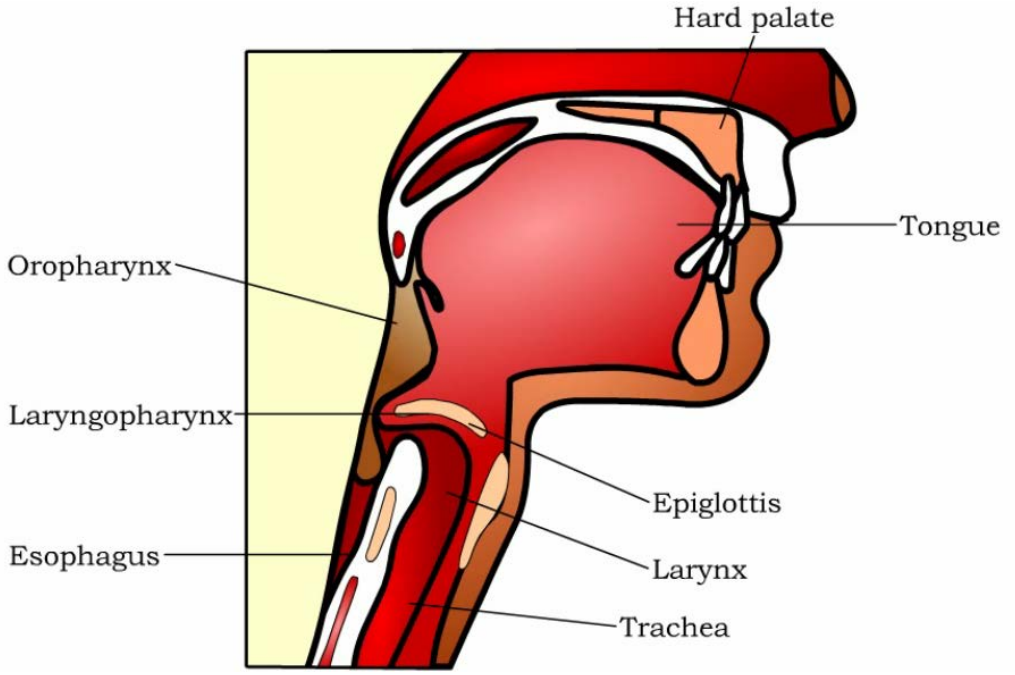
Mastication

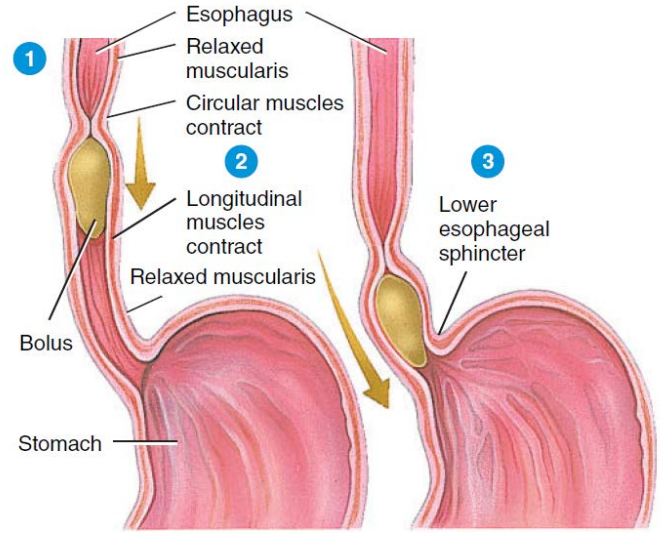
- Mastication or chewing, is a voluntary process, regulated by the CNS, and performed by muscles above and below the mandible.
- Skeletal muscles elevate the mandible , closing the mouth and moving the mandible side to side to chew.
- During chewing, food is :
  - Cut and ground by teeth.
  - Manipulated by the tongue, lips and cheeks.
  - Pushed toward the oropharynx.



Deglutition

- Swallowing occurs in three stages:
  - Voluntary stage in the mouth
  - Involuntary pharyngeal stage
  - Involuntary esophageal stage
- During the voluntary stage the tongue pushes the food bolus into the oropharynx.
- During the involuntary pharyngeal stage the bolus is moved through the laryngopharynx into the oesophagus.
- During the involuntary esophageal stage the bolus travels down the esophagus via **peristalsis**.
- Peristalsis is wave like movement of contractions and relaxations that propels the food down the GI tract
- Sphincters regulate the movement of food down the esophagus to the stomach.

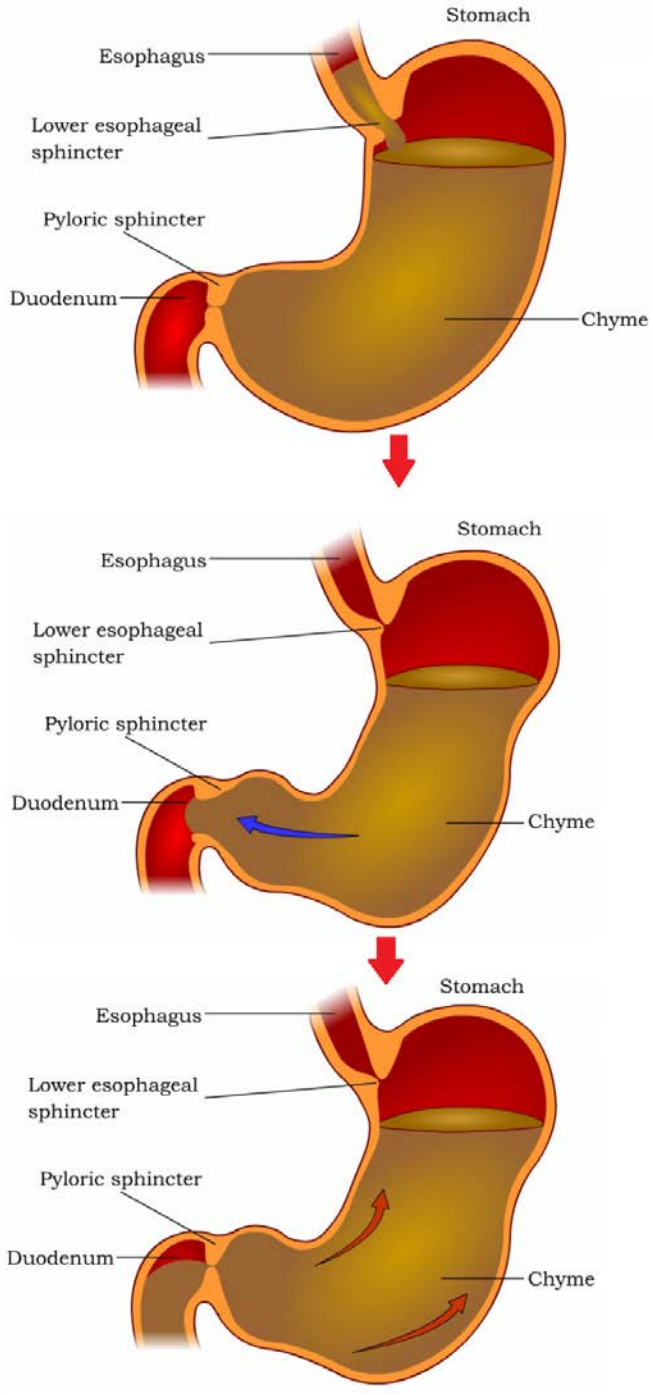




Esophageal stage of swallowing

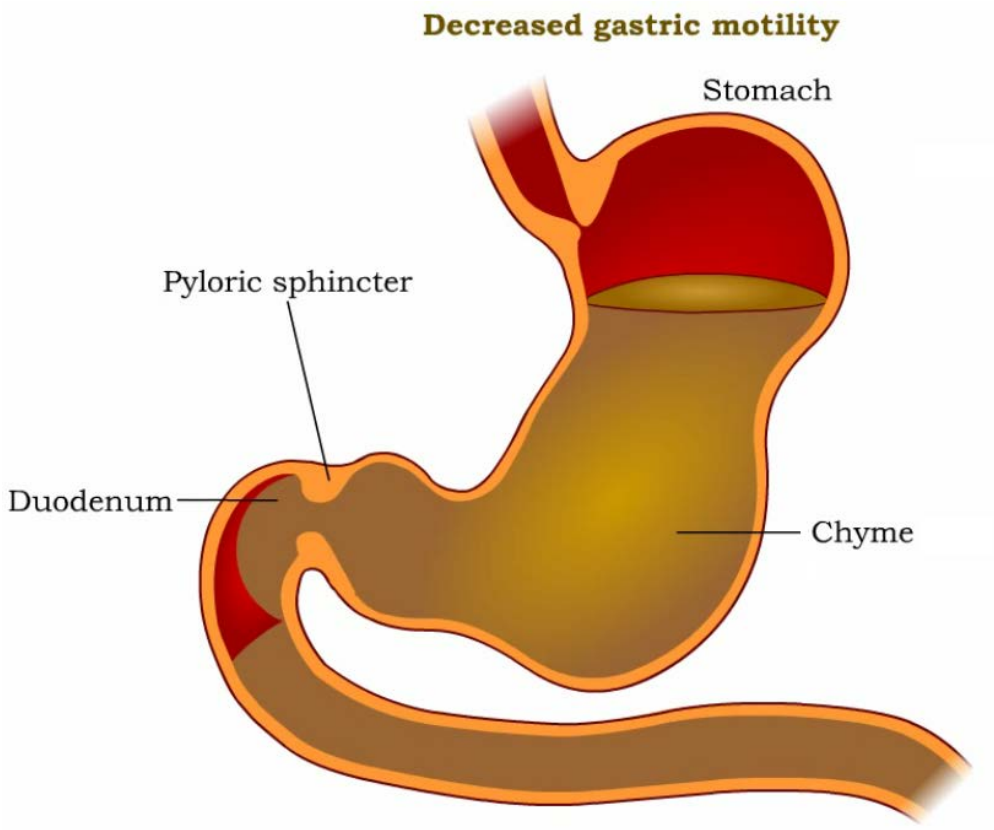
Stomach peristalsis

- Food enters, distending the stomach.
- Stretch receptors activate enteric reflexes that promote peristaltic movements.
- These movements , called mixing waves , begin to mix the food with stomach secretion.
- Mixing waves force the digestive food (chyme) toward and through the pyloric sphincter.
- Most food does not exit the stomach, so it moves back and forth in a churning digestive motion.
- The parasympathetic nervous system stimulates digestive movements in the stomach.



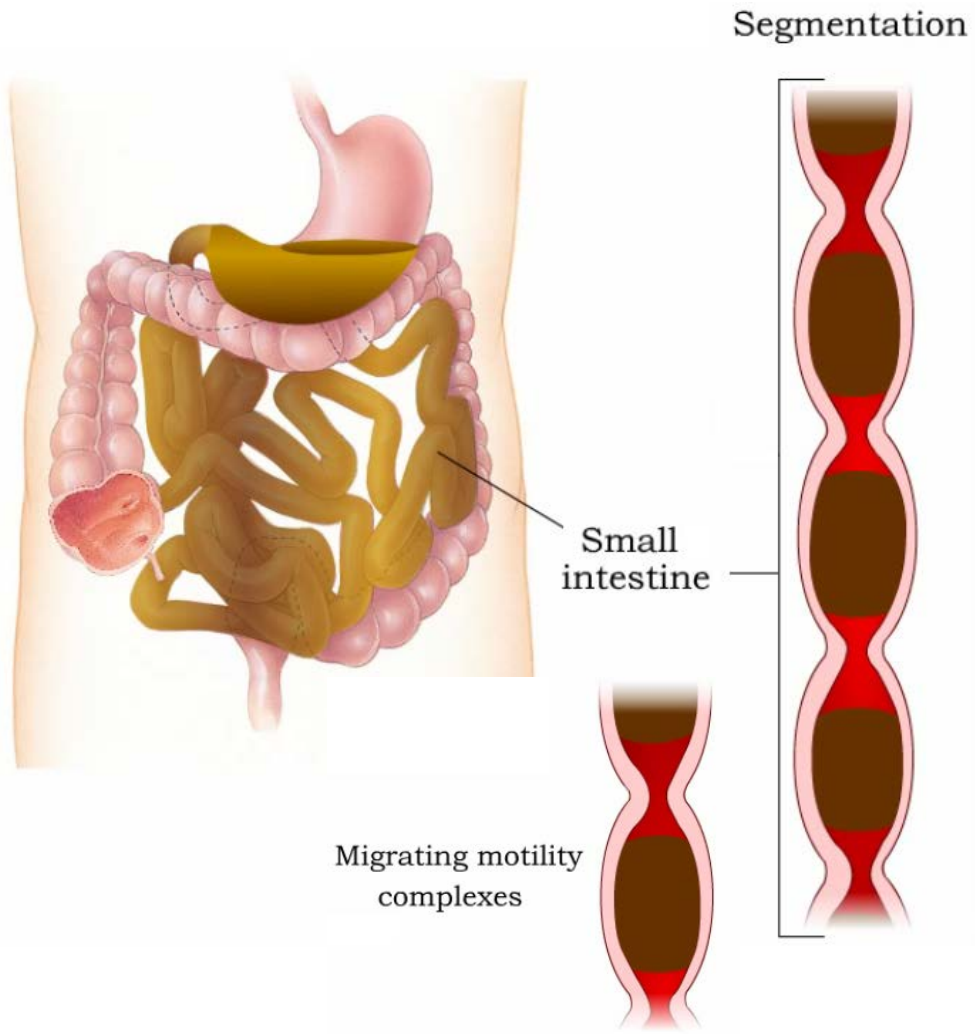
Enterogastric reflex

- The enterogastric reflex is triggered when more and more chyme leaves the stomach, distending the stretch receptors in the duodenum.
- The enterogastric reflex :
  - Inhibits excessive amounts of chyme entering the duodenum.
  - Reduce intestinal cell erosion by limiting inflow of a gastric acid.
  - Increase duration of digestion of chyme before it is moved to the small intestine
  - The motor impulses in this reflex are sympathetic.



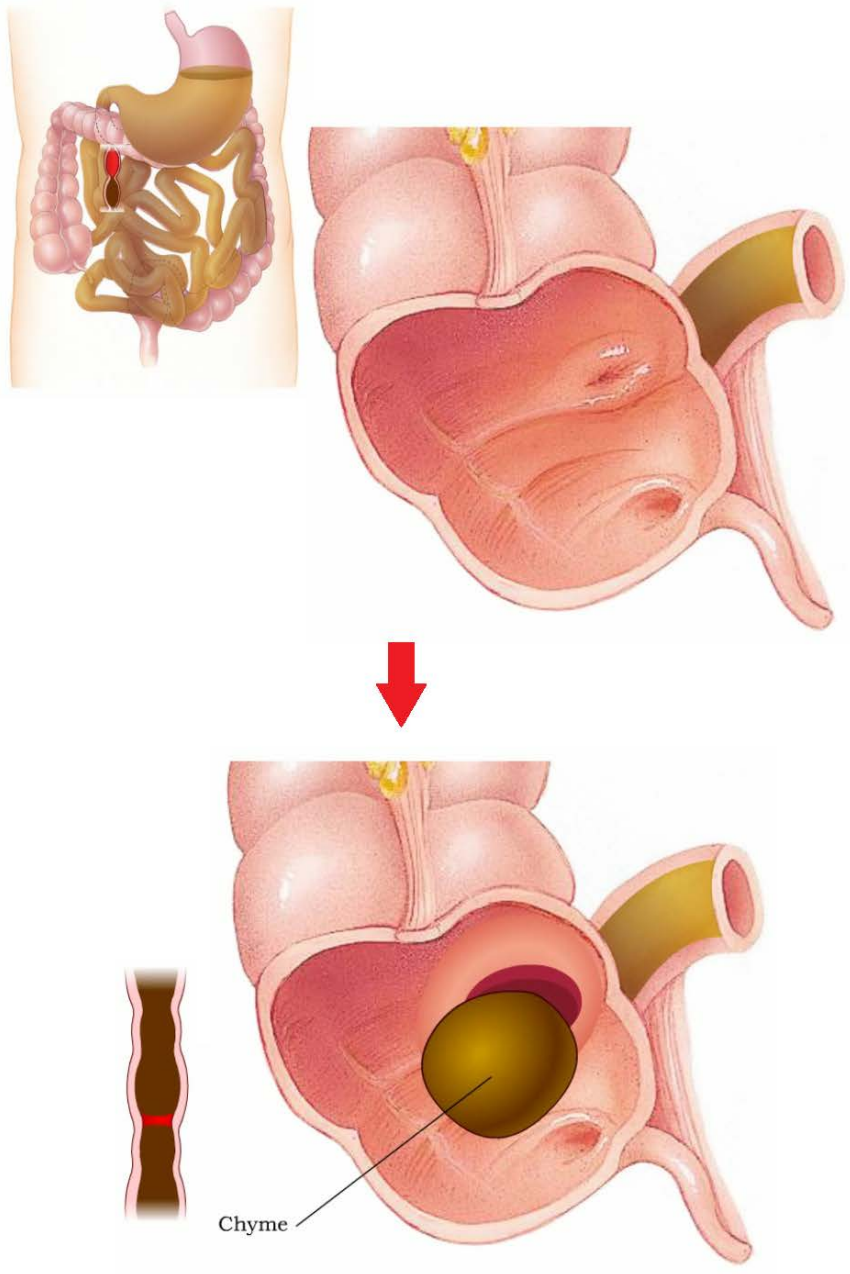
Segmentation and migrating motility complexes

- Within a few hours , most of the stomach contents are in the duodenum.
- Distension of stretch receptors in the small intestine activates a reflex that stimulates segmentation, a mixing movement.
- During segmentation, sections of the intestine are constricted.
- This movements increases digestion and absorption in the small intestine.
- There is no net movement of chime
- **Migrating motility complexes(MMC)** are peristaltic movements stimulated by decrease in distension once most nutrients have been absorbed.
- MMC propel undigested and liquefied chyme toward the **ileocecal valve**.



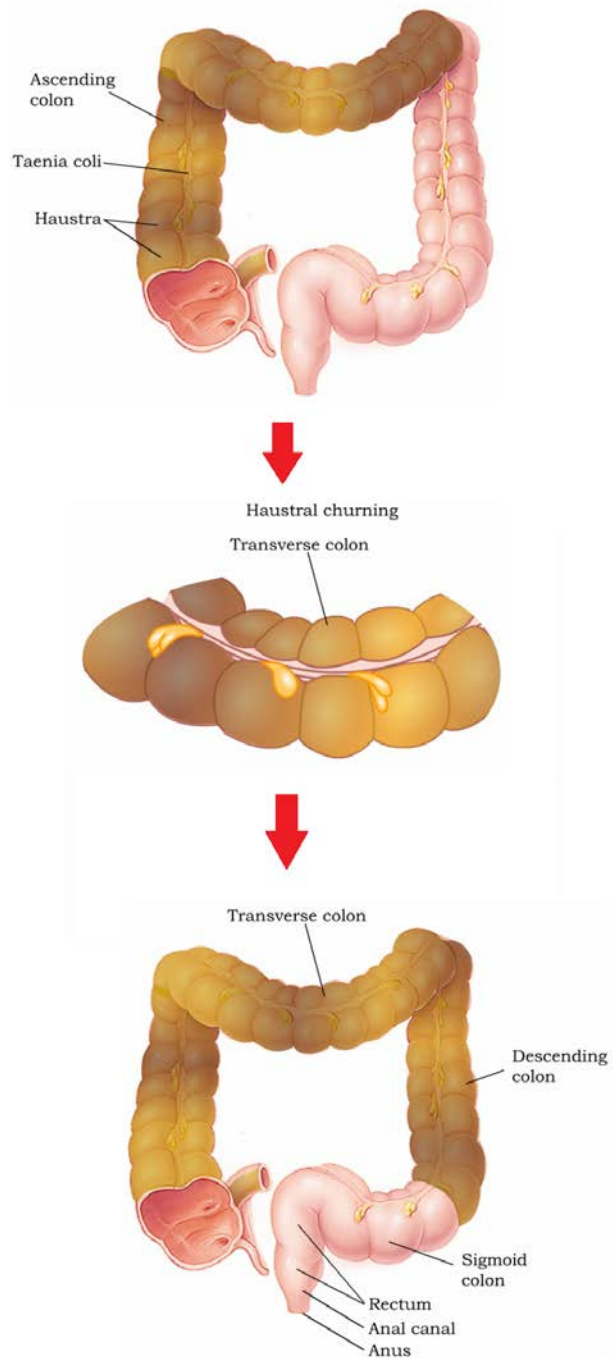
Gastroileal reflex

- The ileocecal valve is normally closed , so chyme cannot enter the large intestine.
- The gastroileal reflex is triggered when food enters and distends the stomach.
- MMC are intensified by this reflex, forcing chyme through the ileocecal valve into the cecum.



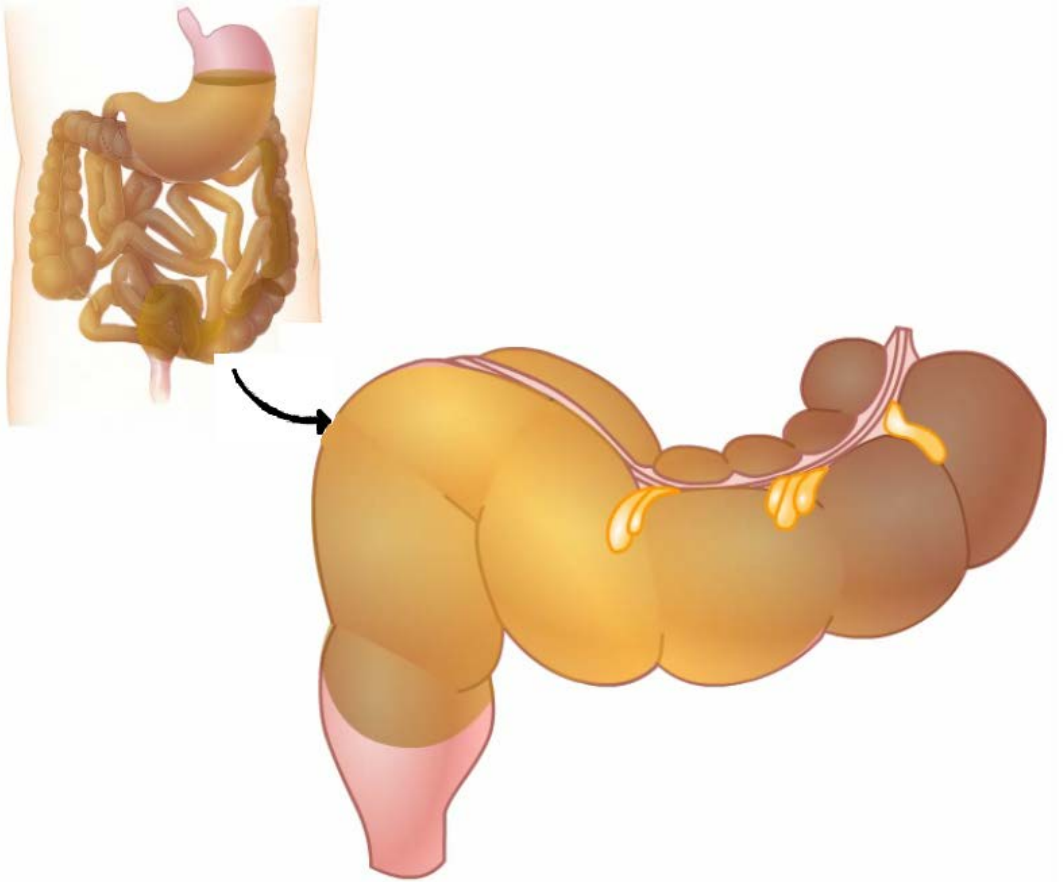
Haustral churning

- As the cecum becomes filled and distends , a local reflex causes:
  - closure of ileocecal valve.
  - Activation of **haustral churning**.
- Haustral churning mixes the chyme , which helps absorption of water , salts, and vitamins.
- It also propels the contents of the colon along the large intestine.



Gastrocolic reflex and mass peristalsis

- The **gastrocolic reflex** is also triggered when food enters and distends the stomach.
- This reflex intensifies strong **mass peristalsis** movements that force feces into the rectum.



Defecation

- The defecation reflex is activated by stretch receptors stimulated by the filling of the rectum.
- Defecation is an **ANS reflex** in which sensory impulses are sent to the control centre in the spinal cord.
- Parasympathetic impulse travel down the **spinal sacral nerves** and:
  - stimulate longitudinal contraction of the rectum forcing feces into anal canal.
  - Relax the internal anal sphincter allowing the feces to move toward the external anal sphincter.
- The **voluntary relaxation** of the **external anal sphincter** allows defecation to be completed