GI Motility
Learning Objectives

1. Describe the functions of chewing.
2. Describe the swallowing sequence and identify voluntary and involuntary components.
3. Compare and contrast primary and secondary esophageal peristalsis.
4. Describe the motor patterns of the stomach following ingestion of a meal.
5. Describe the segmenting and peristaltic patterns of motility seen in the small intestine.
6. Describe the basic electrical rhythm (BER) of each region of the GI tract. Explain the role of Interstitial Cells of Cajal in the origin and propagation of the BER.
7. Describe the sequence of events occurring during reflexive defecation, differentiating those movements under voluntary control and those under intrinsic control.
8. Discuss the role of other GI reflexes including the gastrocolic, gastroileal and ileogastric reflexes.
9. Contrast patterns of motility in the stomach and intestine with that during the fed and fasting states.
Chewing and Swallowing

Chewing

1. Mixes food with saliva – lubricating for swallowing
2. Reduces food particle size
3. Mixes ingested carbohydrates with salivary amylase to begin digestion

- Has both voluntary and involuntary components – involuntary involves reflexes; voluntary can override reflexes at any time

Swallowing

- Initiated voluntarily in mouth but thereafter is under involuntary control → results in propulsion of food from mouth – stomach; respiration is inhibited and entry of food into trachea is prevented

- Reflex controlled by swallowing center in medulla

- 3 phases involved: oral, pharyngeal and esophageal
Oral or Voluntary Phase

- 1st phase of swallowing - voluntary
- Initiated when tongue forces bolus of food back toward pharynx - stimulates the tactile receptors that initiate the swallowing reflex
- Swallowing center: Somatosensory receptors (pharynx) → swallowing center (medulla) → musculature of pharynx and upper esophagus
Pharyngeal Phase

- 2nd phase of swallowing - reflexive

- Functions to propel bolus from mouth through pharynx to esophagus – breathing is inhibited

1. Soft palate pulled upwards to create narrow passage for food to move into pharynx without reflux into nasopharynx

2. Epiglottis moves to cover larynx opening; larynx moves upward against epiglottis to prevent food into trachea

3. Upper esophageal sphincter (UES) relaxes allowing food to pass from pharynx to esophagus

4. Peristaltic wave of contraction initiated in pharynx and propels food through open sphincter
- 3rd phase of swallowing - part reflexive; part ENS

- Food is propelled through esophagus to stomach. Once bolus of food passes the UES the sphincter then contracts – no reflux into pharynx

- The bolus is then rapidly moved down the esophagus by a primary peristaltic wave coordinated by swallowing center - clears the esophagus of food

- If primary peristaltic wave is does not clear esophagus local distention of the esophagus initiates a secondary peristaltic wave (partially mediated by the enteric nervous system and esophageal sensory fibers at distension site travelling downward)
Motility is to propel food contents from mouth to anus: contraction behind the contents and relaxation ahead of it

Esophageal motility: UES opens – 1° peristaltic contraction - as peristaltic wave and food bolus approach lower esophageal sphincter (LES) sphincter opens – mediated by VIP- LES must be relaxed as bolus passes into stomach- orad portion of stomach must also relax to accept bolus- receptive relaxation or accommodation (decreases pressure in orad stomach to allow food entry)

The control of gastric emptying is complex and involves the intrinsic motility of the gastric smooth muscle, ENS, ANS control over the ENS function, and several gut hormones

Afferent innervation: sensory fibers respond to intragastric pressure, pH, gastric distension

Autonomic control: Parasympathetic stimulation increases gastric smooth motility and secretions while sympathetic stimulation decreases gastric motility and secretions
Stomach

3 anatomic divisions: Fundus, body and antrum

Divided in 2 major areas:

a. **Orad portion**: Fundus and a proximal portion of the body; proximal

b. **Caudad portion**: Distal body and the antrum; distal

Major functions:
1. **Reservoir** (fundus and body) for the large volume of food
2. Fragment food into smaller particles and mix chyme with gastric secretions \( \rightarrow \) begin digestion in the antrum
3. Empty gastric contents into the duodenum at a controlled rate
Gastric Motility

3 components:
1. Relaxation of orad stomach to receive bolus from esophagus
2. Contractions to reduce size of bolus and mix it with gastric secretions to initiate digestion
3. Gastric emptying to propel chyme into intestines

- **Orad**: Thin-walled; receives food bolus through receptive relaxation

- **Caudad**: Thick-walled; produces contractions for mixing, digestion and propulsion into small intestine
  - Waves of contraction begin in middle of body and move along caudad stomach; increase in strength as approach pylorus; mixes contents and periodically propels contents through pylorus into duodenum
  - Not all chyme goes into duodenum as contractions also close pylorus propelling contents back into stomach for further mixing and reduction - Retropulsion
Gastric Emptying

- After meal, stomach contains 1.5 L – solids, liquids, gastric secretions; takes ~3 hours to empty into duodenum

- Rate closely regulated to provide adequate time for gastric H\(^+\) neutralization in duodenum & digestion and absorption of nutrients

- 2 major factors slow or inhibit gastric emptying: Fat & H\(^+\) in duodenum

- Effects of fat mediated by CCK – slows emptying for slow chyme delivery to duodenum & adequate fat digestion

- H\(^+\) (low pH) detected by ENS reflexes and relay info to gastric smooth muscle to slow emptying – permitting H\(^+\) neutralization by pancreatic HCO\(_3^-\)
Small Intestine Motility

- Functions of small intestine to digest and absorb nutrients

- Motility serves to:
  1. Mix chyme with digestive enzymes / pancreatic secretions
  2. Expose nutrients to intestinal mucosa from absorption
  3. Propel unabsorbed chyme into large intestine

- Frequency of slow waves determine APs & contractions

- Both PNS and SNS innervation: PNS increases contraction of intestinal smooth muscle (ACh, VIP, enkephalins, motilin); SNS decreases contraction

- 2 patterns of contractions in small intestine: segmentation and peristalsis – each coordinated by ENS
Slow Waves or Basic Electrical Rhythm (BER)

- Rhythmic fluctuations of the membrane potential between -65 and -45mV

- Different rhythm in each area of the GI tract, e.g. higher in duodenum than in the jejunum than in the ileum.

- Initiated by pacemaker cells, interstitial cells of Cajal
  -- (have smooth muscle-like features In stomach and small intestine cells are located in the outer circular muscle layer near the myenteric plexus. In colon located at the submucosal border of the circular muscle layer)
Segmentation

- **Mixes chyme** and exposes it to pancreatic enzymes and secretions

- **Intestines contract:** Bolus of food is split in both orad and caudad directions

- **Intestines relax:** Split bolus merges back together

- Back & forth movement mixes chyme with no forward movement along small intestine

- Initiated in duodenum by distension (intrinsic) with chyme; initiated in ileum by gastrin
Peristalsis

- Propels chyme along small intestine to large intestine

- Wave of contraction occurs at point behind bolus while portion of intestine in front of bolus relaxes; chyme propelled in caudad direction – repeat sequence of contractions

- Neurotransmitters involved in orad contraction: ACh and substance P; caudad relaxation: VIP and NO
- **Myoelectric or migrating motor complex (MMC):** Small rhythmic gastro-intestinal contractions which occur at 90 min intervals during the fasting state.

- **Housekeeper of small intestine**
  - clears food particles remaining from previous meal by enabling particles > 2 mm in diameter to pass from stomach into duodenum
  - inhibits migration of colonic bacteria into distal ileum

- **Mediated by motilin**

- **Eating abolishes MMC**
Test Question

The type of GI movement primarily responsible for mixing chyme with digestive juices in the intestine is:

a. Segmentation
b. Peristalsis
c. Mass movement
d. Haustration
e. Migrating myoelectric complex
Small Intestinal Reflexes

- **Gastroileal reflex:** Increased motility in the ileum associated with gastric filling, clearing the ileum for incoming chyme. Involves both gastrin and long reflexes (vagal)

- **Ileogastric reflex:** Fat in the ileum inhibits gastric emptying. May involve neurotensin

- **Intestinointestinal reflex:** Distension of one segment of small intestine inhibits motility elsewhere in the small intestine. Involves extrinsic innervation
Large Intestine

- Contents = feces – destined for excretion

- Contents of small intestine enter cecum and proximal colon – ileocecal sphincter contracts preventing reflux into ileum- fecal matter moves from cecum through colon to rectum to anal canal

- Segmentation contractions occur in cecum and proximal colon: mixes contents; are associated with sac-like segments called haustra (Fibers in external muscle layer form outpouchings)

- Mass movements occur in colon 1-3 times/day - simultaneous contractions of smooth muscle over a large area which move contents over long distances; propels fecal matter into rectum where stored until defecation

- Movements in the colon are coordinated by the BER
Colonic Reflexes

- Colonocolonic reflex: Distension of one part of the colon elicits reflex relaxation in other parts of the colon → partly mediated by the sympathetic fibers

- Gastrocolic reflex: The motility of proximal and distal colon and the frequency of mass movements increase after a meal enters the stomach. Mediated by CKK and gastrin
Rectum

- **Defecation**: Removal of feces from rectum. Initiated when rectum is distended; defecation center in medulla

- **Rectosphincteric reflex**: As rectum fills with feces, smooth muscle wall contracts and internal anal sphincter relaxes—no defecation as external anal sphincter tonically contracted

- Once rectum fills to 25% of capacity- urge to defecate

- When appropriate, external anal sphincter is relaxed voluntarily, rectal smooth muscle contracts creating pressure- feces forced out through anal canal

- **Intra-abdominal pressure created** can be increased by a Valsalva maneuver (expiring against a closed glottis)
Test Question

Distension of the rectum results in reflex relaxation of which one of the following?

a. internal anal sphincter
b. external anal sphincter
c. ileocecal sphincter
d. distal colon
e. jejunum
**Summary**

- **3 swallowing phases:** oral, pharyngeal, esophageal

- **Motility:** MMC, BER, segmentation, peristalsis, mass movement

- **Small intestinal reflexes:** Gastroileal reflex; ileogastric reflex; intestinointestinal reflex

- **Colonic reflexes:** Colonocolonic reflex; gastrocolic reflex

- **Rectal reflex:** Rectosphincteric reflex

- **Law of the gut/ intestine:** The peristaltic reflex plus the anal direction of movement of the peristalsis; When a bolus of the material placed in the small intestine, the intestine may contract oral to the bolus and relax aboral to the bolus. This propels the bolus in an aboral direction, like a peristaltic wave