Digestion Pt. 2

Regulation of GI Function

Digestion is complicated. There are many control mechanisms (local & neural).

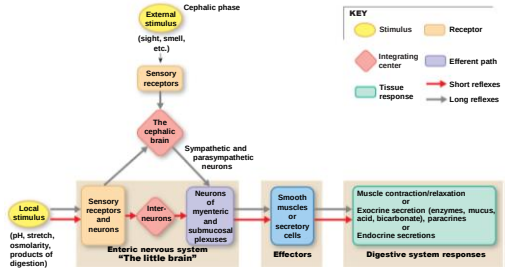
Reflexes:

- **Long reflexes integrated in CNS**
- **Short reflexes integrated in ENS**
- **Reflexes involving GI peptides**

Integration of long and short reflexes in the digestive system

Long Reflexes

- **Cephalic reflexes (long-reflex that originates outside of digestive system)**
- **Emotions on GI tract (butterflies/travelers tummy)? ANS?**



Integration of long and short reflexes in the digestive system

Short Reflexes : Integration is in ENS not CNS

- **Enteric nervous system in gut wall**
- **refelexes originate within the ENS**
- **motility, secretion can be stimuli**
- **ENS integrates sensory info & initiates response via submucosal neurons**

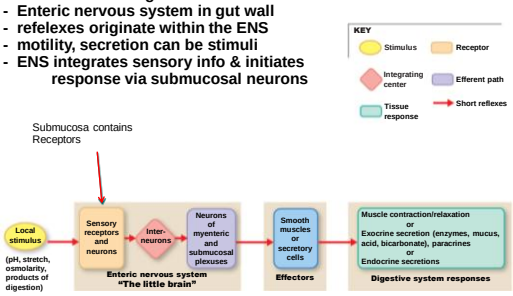


Figure 21-11 (1 of 3)

Regulation of GI Function

Note: SNS and PNS have an effect – (long or short reflex?

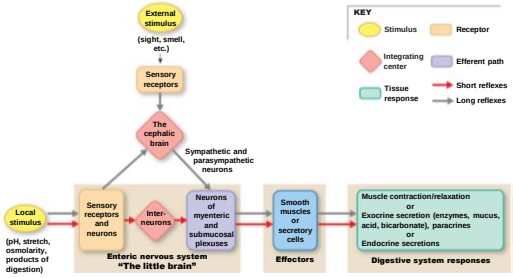


Figure 21-11 (3 of 3)

Reflexes involving GI Peptides

- **Peptides released by secretory cells can act as hormones/paracrines**
  - **Hormones: released into blood can act on GI tract, accessories, brain**
  - **Paracrines: secreted into lumen or ECF (act on cell or surrounding cells)**
- **EG:**

CCK: - Hormone

- **Acts on brain**
  - **Satiety**
- **Also a NT!?**

Ghrelin: Hormone

- **Acts on brain**
  - **Were hungry**

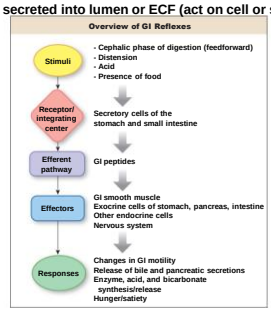


Figure 21-12

Can work independently of CNS

ENS Shares Features with CNS

- **Intrinsic neurons (occur totally in gut – like interneurons in CNS)**
- **Neurotransmitters and neuromodulators (> 30 that are identical to those found in brain)**
- **Glial cells (similar to astrocytes)**
- **Diffusion barrier (caps that surround ganglia have barriers)**
- **Integrating center (does its own)**

Digestive Hormones

TABLE 21-1 The Digestive Hormones

	STIMULUS FOR RELEASE	PRIMARY TARGET(S)	PRIMARY EFFECT(S)	OTHER INFORMATION
STOMACH				
Gastrin	Peptides and amino acids; neural reflexes	ECL cells and parietal cells	Stimulates gastric acid secretion and mucosal growth.	Somatostatin inhibits release.
INTESTINE				
Cholecystokinin (CCK)	Fatty acids and some amino acids	Gallbladder, pancreas, stomach	Stimulates gallbladder contraction and pancreatic enzyme secretion. Inhibits gastric emptying and acid secretion.	Promotes satiety. Some effects may be due to CCK as a neurotransmitter.
Secretin	Acid in small intestine	Pancreas, stomach	Stimulates bicarbonate secretion. Inhibits gastric emptying and acid secretion.	
Motilin	Fasting: periodic release every 1.5–2 hours	Gastric and intestinal smooth muscle	Stimulates migrating motor complex.	Inhibited by eating a meal.
Gastric inhibitory peptide (GIP)	Glucose, fatty acids, and amino acids in small intestine	Beta cells of pancreas	Stimulates insulin release (feedforward mechanism). Inhibits gastric emptying and acid secretion.	
Glucagon-like peptide 1 (GLP-1)	Mixed meal that includes carbohydrates or fats in the lumen	Endocrine pancreas	Stimulates insulin release. Inhibits glucagon release and gastric function.	Promotes satiety.

The Cephalic Phase

Anticipatory stimuli and food in the mouth activates neurons in Medulla oblongat

- **Chemical and mechanical digestion begins in the mouth**

Chemical -

- **Salivary secretion is under autonomic control**
  - **Softens and lubricates food**
  - **Chemical digestion: Salivary amylase and some lipase**
  - **Lysozyme: antibacterial enzyem**
  - **Immunoglobulins: work on bacteria and viruses**

Mechanical -

- **Chewing: mastication**

Swallowing Reflex

Swallowing: Deglutition
- a reflex

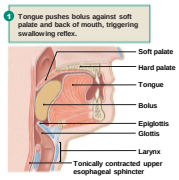


Figure 21-24, step 1

Swallowing Reflex

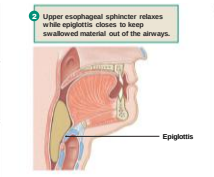


Figure 21-24, step 2

Swallowing Reflex

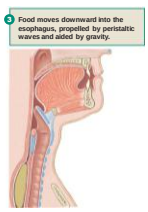


Figure 21-24, step 3

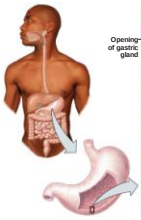
The Gastric Phase

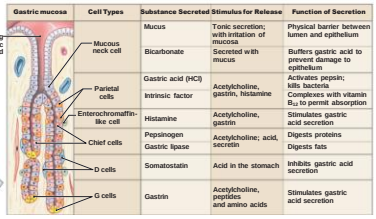
Stomach has 3 main functions:

- **Storage (upper stomach)**
- **Digestion**
  - **Lower Stomach**
  - **Acid, enzymes, and signal molecules**
- **Protection**
  - **Bacteria & other Pathogens**
  - **From itself**

The Gastric Phase

- **Acid secretion: Parietal cells**
- **Enzyme secretion: Chief cells (pepsinogen to pepsin)**
- **Paracrine secretion: ECL secrte histamine promotes HCl release**
  D Cells secrete Somatostatin inhibits Gastric juice release
- **Hormone release; G-cells secrete gastrin stimulate gastric juice release**

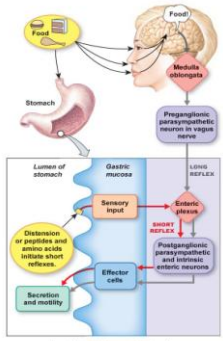




Gastric mucosa	Cell Types	Substance Secreted	Stimulus for Release	Function of Secretion
	Mucous neck cell	Mucus	Tonic secretion; with irritation of mucosa	Physical barrier between lumen and epithelium
		Bicarbonate	Secreted with mucus	Buffers gastric acid to prevent damage to epithelium
	Parietal cells	Gastric acid (HCl)	Acetylcholine, gastrin, histamine	Activates pepsin; kills bacteria
		Intrinsic factor		Complexes with vitamin B_{12} to permit absorption
	Enterochromaffin-like cell	Histamine	Acetylcholine, gastrin	Stimulates gastric acid secretion
	Chief cells	Pepsinogen	Acetylcholine; acid, secretin	Digests proteins
		Gastric lipase		Digests fats
	D cells	Somatostatin	Acid in the stomach	Inhibits gastric acid secretion
	G cells	Gastrin	Acetylcholine, peptides and amino acids	Stimulates gastric acid secretion

Figure 21-25

Long and short reflexes of Cephalic and Gastric Phases



The Gastric Phase

- Integration of cephalic and gastric phase secretion in the stomach

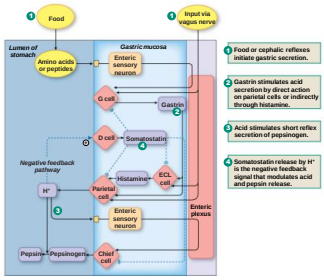


Figure 21-26

The Gastric Phase

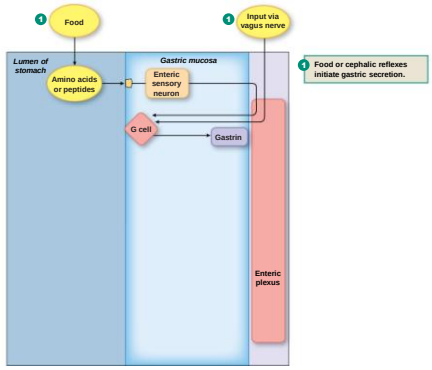


Figure 21-26, step 1

The Gastric Phase

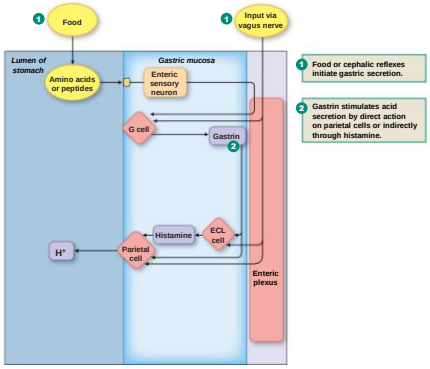


Figure 21-26, steps 1–2

The Gastric Phase

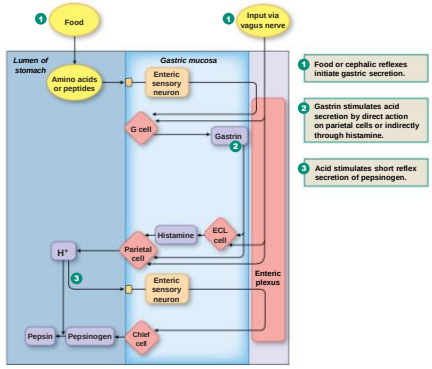


Figure 21-26, steps 1–3

The Gastric Phase

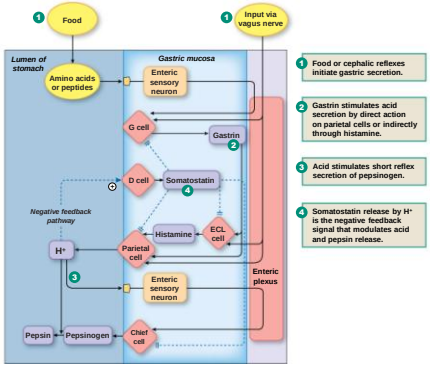


Figure 21-26, steps 1–4

How Mucus and Bicarbonate protect us

- The mucus-bicarbonate barrier of the gastric mucosa
- Still NSAIDS, Helicobactor pylori, over production of HCl or Gastrin can be bad

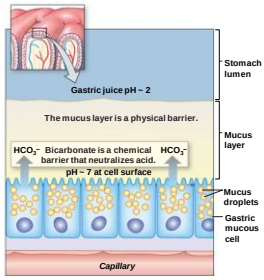


Figure 21-27

The Intestinal Phase

- Begins as chyme enters small intestine
  - Activates ENS which slows gastric motility and secretion
  1. Secretin: inhibits acid secretion and stimulates pancreatic HCO3
  2. CCK: secreted into blood if a fatty meal: stimulates Bile release and slows gastric release into intestine
  3. GIP and GLP1 promote insulin release
  4. Hyperosomotic chyme triggers receptors to inhibit gastric release

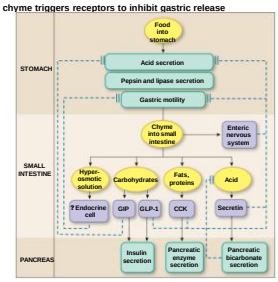


Figure 21-28

The Intestinal Phase

- Bicarbonate neutralizes gastric acid
- Goblet cells secrete mucus for protection and lubrication
- Bile
  - Fat digestion
- Brush border enzymes (peptidases, disacchardases, proteases (enteropeptidase)

The Intestinal Phase

Zymogens: inactive enzymes

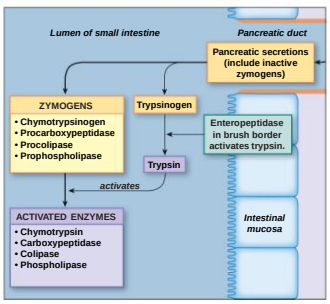


Figure 21-29

Hepatic Portal System

- Most fluid is absorbed in the small intestine (7.5 of 9 l)
- Most nutrients pass from SI to Liver via Hepatic Portal System

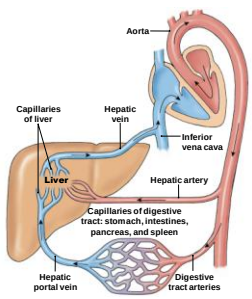


Figure 21-30

The Intestinal Phase

- Most digestion occurs in small intestine
- Large intestine concentrates waste for excretion
- Motility in large intestine
  - Mass movement triggers defecation
    - Occurs 3 – 4 times a day
    - Responsible for Defecation reflex
- Digestion and absorption in large intestine
  - Digestion: bacteria can break down some carbs and proteins
    - produces lactate, fatty acids, butyric acid (some of which is absorbed)
    - Bacteria produces Vit. K

The Intestinal Phase: Anatomy of the Large Intestine

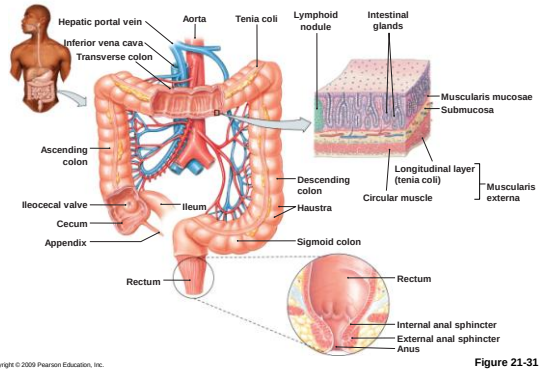


Figure 21-31

The Intestinal Phase: Anatomy of the Large Intestine

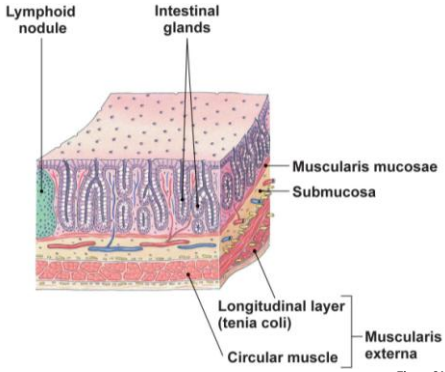


Figure 21-31 (2 of 3)

The Intestinal Phase: Defication reflex

Movement of feces into empty rectum triggers a spinal reflex

1. Smooth muscle of internal anal sphincter relaxes
2. Peristalsis in rectum moves "the package" towards anus
3. External anal sphincter is consciously relaxed

- Valsalva manueuver

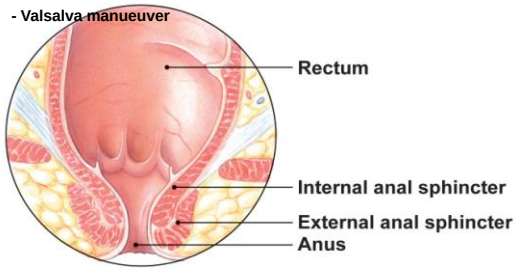


Figure 21-31 (3 of 3)

Immune Function

Peyers patches – lymphatic tissue (GALT or MALT):

- M cells on Peyers patches "sample" contents of the gut
  - Have antigen receptors
  - Move antigen by trancytosis to GALT
  - Macrophages and Lymphocytes do their thing
    - Cytokines trigger inflammatory response – or
    - Increase in Cl^-, fluid, and mucus secretion
- Vomiting (emisis) a protective reflex