

The Vertebrate (mostly human) Digestive System

Mouth - mastication,
lubrication, digestion

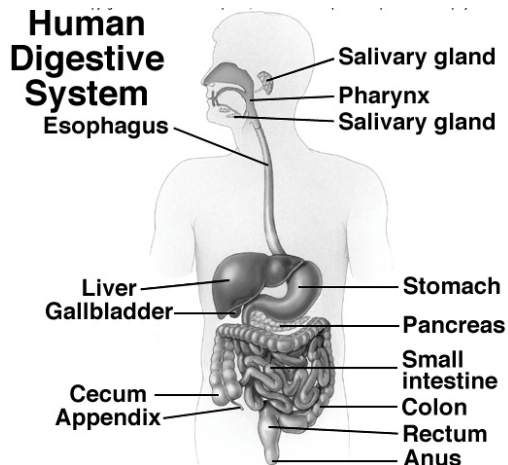
Pharynx and Esophagus -
swallowing

Stomach - some digestion

Small intestine - most
digestion and absorption

Large intestine - some
absorption

Rectum - packaging



Liver - produces bile - aids in fat digestion

Pancreas - produces many digestive enzymes

Gastrointestinal tract has a layered structure

Lumen - interior space

Mucosa - innermost layer
of epithelium

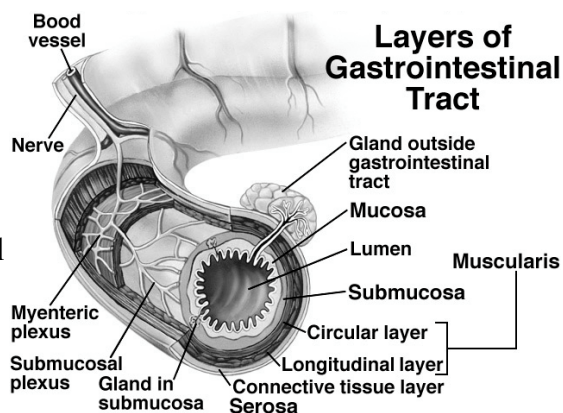
Submucosa - connective
tissue

Muscularis - double layer
of smooth muscle
circular and longitudinal

Serosa - connective tissue
covers exterior

Nerve plexuses - in
submucosa, regulate
activities

Glands - in submucosa and outside serosa - secrete substances into
lumen



The Mouth

The teeth cut and grind food - mastication

Tongue mixes food with saliva

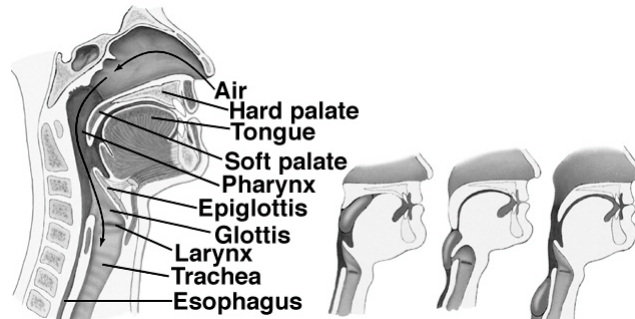
Salivary glands produce saliva - empty through mucosa of mouth

salivary amylase initiates breakdown of starch

Secretion of saliva controlled by the nervous system

low level continuous secretion keeps the mouth moist

high level secretion stimulated by sight, smell, or idea of food



Swallowing

Food passes to the back of the mouth

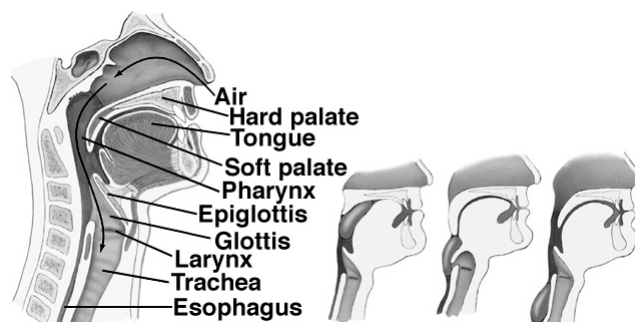
Palate elevates, pushes against rear of pharynx

Seals off nasal cavity - a good thing

Pressure on pharynx stimulates swallowing center in brain

Swallowing center inhibits respiration - a good thing

Seals trachea - raises larynx and closes glottis with epiglottis

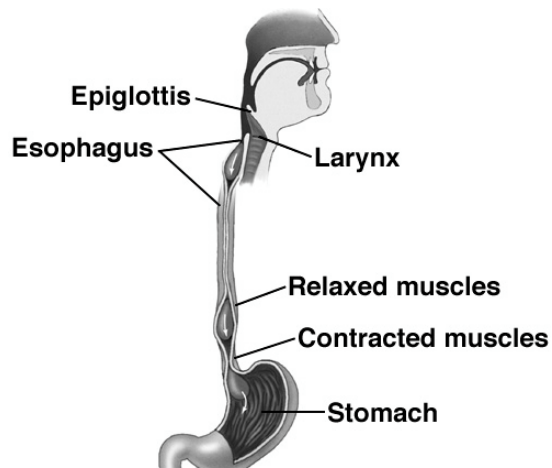


Esophagus

Upper 1/3 of esophagus enveloped in voluntary skeletal muscle

Lower 2/3 enveloped in involuntary smooth muscle

Food propelled by peristaltic waves of muscular contractions

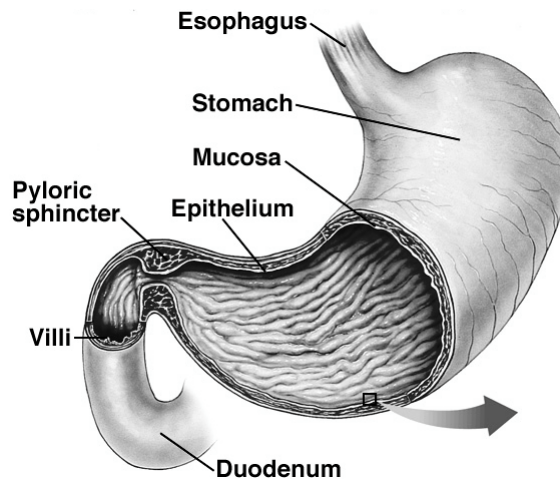


Entry of food into stomach controlled by gastric sphincter - prevents food in stomach from re-entering esophagus

Stomach

Sack-like, thick walled, muscular, with highly convoluted interior mucosa
smooth muscle churns food

Glands in mucosa produce secrete several compounds

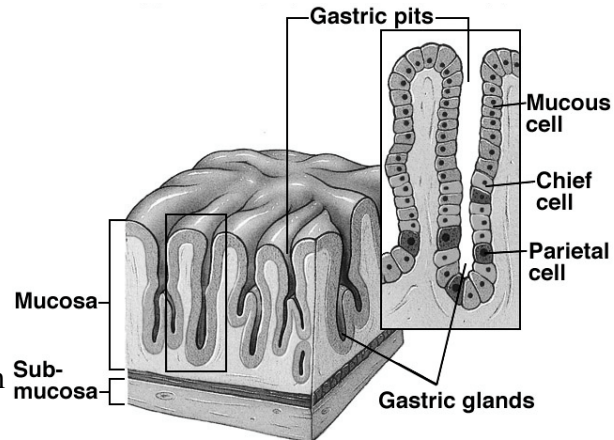


Parietal cells secrete HCl and intrinsic factor (for B₁₂ absorption)
 Chief cells secrete pepsinogen, an inactive protease
 Active proteases in stomach activate pepsinogen to pepsin
 Digestion in stomach restricted to protein digestion
 proteins reduced to smaller polypeptides
 HCl aids protein digestion by denaturing proteins

Stomach produces 2 l
 gastric secretions/day
 Stomach pH = 2

No digestion of
 carbohydrates or fats

The acidic food mixture
 produced in the stomach
 is called "chyme"

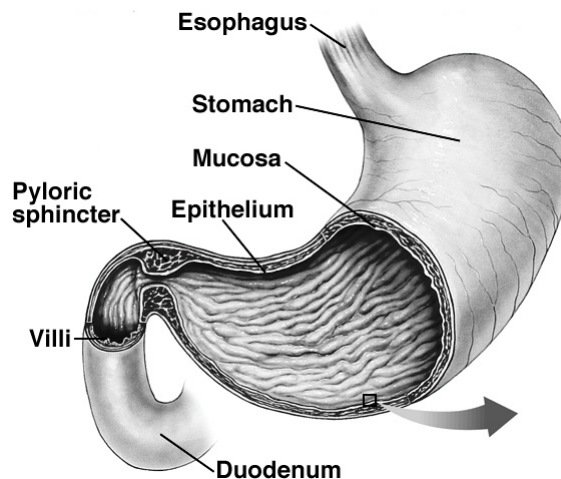


Little absorption occurs in stomach - some water, alcohol, aspirin

Chyme leaves
 stomach and enters
 duodenum through
 pyloric sphincter

Capacity of
 duodenum is small
 compared to stomach

Rate of dumping
 controlled by
 nervous system and
 hormones



Small Intestine

about 6 m long

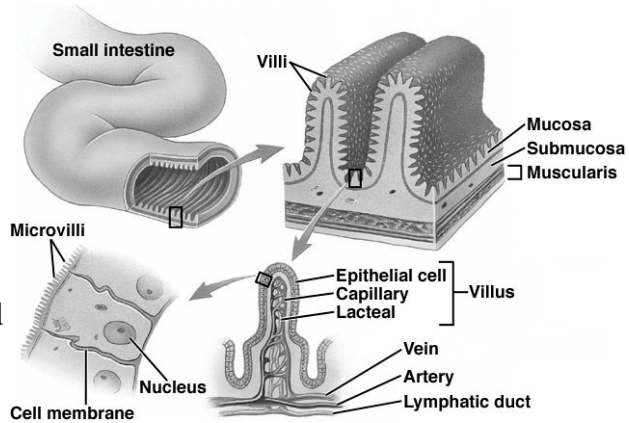
composed of three sections - duodenum, jejunum, ileum
most digestion occurs in duodenum and jejunum

Duodenum is 25 cm long - remainder is jejunum and ileum
receives chyme, pancreatic enzymes, bile from liver

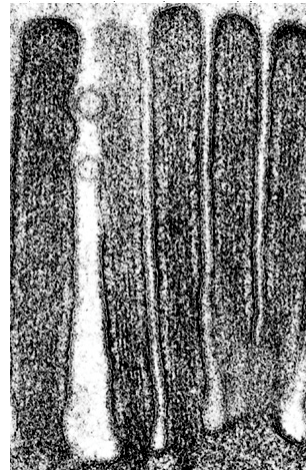
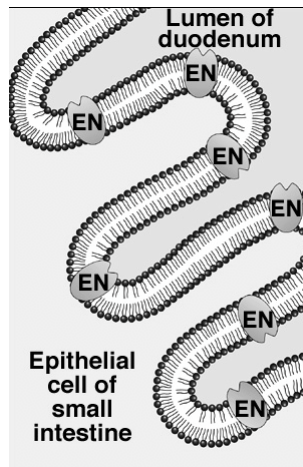
Epithelial wall has many folds - villi

Villi have cytoplasmic projections-microvilli

Both increase surface area for absorption and secretion



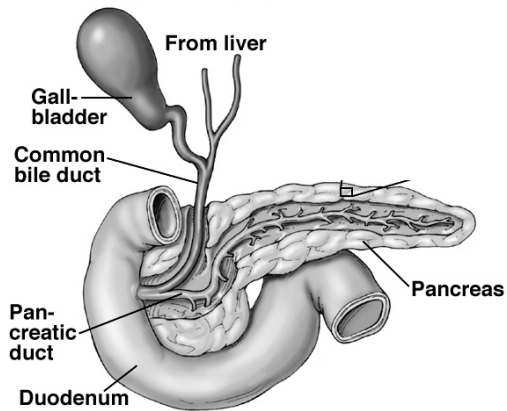
Epithelial wall also called “brush border”
Brush border has embedded enzymes that hydrolyze lactose, sucrose and other sugars



Accessory Organs

Pancreas

Pancreas - at junction of stomach and small intestine
Connected via pancreatic duct
Has both exocrine and endocrine functions
Fluid contains many enzymes
proteases (trypsin and chymotrypsin)
pancreatic amylase and fat digesting lipase

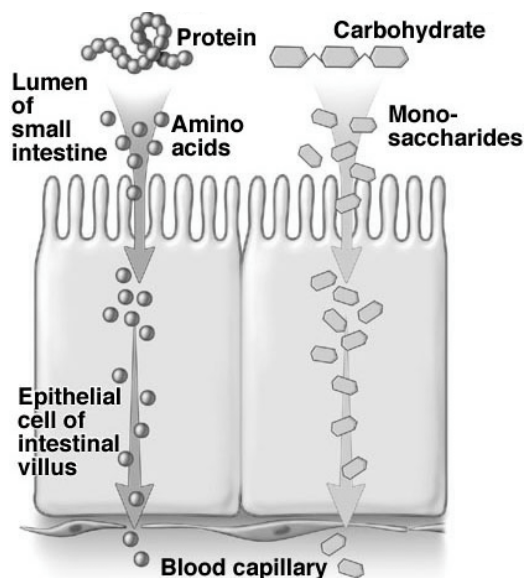


Enzymes released as inactive zymogens,
activated by brush border enzymes
Fluid also contains bicarbonate to neutralize HCl
Chyme in intestine becomes slightly alkaline

Absorption in the Small Intestine

Amino acids and simple sugars transported across brush border - through epithelial cells and into capillaries within villi

Blood carries digestion products to liver - via hepatic portal vein



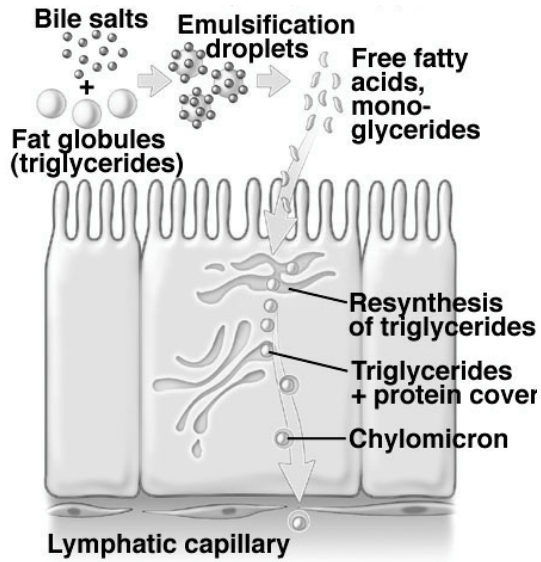
Fats hydrolyzed into fatty acids and monoglycerides

Absorbed by intestinal epithelium and reassembled into triglycerides

New fats combined with proteins to form water-soluble chylomicrons

Absorbed into lymphatic capillaries

Contents of lymphatic system enter blood stream in veins near neck



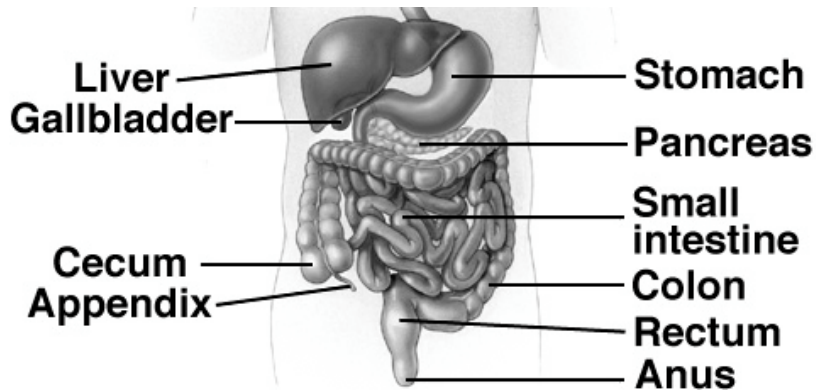
Each day 9 liters of chyme passes small intestine

Nearly all fluids and solids are absorbed

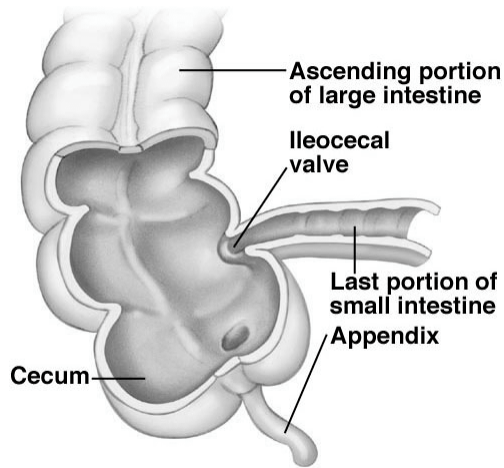
8.5 liters absorbed in the small intestine

350 milliliters reabsorbed in the large intestine

50 grams of solids and 100 milliliters of liquid leave as feces



Large Intestine (colon)
 Has no digestive function
 absorbs 4% of fluids
 Surface lacks villi
 about 1 m long
 Harbors symbiotic bacteria
 Absorbs sodium, vitamin K,
 other products of bacterial
 metabolism
 Small intestine empties into
 large intestine through
 ileocecal valve just above
 cecum and appendix

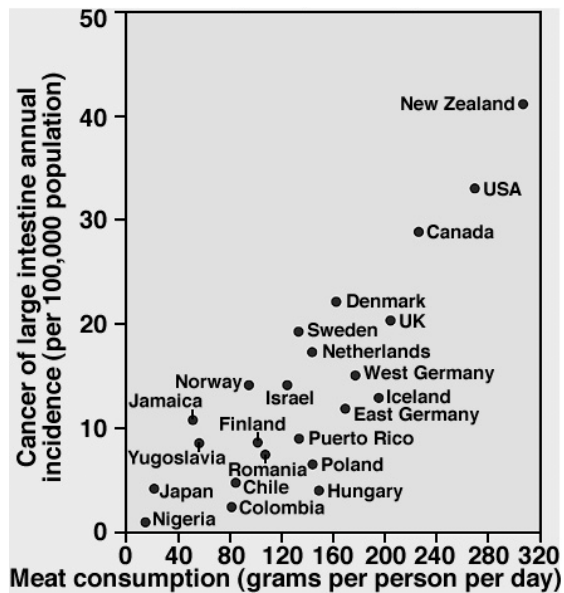


Primary function is to compact and store feces
 Bacteria are incorporated into feces
 Bacterial fermentation produces gas

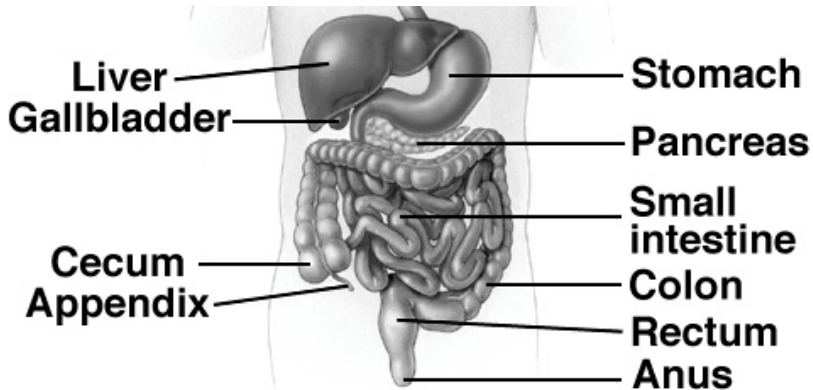
Human colon evolved to process food with high cellulose content

Low fiber diets result in
 slower passage of food
 through colon

May be associated with
 high level of colon
 cancer in U. S.



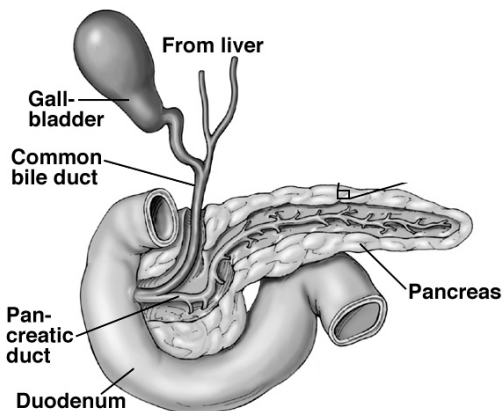
The rectum - terminal portion of the large intestine
Feces pass into rectum by peristaltic contractions



Material exits anus through two sphincters
First sphincter is smooth muscle, opens involuntarily
Second sphincter is striated muscle
under voluntary control - a very good thing

Accessory Organs

Pancreas - at junction of
stomach and small intestine
Connected via pancreatic duct
Has both exocrine and
endocrine functions
Fluid contains proteases
(trypsin and chymotrypsin)
pancreatic amylase and
fat digesting lipase

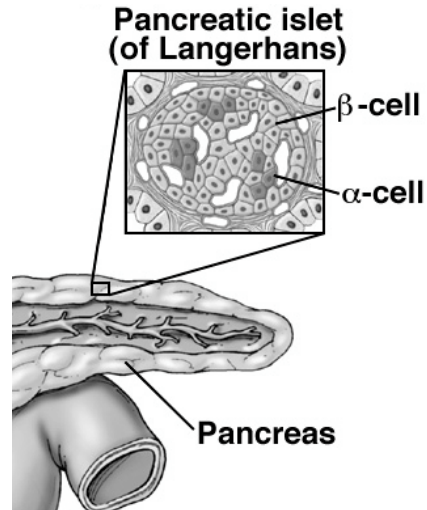


Enzymes released as inactive zymogens,
activated by brush border enzymes
Fluid also contains bicarbonate to neutralize HCl
Chyme in intestine becomes slightly alkaline

Pancreas is also an endocrine gland
 Produces hormones that regulate blood sugar level
 Produced in islets of Langerhans clustered throughout pancreas
 Most important pancreatic hormones are insulin and glucagon

Insulin - produced by β -cells -
 released in response to high
 blood sugar
 stimulates sugar uptake by liver
 and muscles - converted to
 glycogen

Glucagon - produced by α -cells -
 released in response to low
 blood sugar
 stimulates release of sugar from
 liver - from stored glycogen



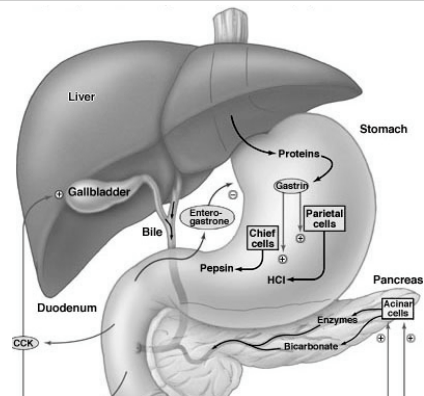
Liver and Gallbladder

Main secretion of liver is bile
 a fluid with bile pigments
 and bile salts

Bile pigments are waste products
 from destruction of red blood cells

Bile salts are lipid and water soluble
 Emulsify fats
 Allows faster digestion of fat

Bile is stored and concentrated in gall bladder
 Fatty food in duodenum triggers contraction of gallbladder to
 release bile



Contraction of gallbladder may result in pain under right shoulder
 blade

Regulatory Functions of the Liver

Hepatic portal vein carries blood from stomach and intestine to liver

Liver absorbs or chemically modifies substances

Alcohol, drugs, toxins metabolized by liver cells

Ammonia from intestinal bacteria converted into urea

Controls level of many substances produced by body

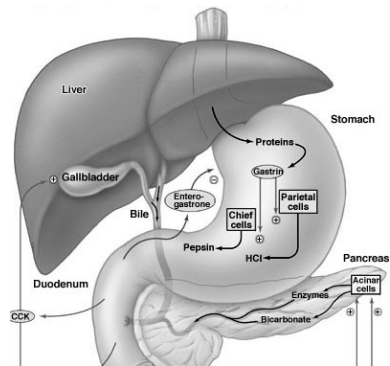
Steroid hormones converted into less active forms

Terminal products of metabolism eliminated in feces or through kidneys

Produces proteins found in blood plasma

Includes most blood clotting factors

Maintains blood protein concentration within narrow limits



Neural and Hormonal Regulation of Digestion

Nervous Control

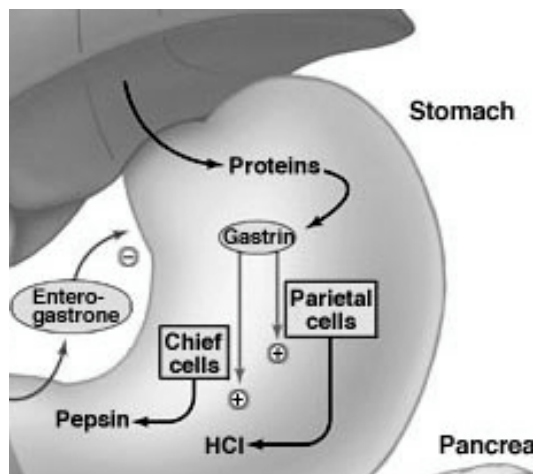
Sight/Smell of food stimulates salivary and gastric secretions

Hormonal Control

Food in stomach stimulates secretion of gastrin by stomach

Gastrin stimulates secretion of pepsinogen and HCl

Low stomach pH reduces secretion of gastrin



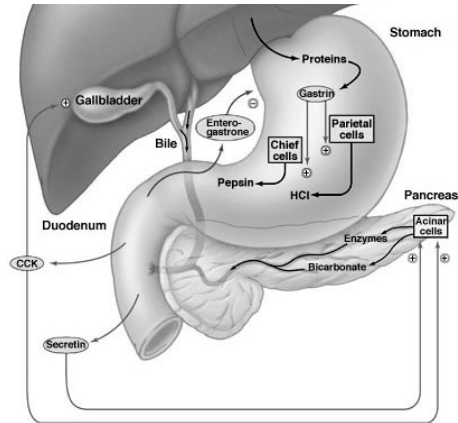
Passage of chyme from stomach inhibits stomach contractions

Process mediated by neural impulses and enterogastrone proteins

Gastric inhibitory peptide (GIP) is one enterogastrone

GIP released by duodenum

Production stimulated most strongly by fat in chyme



Cholecystokinin (CCK) is secreted in response to fat in chyme

Stimulates contraction of gallbladder to release bile

Secretin released in response to low pH chyme

Stimulates pancreas to release bicarbonate and enzymes