DIGESTIVE SYSTEM

Accessory Organs
- Salivary Glands
- Teeth

Alimentary Canal
- Oral Cavity
- Oral Pharynx
- Esophagus
- Stomach
- Small Intestine
- Large Intestine
- Rectum
- Anus

Functions of GI Tract:
A) Prepares food
B) Digests food
C) Absorbs food
D) Eliminates waste
DIGESTIVE SYSTEM: OVERVIEW

- The alimentary canal or gastrointestinal (GI) tract digests and absorbs food
- Alimentary canal – mouth, pharynx, esophagus, stomach, small intestine, and large intestine
- Accessory digestive organs – teeth, tongue, gallbladder, salivary glands, liver, and pancreas
DIGESTIVE PROCESS

- The GI tract is a “disassembly” line
  - Nutrients become more available to the body in each step
- There are six essential activities:
  - Ingestion, propulsion, and mechanical digestion
  - Chemical digestion, absorption, and defecation
DIGESTIVE PROCESS

Ingestion

Mechanical digestion
- Chewing (mouth)
- Churning (stomach)
- Segmentation (small intestine)

Propulsion
- Swallowing (oropharynx)
- Peristalsis (esophagus, stomach, small intestine, large intestine)

Chemical digestion

Stomach

Small intestine

Large intestine

Absorption
- Lymph vessel
- Blood vessel
- Mainly H₂O

Defecation

Anus
GASTROINTESTINAL TRACT ACTIVITIES

- Ingestion – taking food into the digestive tract
- Propulsion – swallowing and peristalsis
  - Peristalsis – waves of contraction and relaxation of muscles in the organ walls
- Mechanical digestion – chewing, mixing, and churning food
DIGESTIVE SYSTEM PERISTALSIS X-RAYS

Peristalsis

Coordinated waves of smooth muscle contraction
GASTROINTESTINAL TRACT ACTIVITIES

- Chemical digestion – catabolic breakdown of food
- Absorption – movement of nutrients from the GI tract to the blood or lymph
- Defecation – elimination of indigestible solid wastes
REGULATION OF DIGESTION INVOLVES:

+ Mechanical and chemical stimulitretch receptors, osmolarity, and presence of substrate in the lumen
+ Extrinsic control by CNS centers
+ Intrinsic control by local centers
 Mechano- and chemoreceptors respond to:

- Stretch by the presence of food
- Osmolarity – solute concentration
- pH of contents
- Presence of end products of digestion

They initiate reflexes that:

- Activate or inhibit digestive glands to secrete digestive juices
- Mix lumen contents and move them along
NERVOUS CONTROL OF THE GI TRACT

- **Intrinsic controls**
  + Nerve plexuses near the GI tract initiate short reflexes
  + Short reflexes are mediated by local enteric plexuses (gut brain)

- **Extrinsic controls**
  + Long reflexes arising within or outside the GI tract
  + Involve CNS centers and extrinsic autonomic nerves
PERITONEUM AND PERITONEAL CAVITY

- Peritoneum – serous membrane of the abdominal cavity
  - Visceral – covers external surface of most digestive organs
  - Parietal – lines the body wall

- Peritoneal cavity
  - Lubricates digestive organs
  - Allows them to slide across one another
PERITONEUM AND PERITONEAL CAVITY

- Mesentery – double layer of peritoneum that provides:
  + Vascular and nerve supplies to the viscera
  + A means to hold digestive organs in place and store fat
- Retroperitoneal organs – organs outside the peritoneum
- Peritoneal organs (intraperitoneal) – organs surrounded by peritoneum
Peritoneal Cavity Surgery
Acute Peritonitis
Arteries and the organs they serve include:
- The hepatic, splenic, and left gastric: spleen, liver, and stomach
- Inferior and superior mesenteric: small and large intestines

Hepatic portal circulation:
- Collects nutrient-rich venous blood from the digestive viscera
- Delivers this blood to the liver for metabolic processing and storage
LAYERS OF THE ALIMENTARY CANAL

- Mucosa
  - Secretes mucus, enzymes and hormones
  - Absorption of end products of digestion into blood
  - Protection against disease
- Submucosa
  - Dense connective tissue with blood, lymph and nerves
- Muscularis externa or muscularis
  - Responsible for peristalsis and segmentation
- Serosa
  - Actually the visceral peritoneum
LAYERS OF GI LUMEN

LUMEN

- MUCOSA
- SUBMUCOSA
- CIRCULAR MUSCLE
- LONGITUDINAL MUSCLE
- SEROSA

VISCERAL PERITONEUM
**ENTERIC NERVOUS SYSTEM**

- Composed of two major intrinsic nerve plexuses
  + Submucosal nerve plexus – regulates glands and smooth muscle in the mucosa
  + Myenteric nerve plexus – Major nerve supply that controls GI tract mobility
- Segmentation and peristalsis are largely automatic involving local reflex arcs
- Linked to the CNS via long autonomic reflex arc
MOUTH

- Oral or buccal cavity:
  + Is bounded by lips, cheeks, palate, and tongue
  + Has the oral orifice as its anterior opening
  + Is continuous with the oropharynx posteriorly

- To withstand abrasions:
  + The mouth is lined with stratified squamous epithelium
  + The gums, hard palate, and dorsum of the tongue are slightly keratinized
LIPS AND CHEEKS

- Have a core of skeletal muscles
  - Lips: orbicularis oris
  - Cheeks: buccinators

- Vestibule – bounded by the lips and cheeks externally, and teeth and gums internally

- Oral cavity proper – area that lies within the teeth and gums

- Labial frenulum – median fold that joins the internal aspect of each lip to the gum
PALATE

- Hard palate
  - Assists the tongue in chewing
  - Slightly corrugated on either side of the raphe (midline ridge) which helps to create friction

- Soft palate – mobile fold formed mostly of skeletal muscle
  - Closes off the nasopharynx during swallowing
TONGUE

- Occupies the floor of the mouth and fills the oral cavity when mouth is closed

- Functions include:
  - Gripping and repositioning food during chewing
  - Mixing food with saliva and forming the bolus
  - Initiation of swallowing, and speech
**TONGUE**

- Intrinsic muscles change the shape of the tongue
- Extrinsic muscles alter the tongue’s position
- Lingual frenulum secures the tongue to the floor of the mouth
TONGUE

- Epiglottis
- Palatopharyngeal arch
- Palatine tonsil
- Lingual tonsil
- Palatoglossal arch
- Sulcus terminalis
- Circumvallate papilla
- Filiform papillae
- Fungiform papilla
- Dorsum of tongue
SALIVARY GLANDS

- Produce and secrete saliva that:
  + Cleanses the mouth
  + Moistens and dissolves food chemicals
  + Aids in bolus formation
  + Contains enzymes that break down starch

- Three pairs of extrinsic glands – parotid, submandibular, and sublingual

- Intrinsic salivary glands (buccal glands) – scattered throughout the oral mucosa
SALIVARY GLANDS

- Parotid – lies anterior to the ear between the masseter muscle and skin
  + Parotid duct – opens into the vestibule next to the second upper molar
- Submandibular – lies along the medial aspect of the mandibular body
  + Its ducts open at the base of the lingual frenulum
- Sublingual – lies anterior to the submandibular gland under the tongue
  + It opens via 10-12 ducts into the floor of the mouth
SALIVA

- Secreted from serous and mucous cells of salivary glands
- A 97-99.5% water, hypo-osmotic, slightly acidic solution containing
  + Electrolytes
  + Digestive enzyme – salivary amylase
  + Proteins – mucin, lysozyme, defensins
  + Metabolic wastes – urea and uric acid
CONTROL OF SALIVATION

- Intrinsic glands keep the mouth moist
- Extrinsic salivary glands secrete serous, enzyme-rich saliva in response to:
  + Ingested food which stimulates chemoreceptors and pressoreceptors
  + The thought of food
- Strong sympathetic stimulation inhibits salivation and results in dry mouth
Halitosis
Primary and permanent dentitions have formed by age 21

Primary – 20 deciduous teeth that erupt at intervals between 6 and 24 months

Permanent – enlarge and develop causing the root of deciduous teeth to be resorbed and fall out between the ages of 6 and 12 years
  + All but the third molars have erupted by the end of adolescence
  + There are usually 32 permanent teeth
CLASSIFICATION OF TEETH

- Teeth are classified according to their shape and function
  - Incisors – chisel-shaped teeth adapted for cutting or nipping
  - Canines – conical or fanglike teeth that tear or pierce
  - Premolars (bicuspids) and molars – have broad crowns with rounded tips and are best suited for grinding or crushing

- During chewing, upper and lower molars lock together generating crushing force
TOOTH STRUCTURE

- Two main regions – crown and the root
- Crown – exposed part of the tooth above the gingiva (gum)
- Enamel – acellular, brittle material composed of calcium salts and hydroxyapatite crystals is the hardest substance in the body
  - Encapsules the crown of the tooth
- Root – portion of the tooth embedded in the jawbone
TOOTH STRUCTURE

- Enamel
- Dentin
- Dentinal tubules
- Pulp cavity (contains blood vessels and nerves)
- Gingiva (gum)
- Cementum
- Root canal
- Periodontal ligament
- Apical foramen
- Bone
TOOTH AND GUM DISEASE

- Dental caries – gradual demineralization of enamel and dentin by bacterial action
  + Dental plaque, a film of sugar, bacteria, and mouth debris, adheres to teeth
  + Acid produced by the bacteria in the plaque dissolves calcium salts
  + Without these salts, organic matter is digested by proteolytic enzymes
  + Daily flossing and brushing help prevent caries by removing forming plaque
TOOTH AND GUM DISEASE: PERIODONTITIS

- Gingivitis – as plaque accumulates, it calcifies and forms calculus, or tartar
- Accumulation of calculus:
  + Disrupts the seal between the gingivae and the teeth
  + Puts the gums at risk for infection
- Periodontitis – serious gum disease resulting from an immune response
  + Risk factors include smoking, diabetes, and oral or tongue or lip piercing
From the mouth, the oro- and laryngopharynx allow passage of:
- Food and fluids to the esophagus
- Air to the trachea
Lined with stratified squamous epithelium and mucus glands
Has two skeletal muscle layers
- Inner longitudinal
- Outer pharyngeal constrictors
ESOPHAGUS

- Muscular tube going from the laryngopharynx to the stomach
- Travels through the mediastinum and pierces the diaphragm
- Joins the stomach at the cardiac orifice
- The empty esophagus is folded longitudinally and flattens when food is present
- Glands secrete mucus as a bolus moves through the esophagus
GERD
Food is ingested
Mechanical digestion begins (chewing)
Propulsion is initiated by swallowing
Salivary amylase begins chemical breakdown of starch
The pharynx and esophagus serve as conduits to pass food from the mouth to the stomach
DEGLUTITION (SWALLOWING)

- Involves the coordinated activity of the tongue, soft palate, pharynx, esophagus and 22 separate muscle groups
- Buccal phase – bolus is forced into the oropharynx
- Pharyngeal-esophageal phase – controlled by the medulla and lower pons
  - All routes except into the digestive tract are sealed off
- Peristalsis moves food through the pharynx to the esophagus
DEGLUTITION (SWALLOWING)

(a) Upper esophageal sphincter contracted
(b) Upper esophageal sphincter relaxed
(c) Upper esophageal sphincter contracted

Relaxed muscles
Circular muscles contract, constricting passageway and pushing bolus down
Relaxed muscles
Gastroesophageal sphincter open

Longitudinal muscles contract, shortening passageway ahead of bolus
Gastroesophageal sphincter closed

Bolus of food
Uvula
Bolus
Epiglottis
Bolus
Trachea
Esophagus
Stomach

47
5/6 of stomach left of midline

Fundus of stomach and diaphragm

Spleen sits between

- Adult stomach  6”-10” long
- Empty stomach volume 50 ml.
- Full stomach 1 gallon

When empty, stomach collapses inward into wrinkles or folds called rugae
Chemical breakdown of proteins begins and food is converted to chyme
Cardiac region – surrounds the cardiac orifice
Fundus – dome-shaped region beneath the diaphragm
Body – midportion of the stomach
Pyloric region – made up of the antrum and canal which terminates at the pylorus
The pylorus is continuous with the duodenum through the pyloric sphincter
STOMACH

- Greater curvature – entire extent of the convex lateral surface
- Lesser curvature – concave medial surface
- Lesser omentum – runs from the liver to the lesser curvature
- Greater omentum – drapes inferiorly from the greater curvature to the small intestine
Muscularis – has an additional oblique layer that:

- Allows the stomach to churn, mix, and pummel food physically
- Breaks down food into smaller fragments

Gastric pits contain gastric glands that secrete gastric juice, mucus, and gastrin
Gastric Ulcer
Gastric glands of the fundus and body have a variety of secretory cells:

- Mucous neck cells – secrete acid mucus
- Parietal cells – secrete HCl and intrinsic factor
The stomach is exposed to the harshest conditions in the digestive tract.

To keep from digesting itself, the stomach has a mucosal barrier with:

- A thick coat of bicarbonate-rich mucus on the stomach wall
- Epithelial cells that are joined by tight junctions
- Gastric glands that have cells impermeable to HCl

Damaged epithelial cells are quickly replaced.
The stomach:

- Holds ingested food
- Degrades this food both physically and chemically
- Delivers chyme to the small intestine
- Enzymatically digests proteins with pepsin
- Secretes intrinsic factor required for absorption of vitamin $\text{B}_{12}$
REGULATION OF GASTRIC SECRETION

- Neural and hormonal mechanisms regulate the release of gastric juice
- Stimulatory and inhibitory events occur in three phases
  - Cephalic (reflex) phase: prior to food entry
  - Gastric phase: once food enters the stomach
  - Intestinal phase: as partially digested food enters the duodenum
CEPHALIC PHASE

- **Excitatory events include:**
  + Sight or thought of food
  + Stimulation of taste or smell receptors

- **Inhibitory events include:**
  + Loss of appetite or depression
  + Decrease in stimulation of the parasympathetic division
GASTRIC PHASE

- **Excitatory events include:**
  - Stomach distension
  - Activation of stretch receptors (neural activation)
  - Activation of chemoreceptors
  - Release of gastrin to the blood

- **Inhibitory events include:**
  - A pH lower than 2
  - Emotional upset that overrides the parasympathetic division
Excitatory phase – low pH; partially digested food enters the duodenum and encourages gastric gland activity

Inhibitory phase – distension of duodenum, presence of fatty, acidic, or hypertonic chyme, and/or irritants in the duodenum

- Initiates inhibition of local reflexes and vagal nuclei
- Closes the pyloric sphincter
- Releases enterogastrones that inhibit gastric secretion
RESPONSE OF THE STOMACH TO FILLING

- Stomach pressure remains constant until about 1L of food is ingested
- Relative unchanging pressure results from reflex-mediated relaxation and plasticity
- Reflex-mediated events include:
  - Receptive relaxation – as food travels in the esophagus, stomach muscles relax
  - Adaptive relaxation – the stomach dilates in response to gastric filling
Peristaltic waves move toward the pylorus at the rate of 3 per minute

Most vigorous peristalsis and mixing occurs near the pylorus

Chyme is either:
  - Delivered in small amounts to the duodenum or
  - Forced backward into the stomach for further mixing
Gastric emptying is regulated by:

- The neural enterogastric reflex
- Hormonal (enterogastrone) mechanisms

These mechanisms inhibit gastric secretion and duodenal filling.

- Carbohydrate-rich chyme quickly moves through the duodenum
- Fat-laden chyme is digested more slowly causing food to remain in the stomach longer
GASTRIC BYPASS SURGERY

Gastric Bypass Surgery

Before Surgery

After Surgery

Stomach

Pouch

Stomach (bypassed)

Duodenum

Jejunum

Small intestine

Jejunum (bypassed)
SMALL INTESTINE - GROSS ANATOMY
- All absorption is in small intestine
- 20' long  1"-1 1/2" diameter
- 3 divisions
  - Duodenum
    - Latin: "12 finger width"
    - Shortest division (2 1/10" long)
    - Very important because the bile duct delivers bile here
  - Jejunum
    - Latin is "empty"
    - 8'-10' long
  - Ileum
    - Latin is "twisted"
    - 12' long
- Runs from pyloric sphincter (stomach/duodenum) to the ileocecal valve (ileum or small intestine to cecum or colon)
SMALL INTESTINE: GROSS ANATOMY

- Runs from pyloric sphincter to the ileocecal valve
- Has three subdivisions: duodenum, jejunum, and ileum
- The jejunum extends from the duodenum to the ileum
- The ileum joins the large intestine at the ileocecal valve
**Lumen**

- **Villi**
- **Plicae**
- **Muscular Layer**
- **Serous Layer**

**Plicae**

**Villi** & **Microvilli**

**Intestinal Crypts**

- Cells that line villi; like a conveyor belt, regenerate every 3-4 cells

**Brunner Glands** on Duodenum

- Neutralize acids to 7.6
Structural modifications of the small intestine wall increase surface area

- Plicae circulares: deep circular folds of the mucosa and submucosa
- Villi – fingerlike extensions of the mucosa
- Microvilli – tiny projections of absorptive mucosal cells’ plasma membranes
Intestinal Juice

- Secreted by intestinal glands in response to distension or irritation of the mucosa
- Slightly alkaline and isotonic with blood plasma
- Largely water, enzyme-poor, but contains mucus
LIVER

- The largest gland in the body
- Superficially has four lobes – right, left, caudate, and quadrate
- The falciform ligament:
  + Separates the right and left lobes anteriorly
  + Suspends the liver from the diaphragm and anterior abdominal wall
Bile leaves the liver via:

- Bile ducts, which fuse into the common hepatic duct
- The common hepatic duct, which fuses with the cystic duct
  - These two ducts form the bile duct
Hexagonal-shaped liver lobules are the structural and functional units of the liver

- Composed of hepatocyte (liver cell) plates radiating outward from a central vein
- Portal triads are found at each of the six corners of each liver lobule

Portal triads consist of a bile duct and

- Hepatic artery – supplies oxygen-rich blood to the liver
- Hepatic portal vein – carries venous blood with nutrients from digestive viscera
Hepatocytes’ functions include:
- Production of bile
- Processing bloodborne nutrients
- Storage of fat-soluble vitamins
- Detoxification
A yellow-green, alkaline solution containing bile salts, bile pigments, cholesterol, neutral fats, phospholipids, and electrolytes

- Bile salts are cholesterol derivatives that:
  + Emulsify fat
  + Facilitate fat and cholesterol absorption
  + Help solubilize cholesterol

- The chief bile pigment is bilirubin, a waste product of heme
Thin-walled, green muscular sac on the ventral surface of the liver
Stores and concentrates bile by absorbing its water and ions
Releases bile via the cystic duct, which flows into the bile duct
Acidic, fatty chyme causes the duodenum to release:
+ Cholecystokinin (CCK) and secretin into the bloodstream

Bile salts and secretin transported in blood stimulate the liver to produce bile

Cholecystokinin causes:
+ The gallbladder to contract
+ The hepatopancreatic sphincter to relax

As a result, bile enters the duodenum
REGULATION OF BILE RELEASE

1. Acidic, fatty chyme entering duodenum causes release of cholecystokinin and secretin from duodenal wall enteroendocrine cells.

2. Cholecystokinin and secretin enter the bloodstream.

3. Bile salts and secretin transported via bloodstream stimulate liver to produce bile more rapidly.

4. Vagal stimulation causes weak contractions of gallbladder.

5. Cholecystokinin (via bloodstream) causes gallbladder to contract and hepatopancreatic sphincter to relax; bile enters duodenum.

PANCREAS

- Location
  - Lies deep to the greater curvature of the stomach
  - Encircled by the duodenum and the tail abuts the spleen

- Exocrine function
  - Secretes pancreatic juice which breaks down food
  - Acini (clusters of secretory cells) contain zymogen granules with digestive enzymes

- Endocrine function
  - Release of insulin and glucagon
Pancreatic Duct -
- secretes digestive enzymes
- exocrine function
- ducts of Langerhans cells
- glucagon & insulin
- endocrine function

Pancreas
Ductenum
Head
Tail
Islets of Langerhans cells
PANCREATIC JUICE

- Water solution of enzymes and electrolytes
  + Neutralizes acid chyme
  + Provides environment for pancreatic enzymes
- Enzymes are released in inactive form and activated in the duodenum
- Active enzymes secreted
  + Amylase, lipases, and nucleases
  + These enzymes require ions or bile for optimal activity
REGULATION OF PANCREATIC SECRETION

- Secretin and CCK are released when fatty or acidic chyme enters the duodenum
- CCK and secretin enter the bloodstream
- Upon reaching the pancreas:
  - CCK induces the secretion of enzyme-rich pancreatic juice
  - Vagal stimulation also causes release of pancreatic juice
As chyme enters the duodenum:

- Carbohydrates and proteins are partially digested
- No fat digestion has taken place
- Chyme is released slowly into the duodenum
- Mixing is required for proper digestion
- Virtually all nutrient absorption takes place in the small intestine
The most common motion of the small intestine is segmentation
- Initiated by intrinsic pacemaker cells
- Moves contents steadily toward the ileocecval valve

After nutrients have been absorbed:
- Peristalsis begins with each wave starting distal to the previous
- Meal remnants, bacteria, mucosal cells, and debris are moved into the large intestine
CONTROL OF MOTILITY

- Local enteric neurons of the GI tract coordinate intestinal motility
- Cholinergic neurons cause:
  - Contraction and shortening of muscle layer
  - Distension of the intestine
- The gastroileal reflex and gastrin:
  - Relax the ileocecal sphincter
  - Allow chyme to pass into the large intestine
LARGE INTESTINE

- Has three unique features:
  - Teniae coli – three bands of smooth muscle
  - Haustra – pocketlike sacs caused by muscle tone
  - Epiploic appendages – fat-filled pouches of visceral peritoneum
LARGE INTESTINE

- Is subdivided into the cecum, appendix, colon, rectum, and anal canal
- The saclike cecum:
  - Lies below the ileocecal valve in the right iliac fossa
  - Contains a wormlike vermiform appendix
Figure 23.29a

- Left colic (splenic) flexure
- Transverse mesocolon
- Epiploic appendages
- Descending colon
- Cut edge of mesentery
- Teniae coli
- Sigmoid colon
- Cecum
- Ileocecal valve
- Ileum
- Superior mesenteric artery
- Hastrum
- Ascending colon
- Right colic (hepatic) flexure
- Rectum
- Anal canal
- External anal sphincter
- Vermiform appendix
Picture frames around abdominal wall

Transverse Colon

Sigmoid Colon around iliac crest

Appendix (mucous or lymphocytes)

Large intestine
5' long 2"-3" wide
COLON

- Has distinct regions: ascending colon, hepatic flexure, transverse colon, splenic flexure, descending colon, and sigmoid colon
- The transverse and sigmoid portions are anchored via mesenteries called mesocolons
- The sigmoid colon joins the rectum
- The anal canal, the last segment of the large intestine, opens to the exterior at the anus
VALVES & SPHINCTERS OF THE RECTUM AND ANUS

- Three valves of the rectum stop feces from being passed with gas.
- The anus has two sphincters:
  - Internal anal sphincter of smooth muscle
  - External anal sphincter of skeletal muscle
- These sphincters are closed except during defecation.
MESENTERIES OF DIGESTIVE ORGANS

- Greater omentum
- Transverse colon
- Transverse mesocolon
- Descending colon
- Jejunum
- Mesentery
- Sigmoid mesocolon
- Sigmoid colon
- Ileum
STRUCTURE OF THE ANAL CANAL

- Rectal valve
- Rectum
- Hemorrhoidal veins
- Levator ani muscle
- Anal canal
- External anal sphincter
- Internal anal sphincter
- Anal columns
- Anal sinuses
- Anus
The bacterial flora of the large intestine consist of:
- Bacteria surviving the small intestine that enter the cecum and
- Those entering via the anus

These bacteria:
- Colonize the colon
- Ferment indigestible carbohydrates
- Release irritating acids and gases (flatus)
- Synthesize B complex vitamins and vitamin K
FUNCTIONS OF THE LARGE INTESTINE

- Other than digestion of enteric bacteria, no further digestion takes place
- Vitamins, water, and electrolytes are reclaimed
- Its major function is propulsion of fecal material toward the anus
- Though essential for comfort, the colon is not essential for life
MOTILITY OF THE LARGE INTESTINE

- Haustral contractions
  - Slow segmenting movements that move the contents of the colon
  - Haustra sequentially contract as they are stimulated by distension

- Presence of food in the stomach:
  - Activates the gastrocolic reflex
  - Initiates peristalsis that forces contents toward the rectum
DEFECATION

- Distension of rectal walls caused by feces
  - Stimulates contraction of the rectal walls
  - Relaxes the internal anal sphincter
- Voluntary signals stimulate relaxation of the external anal sphincter and defecation occurs
CHEMICAL DIGESTION

- **Carbohydrates**
  - Enzymes used: salivary amylase, pancreatic amylase, and brush border enzymes

- **Proteins**
  - Enzymes used: pepsin in the stomach
  - Enzymes acting in the small intestine

- **Fats**
  - Absorption via diffusion into intestinal cells
  - Enzymes used: bile salts and pancreatic lipase
Absorption

- Up to 10 L of food, drink, and GI secretions enter the GI tract daily
- Only 1 L or less reaches the large intestine
- Virtually all food, 80% of electrolytes and water absorb in the small intestine
- It is nearly impossible to exceed the absorptive capacity if the GI tract
- At the end of the ileum, all that remains is some water, indigestible food materials, and millions of bacteria
- The debris is passed on into the large intestine
Approximately 9 L of water, mostly derived from GI tract secretions, enter the small intestine daily.

Water is the most abundant substance in chyme.

95% of water is absorbed in the small intestines by osmosis.

Normal rate of water absorption is 300-400 ml/hour.

Water moves in both directions across intestinal mucosa.
MALABSORPTION OF NUTRIENTS

- Results from anything that interferes with delivery of bile or pancreatic juice
- Factors that damage the intestinal mucosa (e.g., bacterial infection)
- Gluten enteropathy (adult celiac disease) – gluten damages the intestinal villi and reduces the length of microvilli
  + Treated by eliminating gluten from the diet (all grains but rice and corn)
DIGESTIVE SYSTEM VIDEOS

- Digestive System Animation
- Normal Colonoscopy
DEVELOPMENTAL ASPECTS

- During fetal life, nutrition is via the placenta, but the GI tract is stimulated toward maturity by amniotic fluid swallowed in utero.
- At birth, feeding is an infant’s most important function and is enhanced by:
  - Rooting reflex (helps infant find the nipple) and sucking reflex (aids in swallowing).
- Digestive system has few problems until the onset of old age.
- During old age the GI tract activity declines, absorption is less efficient, and peristalsis is slowed.
CANCER

- GI cancers rarely have early signs or symptoms
- Metastasized colon cancers frequently cause secondary liver cancer
- Prevention is by regular dental and medical examinations
- Colon cancer is the 2nd largest cause of cancer deaths in males (lung cancer is 1st)
- Regular colon examination should be done for all those over 50