Lecture Notes on the Digestive System

Function

The function of the digestive system is to digest and absorb food. It consists of a tubular gastrointestinal tract and accessory organs that aid in digestion and absorption.

All organisms require food to sustain life. The cells of the body require nutrients for the chemical reactions of enzyme synthesis, cell division, growth and repair and also for the production of heat energy. Most of the food we eat requires considerable processing before it can be used by the cells. It must be broken down mechanically and chemically before it is transported by the blood to the cells.

The activities that are performed by the digestive system include the following activities:

1. Ingestion: the taking of food into the mouth
2. Mastication: chewing food which pulverizes it and mixes it with saliva
3. Deglutination: Swallowing; moving food from the mouth to the pharynx and into the esophagus.
4. Digestion: The mechanical and chemical breakdown of food to prepare it for absorption.
5. Absorption: the passage molecules of food through the mucous membrane of the small intestine and into the blood and lymph for distribution to the cells.
6. Peristalsis: the rhythmic wavelike contractions of the smooth muscle of the intestines that move food through the GI tract.
7. Defecation: the discharge of indigestible wastes (feces) from the GI tract.

Anatomically and functionally the digestive system can be divided into a tubular gastrointestinal (GI) tract and accessory digestive organs. The GI tract which extends from the mouth to the anus is a continuous tube approximately 30 feet (9m) long. It goes through the thoracic cavity and enters the abdominal cavity through the diaphragm.

The organs of the digestive system include the oral cavity (mouth), pharynx, esophagus, stomach, small intestine and large intestine. The accessory organs include teeth, salivary glands, liver, gall bladder and pancreas.

It usually takes about 24-48 hours for food to travel the length of the GI tract. Food travels in an assembly line manner through the tract where it is broken down to the molecular level and transported to the cells. Each region of the GI tract has a specific function in the process.
# Scientific Anatomy

## Digestive System

![Digestive System Diagram]

<table>
<thead>
<tr>
<th>Region</th>
<th>Function</th>
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</thead>
<tbody>
<tr>
<td>Oral cavity</td>
<td>Ingests food; receives saliva; grinds food and mixes it with saliva (mastication); initiates digestion of carbohydrates; forms and swallows soft mass of chewed food called bolus (deglutition)</td>
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<tr>
<td>Pharynx</td>
<td>Receives bolus from oral cavity; autonomically continues deglutition of bolus to esophagus</td>
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<tr>
<td>Esophagus</td>
<td>Transports bolus to stomach by peristalsis; lower esophageal sphincter restricts backflow of food</td>
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<tr>
<td>Stomach</td>
<td>Receives bolus from esophagus; churns bolus with gastric juice; initiates digestion of proteins; carries out limited absorption; moves mixture of partly digested food and secretions (chyme) into duodenum and prohibits backflow of chyme; regurgitates when necessary; generates hunger pangs, which cause a desire to eat</td>
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<tr>
<td>Small intestine</td>
<td>Receives chyme from stomach and secretions from liver and pancreas; chemically and mechanically breaks down chyme; absorbs nutrients; transports wastes through peristalsis to large intestine; prohibits backflow of intestinal wastes from large intestine</td>
</tr>
<tr>
<td>Large intestine</td>
<td>Receives undigested wastes from small intestine; absorbs water and electrolytes; forms, stores, and expels feces when activated by a defecation reflex</td>
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Membranes of the Abdominal Cavity

Most of the digestive organs are located in the abdominal cavity. These organs are covered by **serous membranes** that line the cavity and cover the organs within. Serous membranes secrete a lubricating serous fluid that continuously moistens the organs. The **parietal membrane** lines the wall of the abdominal cavity and the **visceral membrane** covers the internal organs. The membrane that lines the wall of the abdominal cavity is called the **parietal peritoneum**. It comes together to form a double layered peritoneal fold called the **mesentery**. The mesentery supports the GI tract and at the same time allows the small intestine freedom for peristaltic contractions. It also provides a structure for the passage of blood vessels and nerves. The peritoneal membrane continues around the intestinal organs as the visceral peritoneum. The **peritoneal cavity** is the space between the parietal and visceral portions of the peritoneum. Certain organs lie posterior to the peritoneal cavity and are said to be **retroperitoneal**. These organs include most of the pancreas, the kidneys, adrenal glands and portions of the duodenum and colon as well as the abdominal aorta.

**Peritonitis** is an inflammation of the peritoneum usually caused by an infection. This can occur due to trauma, rupture of an organ, an ectopic pregnancy or post operative infection. It is a serious life threatening situation. Treatment usually involves massive doses of antibiotics as well as insertion of a tube to drain excess fluid which accumulates.

Extensions of the parietal peritoneum serve to suspend or anchor organs within the peritoneal cavity. The **falciform ligament** attaches the diaphragm and the anterior abdominal wall to the liver. The **greater omentum** extends from the stomach to the transverse colon forming an apron like covering over most of the small intestine. Function of the omentum includes storage of fat, cushioning visceral organs, supporting lymph nodes and protection against infection. In cases of infection such as appendicitis the
greater omentum may actually compartmentalize the infection, sealing it off from the rest of the peritoneal cavity. The lesser omentum passes from the lesser curve of the stomach and the upper duodenum to the inferior surface of the liver.

**Layers of the GI tract**

The GI tract from the esophagus to the anal canal is comprised of 4 layers or tunics. Each layer performs specific functions in the digestive process.

These layers are:

1. **Mucosa**- the innermost layer lines the lumen of the GI tract. It is both absorptive and secretory in function. It contains lymph nodes as well as goblet cells which secrete mucus. There is also a thin layer of smooth muscle in this tunic.

2. **Submucosa**- this is the second layer, much thicker than the mucosa. It is primarily vascular and nerve containing. Absorbed molecules pass through the mucosa to enter blood or lymph vessels here. The submucosa contain glands and a nerve plexus (Meissner’s plexus) which provides autonomic innervation to the muscle layer in the mucosa.

3. **Tunica muscularis**- This is the primary smooth muscle layer of the GI tract which is responsible for peristalsis. It has an inner circle and an outer longitudinal layer of muscle. Contraction of this layer causes the movement of food as well as helping to pulverize and churn the food with digestive enzymes. There is a large nerve plexus (Auerbach’s plexis) located between the 2 muscle layers. It provides both sympathetic and parasympathetic innervation.

4. **Serosa**- is the outermost layer of the GI tract wall. It is binding and protective in function.
Defense mechanisms of the GI tract

The GI tract has several mechanisms for protecting against harmful materials ingested. The lining of the stomach produces concentrated hydrochloric acid which can kill some organisms. The mucous lining of the GI tract serves as a protective layer as well producing copious amounts of mucous that may dilute harmful substances. The most helpful mechanism is vomiting which is a reflexive response to toxins and irritants. Diarrhea can also help remove harmful substances as well.

Innervation of the GI tract

The GI tract is innervated by the sympathetic and parasympathetic divisions of the nervous system. The vagus nerves are the source of parasympathetic activities in the esophagus, stomach, pancreas, gall bladder, small intestine and part of the large intestine. The lower portion of the large intestine receives parasympathetic innervation from spinal nerves of the sacral region. Stimulation of the parasympathetic nerves increases peristalsis and GI tract secretions. Sympathetic nerve fibers pass through the submucosal and myenteric plexuses that innervate the GI tract. The effect of sympathetic nerves is in opposition to parasympathetic nerves. Sympathetic impulses inhibit peristalsis, reduce secretions and constrict muscle sphincters along the GI tract.

Mouth and Pharynx

The functions of the mouth and associated structures is to act as a receptacle for food, to initiate digestion through mastication (chewing), to swallow food and to form words in speech. The pharynx, which is posterior to the mouth serves as a common passageway for the respiratory and digestive systems. Both the mouth and the pharynx are lined with non keratinized squamous epithelium that is continuously moistened by saliva.
Cheeks, Lips and Palate

The **cheeks** form the lateral walls of the oral cavity. They consist of outer layers of skin, subcutaneous fat and facial muscles that assist in manipulating food in the mouth and inner linings of moistened squamous epithelium. The anterior portion of the cheeks terminate in the lips (superior and inferior) that surround the oral orifice.

The **lips** are fleshy highly mobile organs whose primary function in humans is associated with speech. Lips also serve for suckling (vital for infants), manipulating food and keeping food between upper and lower teeth. Each lip is attached from its inner surface to the gum by a midline fold of mucous membrane called the **labial frenulum**. The lips are formed from the obicularis oris muscle and associated connective tissue and are covered with soft pliable skin. Between the outer skin and the mucous membrane there is a transition zone called the **vermillion**. Lips are reddish brown to red because they are highly vascular and the blood vessels are close to the surface. They also have numerous sensory receptors which aid in determining the temperature and texture of food.

The **palate** which forms the roof of the oral cavity consists of the bony hard palate and the soft palate posteriorly. The **hard palate** is formed by the palatine processes of the maxillae and the horizontal plates of the palatine bones. It is covered by a mucous membrane. Transverse palatine folds or **palatal rugae** are located along the mucous membrane of the hard palate. These serve as friction ridges against which the tongue is placed during swallowing. The **soft palate** is a muscular arch covered by mucous membrane and is continuous with the hard palate anteriorly. Suspended from the middle lower border is a projection called the **palatine uvula**. During swallowing the soft palate and the uvula are drawn upward to form a seal and close the nasopharynx. This prevents food from entering the nasal cavity. There are 2 muscular folds that extend down the sides of the base of the palatine uvula. The anterior fold is called the **glossopalatine arch** and the posterior fold is the **pharyngopalatine arch**. Between these is the **palatine tonsil**.
**Tongue**

The tongue functions to move food around during mastication and in swallowing. It is also essential for speech. It is a skeletal muscle covered by mucous membrane. Extrinsic muscles move the tongue from side to side and in and out. The posterior third of the tongue lies in the pharynx and is attached to the hyoid bone. The inferior surface of the tongue is connected along the midline to the floor of the mouth by the **lingual frenulum**. The surface of the tongue is covered by small elevations called **papillae**. This gives the tongue a rough surface that aids in manipulating food. Different areas of the tongue have sensory taste receptors (taste buds) that are sensitive to four different tastes. These are sweet (tip of tongue), sour (sides of tongue), bitter (back of tongue) and salty (over most of the tongue but more on the sides). Innervation of the tongue comes from 5 cranial nerves. The sense of taste is transmitted by two cranial nerves, the glossopharyngeal nerves and the facial nerves. Taste sensations are transmitted to the medulla oblongata and thalamus and then to the parietal lobes where the information is interpreted. Taste and smell as chemoreceptors are closely related and if one sense is blocked the other will be affected.

**Teeth**

Humans and other mammals have **heterodont dentition**. This means that the teeth are varied to handle different types of food. We have in the most anterior position 4 pairs of incisors- chisel shaped teeth for cutting and shearing food. To each side we have two pairs of cuspid (canine) teeth for holding and tearing. Behind these we have premolars (bicuspids) and molars which are for grinding and crushing food. Humans are **diphyodont**; that is we have two sets of teeth in a lifetime. Twenty deciduous (milk) teeth erupt beginning at 6 months and ending around 2.5 years. Thirty two permanent teeth begin to erupt at around 6 years and continue until around 17. The third molars (wisdom teeth
are the last to emerge. Because the human jaw has been getting smaller overall many people have to have these teeth removed because they become impacted or emerge only partially. The dental cusps of the upper and lower premolars and molars occlude for chewing food. The upper incisors normally form an overbite with the incisors of the lower jaw. Masticated food is mixed with saliva containing digestive enzymes. This initiates the digestive process.

The tooth consists of an exposed crown supported by a neck and anchored firmly in the jaw by a root. The roots of the teeth fit into sockets (dental alveoli) in the alveolar processes of the mandible and maxilla. Each socket is lined with a connective tissue periosteum, the periodontal membrane. The root of the tooth is covered by a bonelike material called cementum. Fibers in the periodontal membrane insert into the cementum to fasten the tooth in its dental alveoli. The gingiva (gum) is the mucous membrane surrounding the alveolar processes in the oral cavity.

The bulk of the tooth is composed of dentin, a substance similar to bone but harder. Covering the dentin on the outside and forming the crown is the enamel. Enamel is composed primarily of calcium phosphate and is the hardest material in the body. The center of the tooth contains the pulp cavity. The pulp cavity contains pulp which is composed of connective tissue, blood vessels, lymph vessels and nerves. The root canal, continuous with the pulp cavity opens to the connective tissue surrounding the root through the apical foramen. The tooth receives nourishment via the vessels traversing the apical foramen. Even though enamel is extremely hard it can be destroyed by bacterial activity (dental caries or tooth decay). These cavities must be filled because new enamel is not produced once teeth erupt. Tooth decay decreases after age 35 but gum disease becomes more of a problem. Inflammation and infection of the gums can lead to bone loss, weakening of the bone joint and loss of teeth if left untreated.
The salivary glands are accessory digestive glands that produce a secretion called saliva. Saliva functions as a solvent in cleansing teeth and dissolving food molecules so they can be tasted. Saliva also contains starch dissolving enzymes (amylase) and lubricating mucous which aids in swallowing. Saliva is secreted continuously in small amounts to keep the mouth moist. The amount secreted daily is around 1-1.5 liters (about a quart and a half). There are small salivary glands in the mucous membranes of the palatal region of the oral cavity. The primary production of saliva takes place outside the oral cavity and are transported to the mouth by the salivary ducts. The three major pairs of extrinsic salivary glands are the parotid, submandibular and sublingual glands. The parotid gland is positioned between the ear and the masseter muscle. Saliva produced in this gland drains through the parotid duct. It is the parotid gland that becomes swollen and infected with mumps. The submandibular gland lies inferior to the body of the mandible, midway along the inner side of the jaw. Saliva produced here empties through the submandibular duct into the floor of the mouth on the lateral side of the lingual frenulum. The sublingual gland lies under the mucous membrane of the floor of the mouth. This gland has several small submandibular ducts that empty into the floor of the mouth in an area posterior to the papilla of the submandibular duct.

Two types of secretory cells, serous and mucous, are found in all salivary glands. Serous cells produce a watery secretion containing digestive enzymes and mucous cells produce a thicker, more viscous secretion. The salivary glands are innervated by both sympathetic and parasympathetic nerves. Sympathetic stimulation causes the secretion of small amounts of viscous saliva. Parasympathetic stimulation causes the secretion of large amounts of watery saliva. This is responsible for the physiological response to smelling tasty food when you are hungry.
Pharynx

The funnel shaped pharynx is a muscular tube that contains a passageway about 5 inches long that connects the oral cavity and nasal cavity to the esophagus and larynx. The pharynx has both digestive and respiratory functions. The supporting walls are skeletal muscle and the inner lining is mucous membrane. The pharynx is divided into 3 regions: the nasopharynx, posterior to the nasal cavity; the oropharynx, posterior to the oral cavity; and the laryngopharynx, at the level of the larynx. The external circular layer of pharyngeal muscles compress the lumen of the pharynx involuntarily during swallowing. The superior constrictor muscle attaches to the bony processes of the skull and mandible and encircles the upper portion of the pharynx. The middle constrictor arises from the hyoid bone and stylohyoid ligament and encircles the middle portion of the pharynx. The inferior constrictor muscles arise from the cartilage of the larynx and encircle the lower portion of the pharynx. During breathing the lower portion of the inferior constrictor muscle is contracted to prevent air from entering the esophagus.
Esophagus

The esophagus is that part of the GI tract that connects the pharynx to the stomach. It is a collapsible tubular organ about 10 inches long originating at the larynx and lying posterior to the trachea. The esophagus lies within the mediastinum of the thorax and passes through the diaphragm just above the opening to the stomach. This opening through the diaphragm is called the esophageal hiatus. The upper third of the esophagus is made up of skeletal muscle, the middle third is a combination of skeletal and smooth muscle. The terminal portion of the esophagus is smooth muscle only. The lower esophageal sphincter is a thickening of circular muscle at the junction of the esophagus and stomach. After food or fluid pass into the stomach this constricts to prevent regurgitation into the esophagus. This occurs normally because thoracic pressure is lower than abdominal pressure. Because this sphincter is not as large or strong as other sphincters of the GI tract backflow can sometimes occur under some conditions. This is what is referred to as heartburn. The acidic stomach contents are coming up into the esophagus. During vomiting the contents of the stomach are regurgitated completely to rid the stomach of some perceived toxin or irritant. In babies, this sphincter’s function is kind of erratic leading them to spit up following a meal. Some mammals have very strong esophageal sphincters. This is the case with rats and mice; which is why they are killed easily by poisoned bait, they cannot regurgitate the poison.

The process of swallowing (deglutination) is a three part process which involves both voluntary and involuntary processes. The first stage which is voluntary involves closing the mouth and interruption of breathing. The tongue is elevated against the roof of the mouth due to contraction of the intrinsic muscles of the tongue and the myohyoid and stylohyoid muscles. The second stage is the passage of the bolus (food) through the pharynx. This is involuntary and is elicited by sensory receptors located at the opening of the oropharynx. Pressure of the tongue against the transverse palatine folds seals off the nasopharynx from the oral cavity and creates pressure that forces the bolus into the oropharynx. The soft palate and uvula are elevated to close off the nasopharynx as the bolus passes. The hyoid bone and larynx are elevated. Elevation of the larynx against the epiglottis seals off the glottis so that food or fluid are less likely to be aspirated into the trachea. Sequential constriction of the constrictor muscles moves the bolus from pharynx to esophagus. The third and final stage is involuntary as well. The bolus is moved to the stomach by means of peristalsis.

Stomach

The stomach - the most distensible part of the GI tract- is located in the upper left quadrant, immediately below the diaphragm. It is a J shaped organ that is continuous with the esophagus and empties into the duodenal portion of the small intestine inferiorly. In the stomach the food is churned mechanically with gastric secretions to form a pasty substance called chyme. Once formed it is moved to the small intestine.

The stomach is divided into four regions: the cardia, fundus, body and pylorus. The cardia is the narrow upper region immediately below the lower esophageal sphincter. The fundus is the dome shaped portion to the left of and in direct contact with the dia-
phragm. The body is the large central portion and the pylorus is the funnel shaped terminal portion. The **pyloric sphincter** is the modified circular muscle at the end of the pylorus where it joins the small intestine. *Pylorus* in Greek means gatekeeper and the pyloric sphincter acts to regulate the flow of chyme into the small intestine.

The wall of the stomach is composed of the same 4 tunics found in the other regions of the GI tract, with 2 principal modifications: an extra oblique muscle layer present in the muscularis, and the mucosa has numerous longitudinal folds called gastric folds or gastric rugae. The mucosa also has microscopic gastric pits and gastric glands.

There are 5 types of cells in the gastric glands that secrete specific products:

1. **Goblet cells** secrete protective mucous.
2. **Parietal cells** secrete hydrochloric acid
3. **Principal cells (chief cells)** secrete pepsinog, an inactive form of the protein digesting enzyme pepsin.
4. **Argentaffin cells** secrete serotonin, histamine and autocrine regulators
5. **Endocrine cells (G cells)** secrete the hormone gastrin into the blood.
In addition to these products the gastric mucosa secretes intrinsic factor, required for the absorption of vitamin b12 in the small intestine.

Regulation of gastric activity is autonomic. Parasympathetic impulses promote gastric activity.

Vomiting is a reflexive protective response where the stomach contents are emptied via the esophagus, pharynx and oral cavity. This action is controlled by the vomiting center of the medulla oblongata. Stimuli within the GI tract, especially the duodenum may activate the vomiting center. Other stimuli such as bad odors or motion sickness act upon it as well. Certain drugs called emetics can stimulate a vomiting reflex. Another related reflex is the gag reflex which can induce vomiting voluntarily. The gag reflex is a reflex contraction of the back of the throat that prevents objects from entering the throat except as part of normal swallowing. This helps prevent choking. Touching the soft palate evokes a strong gag reflex in most people, although people can train themselves to resist the gag reflex.

The mechanics of the vomiting reflex are as follows:

1. Strong sustained contractions of the upper small intestine, followed by a contraction of the pyloric sphincter;
2. Relaxation of the lower esophageal sphincter and contraction of the pyloric portion of the stomach;
3. Shallow inspiration and closure of the glottis
4. Compression of the stomach against the liver by contraction of the diaphragm and abdominal muscles.
This reflexive sequence leads to the forceful ejection of vomit. The feeling of nausea is caused by stimuli in the vomiting center and may or may not lead to vomiting.

**Small Intestine**

The **small intestine**, consisting of the **duodenum, jejunum and ileum**, is the site where digestion is completed and nutrients are absorbed. The small intestine is the portion of the GI tract between the pyloric sphincter of the stomach and the ileocecal valve that opens into the large intestine. It is positioned in the central and lower part of the abdominal cavity and is supported except for the first portion by the mesentery. The fan shaped mesentery permits movement of the small intestine but prevents it from becoming kinked or twisted. Enclosed within the mesentery are blood vessels, nerves and lymphatic vessels that supply the intestinal walls. The small intestine is about 12 feet long (3 m) in a living person but will measure twice that length in a cadaver due to relaxation of the muscular wall. It is called “small” due to its small diameter relative to the large intestine. The small intestine is the body’s major digestive organ and the main site of nutrient absorption. It contains digestive enzymes which aid in the final breakdown and absorption of food.

**Regions of the small intestine**

1. **Duodenum** is a fixed C shaped tube measuring 10 inches from the pyloric sphincter of the stomach to the duodenojejunal flexure. It receives bile secretions from the liver and gall bladder and pancreatic secretions from the pancreatic duct.

2. **Jejunum** extends from the duodenum to the ileum, is approximately 3 feet long. It has a larger lumen and more internal folds than the ileum.

3. **Ileum** (not to be confused with the ilium of the os coxae) makes up the remaining 6-7 feet of the small intestine. It empties into the cecum of the large intestine through
the ileocecal valve. Lymph nodes called mesentary patches are abundant in the walls of the ileum.

Structural modifications of the Small Intestine

Digested food are absorbed across the lining of the intestinal mucosa. Absorption occurs mainly in the jejunum, although some occurs in the duodenum and ileum also. Absorption is aided by structures that increase the surface area of the intestine.

1. **Plicae circulares** are large macroscopic folds of mucosa

2. **Villi** are finger-like macroscopic folds of the mucosa that project into the lumen

3. **Microvilli** are microscopic projections formed by the folding of epithelial cell membranes.

The villi have specialized goblet cells which secrete mucous. Additionally, the center of the villi contain capillaries and lymphatic vessels called **lacteals**. Proteins and carbohydrates are enter the capillaries and fatty acids enter the lacteals.

Muscular contractions of the Small Intestine

Contractions of the longitudinal and circular muscles of the small intestine produce 3 distinct types of movement: rhythmic segmentation, pendular movement and peristalsis.

1. **Rhythmic segmentations** are local contractions of the circular muscle layer. They occur at the rate of 12-16 per minute in regions containing chyme. Rhythmic segmentations churn the chyme with digestive juices and bring it into contact with the
mucosa. During these contractions, the vigorous motion of the villi stirs the chyme and facilitates absorption.

2. **Pendular movements** primarily occur in the longitudinal muscle layer. In this motion, a constrictive wave moves along a segment of the intestine and then reverses and moves in the opposite direction, moving the chyme back and forth. Pendular movements also mix the chyme but do not seem to have a particular frequency.

3. **Peristalsis** is responsible for the propulsion of chyme through the small intestine. These wave-like contractions are weak and relatively short, occurring at a frequency of about 15-18 per minute. Chyme requires about 3-10 hours to travel the length of the small intestine. Both muscle layers are involved in peristalsis.

**Large Intestine**

The large intestine receives food that is undigested or undigestible from the small intestine, absorbs the water and electrolytes from the chyme and passes it as feces out of the GI tract. The large intestine measures about 5 feet in length and 2.5 inches in diameter. The large intestine begins at the end of the ileum in the lower right quadrant of the abdomen. From there it leads superiorly on the right side to a point just below the liver; it then crosses to the left, descends into the pelvis and terminates at the anus. A specialized portion of the **mesentary**, the **mesocolon** supports the transverse portion of the large intestine along the posterior abdominal wall.

The large intestine has little or no digestive function. It absorbs water and electrolytes from the remaining chyme. It also functions to form, store and expel feces from the body.

The large intestine is divided into the **cecum, colon rectum and anal canal**. The cecum is a dilated pouch positioned slightly below the ileocecal valve. The ileocecal valve is a fold of mucous membrane at the junction of the small and large intestine that prevents back flow of chyme. A finger like projection of the cecum called the **appendix** is attached to the inferior margin of the cecum. It contains an abundance of lymphatic tissue but it serves no discernible function. It is thought to be a vestigial remnant of an organ that was functional in our ancestors. Because it is a blind pouch and waste material can accumulate within, inflammation and infection can occur. If not treated, rupture will lead to further infection of the peritoneal cavity, resulting in peritonitis.
The superior portion of the cecum is continuous with the colon, which consists of the ascending, transverse, descending and sigmoid portions. The ascending portion extends superiorly from the cecum along the right abdominal wall to the inferior surface of the liver. The point where the colon bends here is called the hepatic flexure. From this bend it becomes the transverse colon until it reaches another right angle bend on the left side called the splenic flexure. From this point it becomes the descending colon as it tranverses inferiorly on the left. At the bottom of the descending colon it angles again in an S shaped bend known as the sigmoid colon. The end of the line, the last 7.5 inches of the tract is the rectum. The final inch (2-3 cm) is the anal canal. The anus is the external opening of the anal canal. Two sphincter muscles are found in this opening: the internal anal sphincter which is smooth muscle and the external anal sphincter which is skeletal muscle.

Mechanical Action of the Large Intestine

Three types of movements occur throughout the large intestine: peristalsis, haustral churning and mass movement. In Haustral churning, the relaxed haustrum fills with food residue until a point of distension is reached that stimulates contraction of the muscle. This movement churns the food residue and exposes it to the mucosa where the water and electrolytes are absorbed. As this happens food residue becomes solid or semisolid and becomes feces. Mass movement is a strong peristaltic wave which moves the feces towards the rectum. Mass movement occurs only 2-3 times a day, generally after a meal. In infants this response to eating is called the gastrocolic reflex and results in a bowel movement during or shortly after eating.
The defecation reflex normally occurs when rectal pressure rises to a particular level that is determined by individual habit. At this point the internal anal sphincter relaxes to admit feces into the anal canal. During defecation, the longitudinal rectal muscles contract to increase rectal pressure and the internal and external anal sphincters relax. This process is aided by contraction of the abdominal muscles which raise intra-abdominal pressure and help push the feces through the anal canal and out the anus.

Liver

The liver which consists of 4 lobes, processes nutrients and secretes bile, which is stored and concentrated in the gall bladder prior to discharge into the duodenum. The liver is the largest internal organ, weighing about 3.5-4 lbs in an adult. It is positioned beneath the diaphragm. It is reddish brown due to its great vascularity. It has 4 lobes and 2 supporting ligaments. Anteriorly the right lobe is separated from the left lobe by the falciform ligament. Inferiorly the caudate lobe is positioned near the vena cava and the quadrate lobe is adjacent to the gall bladder. The ligamentum teres (round ligament) extends from the falciform ligament to the umbilicus. This ligament is the remnant of the umbilical vein of the fetus. The liver cells, hepatocytes form hepatic plates that are separated by large capillary spaces called liver sinusoids. This allows the liver cells to be in direct contact with blood.

The functions of the liver are numerous. This includes synthesis, storage and release of vitamins; synthesis, storage and release of glycogen and blood proteins, breakdown (phagocytosis) of old red blood cells and bacteria, removal of toxic substances from the blood and production of bile which helps breakdown fats. Bile is produced by the hepatocytes and drains into the bile ducts which in turn drain into the hepatic ducts that carry the bile away from the liver.
The gall bladder is a sac like organ attached to the inferior portion of the liver. This organ stores and concentrates bile which is necessary to breakdown, emulsify and absorb ingested fats. A sphincter valve at the neck of the gall bladder controls the storage of bile. Contraction of the muscularis ejects bile from the gall bladder. Bile is continuously produced by the liver and drains through the hepatic ducts and common bile duct to the duodenum. When the small intestine is empty the sphincter of ampulla constricts and forces the bile up the cystic duct to the gall bladder for storage. Gall stones occur when cholesterol precipitates out of bile and forms solid crystals. Sometimes this leads to blockage of the bile duct and surgery is required to remove the gall stones.
Pancreas

The pancreas functions as a mixed gland in that it has both endocrine and exocrine functions. The endocrine function occurs at the pancreatic islets (islets of Langerhans). The islet cells secrete the hormones insulin and glucagon into the blood. As an exocrine gland the pancreas secretes pancreatic juice through the pancreatic duct which empties into the duodenum. The pancreas is positioned horizontally along the posterior abdominal wall, adjacent to the greater curvature of the stomach. It consists of a head near the duodenum; a body in the center and a tail, positioned near the spleen. All but a portion of the head is retroperitoneal. Within the lobules of the pancreas are the exocrine secretory units called pancreatic acini and the endocrine secretory units called pancreatic islet cells. The glandular portion of the pancreas receives parasympathetic innervation. The pancreatic blood vessels have sympathetic innervation.