Digestive System (peer reviewed and edited)

Slide 1: Digestive System

Slide 2: Functions of the Digestive System

The digestive system functions in ingestion, digestion, absorption, compaction, and defecation. Ingestion or eating is the intake of food. Digestion is the breakdown of food. Digestion can occur through two methods: mechanical and chemical digestion. Mechanical digestion is the physical break down of food such as chewing, grinding, churning, etc. Chemical digestion uses digestive chemicals such as enzymes to break down the food. Absorption is the uptake of nutrients into the body. Compaction involves absorbing water and consolidating the indigestible residue into feces. Defecation refers to the removal of remaining substances that cannot be digested, in other words feces.

Slide 3: Alimentary canal (image)

The digestive tract (alimentary canal) is a tube that moves through the mouth, esophagus, stomach, small intestines, and large intestines. Food moves through the space (lumen) of this tube. There are four basic layers: mucosa, submucosa, muscularis, and serosa.

Let's begin with the mucosa. The **mucosa** is the inner layer which consists of epithelium and connective tissue. This layer functions in secretion and absorption. The **submucosa** layer is made of connective tissue and contains blood vessels, glands, and nerves. This layer functions in support of other layers. The **muscularis** layer is made up of muscle. In the mouth and upper esophagus this layer is made up of skeletal muscle. Beginning in the lower esophagus and throughout the remaining digestive tract, it is made up of smooth muscle. Along most of the digestive tract, it consists of two layers of muscle. The inner muscle layer contains muscle fibers that run around the lumen, where the outer muscle layer runs longitudinally to the lumen. This layer is responsible for moving the food through the digestive tract and mechanical digestion. The outer most layer is called the **serosa**, it acts as a covering and is made of epithelium and connective tissue.

Variations of these layers can be found, depending on the specific organ along the digestive tract.

The accessory organs aid in digestion, usually by producing enzymes or some form of mechanical digestion. They include the teeth, tongue, salivary glands, liver, gall bladder, and pancreas.

Slide 4: Mouth

The mouth is also known as the oral cavity. It functions in ingestion, digestion (both chemical and mechanical), swallowing, speech, and respiration. The mucosa is layered with stratified squamous epithelium.

The tongue is an accessory organ in the mouth made of skeletal muscle. It manipulates food, is vital in speech production, and initiates the swallowing reflex. On it you will find the lingual papillae, various

bumps and projections that are also known as taste buds. The lingual frenulum is a bit of connective tissue that attaches the tongue to the floor of the mouth.

The palate forms the roof of the mouth. The hard palate is the anterior portion that is formed by the maxilla and palatine bone. The soft palate is the posterior portion that is made of skeletal muscle and glandular tissue. Extending from the soft palate is the uvula which functions in keeping food in the oral cavity by closing off the nasal pharynx when swallowing.

Salivary glands are found throughout and around the mouth. There are three: parotid glands (lateral side of mandible, near TMJ joint, over masseter muscle), sublingual glands (under the tongue), and submandibular glands (lateral side of jaw, along the mandible). These salivary glands produce saliva, a fluid substance that starts the chemical digestion of carbohydrates with salivary amylase. Saliva also contains water and mucus to bind and lubricate food.

Slide 5: Mouth

Teeth are responsible for the mechanical breakdown of food in the mouth known as mastication. We have 2 sets, deciduous (juvenile or baby teeth) and permanent (adult teeth). There are three parts to the tooth. The crown is the exposed part of the tooth. The root is the portion below the gum line and the neck is the portion where the crown and root meet. The tooth is composed of three main substances: dentin, enamel, and cementum. Dentin is a hard-yellowish tissue that makes up most of the internal tooth and lines the root canal pulp cavity. Enamel covers the exposed portion of the tooth such as the crown and neck. Cementum covers the root. Cementum and dentin are living tissue and can regenerate through one's life. Once a tooth erupts, enamel cannot be replaced

Slide 6: Pharynx and Esophagus

The pharynx has already been covered in the respiratory system. It also plays a role in the digestive tract, particularly the oropharynx and laryngopharynx. These two parts move the bolus (mixture of saliva and broken up food) to the esophagus.

The esophagus is a straight muscular tube that transports the bolus from the pharynx to the stomach. It starts out as skeletal muscle then transitions into smooth muscle tissue. The wavelike smooth muscle contraction to move the bolus is referred to as peristalsis. The esophageal sphincter is a structure that prevents food from coming back up and destroying the delicate mucosa of the esophagus.

Slide 7: Stomach

The stomach is a muscular sac in the upper left of the abdominal cavity. It functions in storage and digestion of chyme, a mass of partially digested food. The stomach is divided into four regions: cardiac, fundic, body, and pyloric. The pyloric region is separated from the small intestine by the pyloric sphinter, which regulates the passage of chyme.

The stomach has the same lining as the rest of the digestive tract with a few differences. One difference is in the muscularis layer. There are three different layers that form the muscularis of the stomach: Longitudinal, Circular, and an additional layer – the Oblique. These three layers allow for multidimensional contraction and aids with mixing of gastric products and mechanical digestion.

Another difference is that the stomach has rugae. Rugae are wrinkles in the mucosa and submucosa when the stomach is empty. As we eat and the stomach fills, this allows for expansion of the stomach.

The third difference is within the mucosa layer. This will be discussed in the next slide.

Slide 8: Stomach

The histology of the mucosa has a number of structures and cells specific to the stomach. The mucosa of the stomach contains gastric pits, which are depressions in the mucosa lined with columnar epithelium. This epithelium consist of mucous cells, parietal cells, and chief cells. The mucous cells are the most abundant and they secrete mucus. The parietal cells secrete hydrochloric acid (HCL) and intrinsic factor. Intrinsic factor is essential in the absorption of vitamin B12. Without vitamin B12, a person would not be able to make hemoglobin. HCL activates enzymes in the stomach such as lingual lipase and pepsinogen. Chief cells secrete pepsinogen (which is an inactive form of pepsin) and gastric lipase. Pepsinogen is activated by HCl acid and converted to pepsin. In terms of chemical digestion: Pepsin breaks down proteins. Gastric lipase and lingual lipase break down fats.

Collectively, these cells are referred to as gastric glands.

Slide 9: Pancreas

The pancreas is an accessory organ of the digestive system. It is a spongy gland that functions in both the exocrine (acinar cells) and endocrine (islet cells). The pancreas is able to transport pancreatic juice into the small intestine through the pancreatic duct. The pancreatic duct will converge with the common bile duct to join with the small intestine.

The pancreatic juices is made up of a mixture of water, enzymes, electrolytes, and sodium bicarbonate. The enzymes include: pancreatic amylase, trypsin, chymotrypsin, carboxypeptidase, and pancreatic lipase. Pancreatic amylase continues the digestion of carbohydrates. Trypsin, chymotrypsin and carboxypeptidase breakdown proteins. Pancreatic lipase breaks down lipids.

The sodium bicarbonate is an alkaline substance that is secreted into the small intestine to neutralize the HCL acid coming from the stomach.

Slide 10: Liver and Gallbladder

The liver is located in the upper right side of the abdomen. It is divided into four lobes: right, left, quadrate, and caudate. The liver is made of hepatocytes that are cuboidal cells that form sheets to create layers within the liver. It functions in bile production, toxin removal, storage of glycogen and vitamins, and conversion of organic compounds into usable forms. Bile is a yellow-green liquid of bile salts,

bilirubin, water, and cholesterol. The bile salts (bile acids) are steroids that are synthesized from cholesterol and function in emulsifying and absorbing fats. Bilirubin is a pigment that is derived from the decomposition of hemoglobin. Bile also contains cholesterol as a method to eliminate it from the body.

The gallbladder is located on the underside of the liver. It is a small, greenish sac that functions in storing and concentrating bile. The bile leaves the liver through the hepatic duct then fills the bile duct until it overflows into the gallbladder through the cystic duct. The bile duct joins with the pancreatic duct to transport the bile and pancreatic enzymes into the small intestine (duodenum).

Slide 11: Small Intestines

The small intestine is made of 3 segments: duodenum, jejunum, and ileum. The duodenum is the first segment and begins after the pyloric sphincter of the stomach. The chyme is passed from the stomach to the duodenum through the pyloric sphincter. The duodenum functions in chemical digestion and absorption. The chemical digestion occurs due to the pancreatic secretions and bile that are transported into the duodenum. Following the duodenum is the jejunum. This is the the middle segment of the small intestine. Final digestion occurs here as well as continued absorption. The final segment is the ileum. The ileum is thinner and less muscular than the jejunum. Absorption occurs here and this is the primary site where water is absorbed. The ileum is connected to the large intestine by the ileocecal valve. This valve regulates the passage of feces into the large intestine.

Slide 12: Small Intestine

The histological differences in the small intestine include: circular folds, villi, and intestinal crypts.

Circular folds are the largest folds in the intestinal wall, they are found in the mucosa and submucosa. They run the entire length of the small intestine from the duodenum to the ileum, actting like speed bumps that causes the chyme to move more slowly and spiral down the small intestine. This action slows progression so the chyme can mix with the pancreatic enzymes and bile.

The villi are projections of the mucosa and submucosa. The villi are made of simple columnar epithelium and is where final digestion and absorption occurs. The columnar cells contain microvilli, plasma membrane extensions that form the brush border. The brush border increases surface area to aid in contact digestion. They also contain enzymes that allow for digestion such as peptidase, lactase, maltase, and sucrase. Peptidase break down the remaining peptides into amino acids. Lactase, maltase, and sucrase breaks disaccharides into monosaccharides. The epithelium also contains goblet cells that secret mucous.

Inside the villi you will find capillaries and lacteals. A lacteal is a lymphatic vessel that absorbs the majority of fat from the columnar cells, where the remaining nutrients are absorbed into the capillaries.

The intestinal crypts are pores between the villi on the floor of the small intestine. Within the crypts are paneth cells which release enzymes that have an antibacterial function to destroy invading bacteria in the small intestine.

Slide 13: Chemical Digestion and Absorption

Figure 25.31 in your textbook does a wonderful job of following the main types of organic compounds through the digestive tract.

Polysaccharides such as starches begin digestion in the mouth due to salivary amylase. The starches are broken down into disaccharides. In the small intestine the pancreatic amylase further breaks down the polysaccharides into disaccharides. The disaccharides go through final breakdown through contact digestion with the brush borders of the microvilli. The disaccharides are broken down into monosaccharides which are absorbed into the capillaries.

Protein begins digestion in the stomach due to the pepsin. The protein are broken down into small chains of peptides that move to the small intestine. In the small intestine, the trypsin, chymotrypsin, and carboxypeptidase breaks down the chains of peptides into dipeptides. The dipeptides go through contact digestion with the brush borders of the microvilli and are broken down into amino acids which are absorbed into the capillaries

Fats begin digestion in the stomach due to the lingual and gastric lipase. The fats continue to move into small intestine where they are emulsified by bile salts. Pancreatic lipase breakdown triglycerides into monoglycerides and fatty acids. These digested lipids are bundled and transported in the form of micelles into the lacteals.

Water is absorbed into the capillaries.

Slide 14: Large Intestine

The large intestine is structurally broken into different segments: cecum, colon, rectum, and anus.

The cecum is a small pouch at the beginning of the large intestine. It attaches to the appendix and iliocecal valve/junction (which regulates the passage of chyme from the small to large intestine). The appendix contains lymphocytes, immune cells, and some bacteria. The next section is the colon. The colon has 4 parts: the Ascending, Transverse, Descending, and Sigmoid colon. The rectum starts where the colon straightens back out again, after the sigmoid colon. The anus is the final segment of large intestine and is the external opening. It is also referred to as the anal canal. The anus has both external and internal sphincters.

Haustra can be found throughout the cecum and colon. They are small pouches throughout the wall of colon. The tenia coli are longitudinal fibers, a ribbon-like structure that runs the entire length of the colon. They contract the colon lengthwise and help form the haustra.

The large intestines are lined with simple columnar epithelium, except in the last half of the anal canal where it becomes stratified squamous.

No chemical or mechanical digestion occurs here, but there is absorption of water and electrolytes. Additionally, there is fermentation by bacteria. As a by-product, flatus, or gas, is produced by bacteria. They help digest food that we are unable to breakdown and provide us with some additional nutrients, like vitamin K.

Slide 15: Defecation

The large intestine has a mass peristalsis a few times a day. Defecation is the release of indigestible food from the body. A spinal reflex controls the process of defecation. Stretch receptors sense the presence of the feces in the colon and send a message to the spinal cord. The spinal cord responds by contracting the rectum and relaxing the internal anal sphincter. An impulse from the brain allow us to have some voluntary control over this reflex by keeping the external anal sphincter contracted. This allows us to defecate at the appropriate time by relaxing the external anal sphincter.