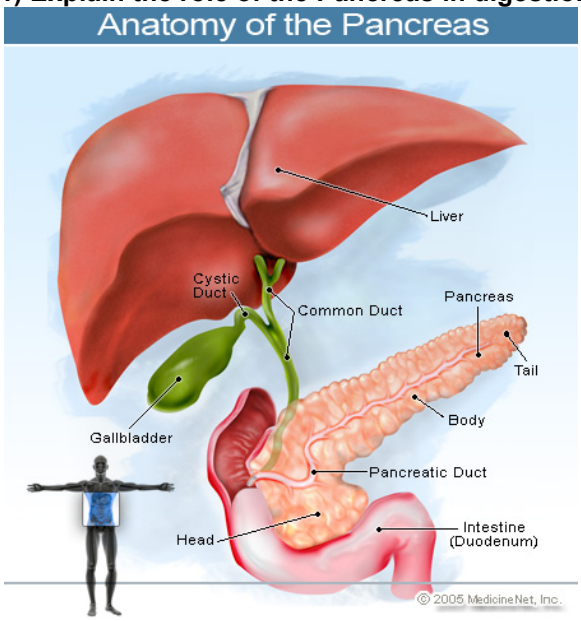
LESSON 2-ASSIGNMENT

1) Explain the role of the Pancreas in digestion.



As chyme floods into the small intestine from the stomach, two things must happen:

- *Acid must be quickly and efficiently neutralized* to prevent damage to the duodenal mucosa
- *Macromolecular nutrients - proteins, fats and starch - must be broken down much further* before their constituents can be absorbed through the mucosa into blood

The pancreas plays a vital role in accomplishing both of these objectives; so vital in fact that insufficient exocrine secretion by the pancreas leads to starvation, even if the animal is consuming adequate quantities of high quality food.

In addition to its role as an exocrine organ, the *pancreas is also an endocrine organ* and the major hormones it secretes –insulin and glucagon - play a vital role in carbohydrate and lipid metabolism. They are, for example, absolutely necessary for maintaining normal blood concentrations of glucose.

Pancreatic juice is composed of two secretory products critical to proper digestion: digestive enzymes and bicarbonate. The enzymes are synthesized and secreted from the exocrine acinar cells, whereas bicarbonate is secreted from the epithelial cells lining small pancreatic ducts.

Digestive Enzymes

The pancreas secretes a magnificent battery of enzymes that collectively have the capacity to reduce virtually all-digestible macromolecules into forms that are capable of, or nearly capable of being absorbed. Three major groups of enzymes are critical to efficient digestion:

1. Proteases

Digestion of proteins is initiated by pepsin in the stomach, but the bulk of protein digestion is due to the pancreatic proteases. Several proteases are synthesized in the pancreas and secreted into the lumen of the small intestine. The two major pancreatic proteases are **trypsin** and **chymotrypsin**, which are synthesized and packaged into secretory vesicles as and the inactive proenzymes trypsinogen and chymotrypsinogen.

As you might anticipate, proteases are rather dangerous enzymes to have in cells, and packaging of an inactive precursor is a way for the cells to safely handle these enzymes. The secretory vesicles also contain a trypsin inhibitor which serves as an additional safeguard should some of the trypsinogen be activated to trypsin; following exocytosis this inhibitor is diluted out and becomes ineffective - the pin is out of the grenade.

Once trypsinogen and chymotrypsinogen are released into the lumen of the small intestine, they must be converted into their active forms in order to digest proteins. Trypsinogen is activated by the enzyme **enterokinase**, which is embedded in the intestinal mucosa.

Once trypsin is formed it activates chymotrypsinogen, as well as additional molecules of trypsinogen. The net result is a rather explosive appearance of active protease once the pancreatic secretions reach the small intestine.

Trypsin and chymotrypsin digest proteins into peptides and peptides into smaller peptides, but they cannot digest proteins and peptides to single amino acids. Some of the other proteases from the pancreas, for instance carboxypeptidase, have that ability, but the final digestion of peptides into amino acids is largely the effect of peptidases on the surface of small intestinal epithelial cells.

2. Pancreatic Lipase

A major component of dietary fat is triglyceride, or neutral lipid. A triglyceride molecule cannot be directly absorbed across the intestinal mucosa. Rather, it must first be digested into 2-monoglyceride and two free fatty acids. The enzyme that performs this hydrolysis is pancreatic lipase, which is delivered into the lumen of the gut as a constituent of pancreatic juice. Sufficient quantities of bile salts must also be present in the lumen of the intestine in order for lipase to efficiently digest dietary triglyceride and for the resulting fatty acids and monoglyceride to be absorbed. This means that normal digestion and absorption of dietary fat is critically dependent on secretions from both the pancreas and liver.

3. Amylase

The major dietary carbohydrate for many species is starch, a storage form of glucose in plants. Amylase (technically alpha-amylase) is the enzyme that hydrolyses starch to maltose (a glucose-glucose disaccharide), as well as the trisaccharide maltotriose and small branchpoints fragments called limit dextrins. The major source of amylase in all species is pancreatic secretions, although amylase is also present in saliva of some animals, including humans.

Other Pancreatic Enzymes

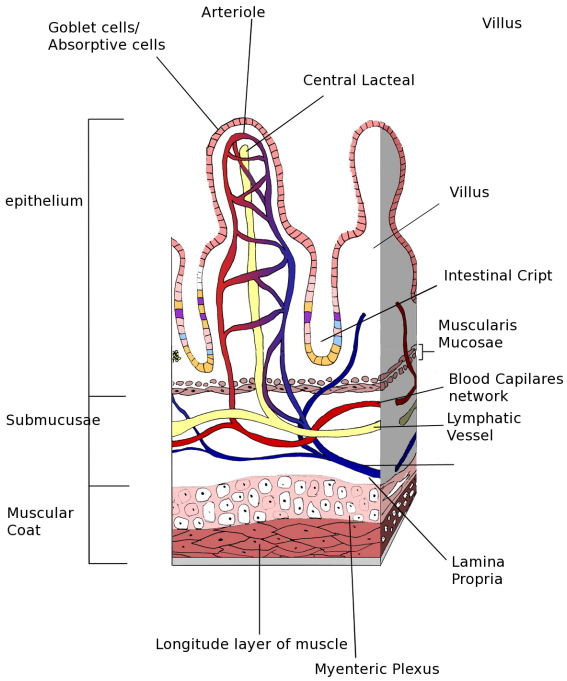
In addition to the proteases, lipase and amylase, the pancreas produces a host of other digestive enzymes, including

ribonuclease, deoxyribonuclease, gelatinase and elastase.

Bicarbonate and Water

Epithelial cells in pancreatic ducts are the source of the bicarbonate and water secreted by the pancreas. Bicarbonate is a base and critical to neutralizing the acid coming into the small intestine from the stomach. The mechanism underlying bicarbonate secretion is essentially the same as for acid secretion parietal cells and is dependent on the enzyme carbonic anhydrase. In pancreatic duct cells, the bicarbonate is secreted into the lumen of the duct and hence into pancreatic juice.

2) Label the diagram titled "The Lining of the Small Intestine".



3) Select four parts of digestive system from the list below and describe their role in digestion.

Salivary Glands: Saliva is produced in and secreted from salivary glands. The basic secretory units of salivary glands are clusters of cells called acini. These cells secrete a fluid that contains water, electrolytes, mucus and enzymes, all of which flow out of the acinus into collecting ducts. Within the ducts, the composition of the secretion is altered. Much of the sodium is actively reabsorbed, potassium is secreted, and large quantities of bicarbonate ion are secreted Small collecting ducts within salivary glands lead into larger ducts, eventually forming a single large duct that empties into the oral cavity.

We have three major pairs of salivary glands that differ in the type of secretion they produce:

- **Parotid glands** produce a serous, watery secretion ;
- **Sub maxillary (mandibular) glands** produce a mixed serous and mucous secretion;
- **Sublingual glands** secrete saliva that is predominantly mucous in character.

Two basic types of acinar epithelial cells exist:

- **Serous cells**, which secrete a watery fluid, essentially devoid of mucus;
- **Mucous cells**, which produce a very mucus-rich secretion;

Acini in the parotid glands are almost exclusively of the serous type, while those in the sublingual glands are predominantly mucous cells. In the sub maxillary glands, it is common to observe acini composed of both serous and mucous epithelial cells. Secretion of saliva is under control of the autonomic nervous system, which controls both the volume and type of saliva secreted. This is actually fairly interesting: a dog fed dry dog food produces saliva that is predominantly serous, while dogs on a meat diet secrete saliva with much more mucus. Potent stimuli for increased salivation include the presence of food or irritating substances in the mouth, and thoughts of or the smell of food. Knowing that salivation is controlled by the brain will also help explain why many psychic stimuli also induce excessive salivation - for example, why some dogs salivate all over the house when it's thundering.

Functions of Saliva:

- **Lubrication and binding**: the mucus in saliva is extremely effective in binding masticated food into a slippery bolus that (usually) slides easily through the esophagus without inflicting damage to the mucosa. Saliva also coats the oral cavity and esophagus, and food basically never directly touches the epithelial cells of those tissues.
- **Solubilizes dry food**: in order to be tasted, the molecules in food must be solubilized.
- **Oral hygiene**: The oral cavity is almost constantly flushed with saliva, which floats away food debris and keeps the mouth relatively clean. Flow of saliva diminishes considerably during sleep, allow populations of bacteria to build up in the mouth -- the result is *dragon breath* in the morning. Saliva also contains lysozyme, an enzyme that lyses many bacteria and prevents overgrowth of oral microbial populations;
- **Initiates starch digestion**: in most species, the serous acinar cells secrete an alpha-amylase which can begin to digest dietary starch into maltose;
- **Provides alkaline buffering and fluid**;
- **Evaporative cooling**: clearly of importance in dogs, which have very poorly developed sweat glands - look at a dog panting after a long run and this function will be clear.

Liver: The liver is the largest glandular organ of the body. It weighs about 3 lb (1.36 kg). It is reddish brown in color and is divided into four lobes of unequal size and shape. The liver lies on the right side of the abdominal cavity beneath the diaphragm. Blood is carried to the liver via two large vessels called the hepatic artery and the portal vein. The hepatic artery carries oxygen-rich blood from the aorta (a major vessel in the heart). The portal vein carries blood containing digested food from the small intestine. These blood vessels subdivide in the liver repeatedly, terminating in very small capillaries. Each capillary leads to a lobule. Liver tissue is composed of thousands of lobules, and each lobule is made up of hepatic cells, the basic metabolic cells of the liver.

Functions of Liver:

- To produce substances that break down fats, convert glucose to glycogen
- Produce urea (the main substance of urine);
- Make certain amino acids (the building blocks of proteins);
- Filter harmful substances from the blood (such as alcohol);
- Storage of vitamins and minerals (vitamins A, D, K and B12);
- Maintain a proper level or glucose in the blood. The liver is also responsible for producing cholesterol. It produces about 80% of the cholesterol in your body.

Stomach: The stomach is an organ of digestion. It has a saclike shape and is located between the esophagus and the intestines. The human stomach is a muscular, elastic, pear-shaped bag, lying crosswise in the abdominal cavity beneath the diaphragm. It changes size and shape according to is position of the body and the amount of food inside. The stomach is about 12 inches (30.5 cm) long and is 6 inches (15.2 cm) wide at its widest point. The stomach's capacity is about 1 qt (0.94 liters) in an adult. Food enters the stomach from the esophagus. The connection between the stomach and the esophagus is called the cardiac sphincter. The cardiac sphincter prevents food from passing back to the esophagus. “Heart burn” is the sensation when stomach juices (gastric juice) are allowed to seep through the sphincter into the esophagus. Once the food enters the stomach, gastric juices are used to break down the food. Some substances are absorbed muscle lining of the stomach. One of the substances the stomach absorbs is alcohol.

The other end of the stomach empties into the duodenum. The duodenum is the first section of the small intestine. The pyloric sphincter separates the stomach from the duodenum.

The stomach is composed of five layers. Starting from the inside and working our way out, the innermost layer is called the mucosa. Stomach acid and digestive juices are made in the mucosa layer. The next layer is called the sub mucosa. The submucosa is surrounded by the muscularis, a layer of muscle that moves and mixes the stomach contents. The next two layers, the subserosa and the serosa are the wrapping for the stomach. The serosa is the outermost layer of the stomach.

Functions of Stomach:

- Storing the food we eat:
- Breaking down the food into a liquidly mixture called chyme:
- Mixing enzymes which is are chemicals that break down food:
- Slowly empties that liquidly mixture into the small intestine.

Gall Bladder: The gallbladder is a small pear-shaped organ that stores and concentrates bile. The gallbladder is connected to the liver by the hepatic duct. It is approximately 3 to 4 inches (7.6 to 10.2 cm) long and about 1 inch (2.5 cm) wide.

Function of Gall Bladder: is to store bile and concentrate. Bile is a digestive liquid continually secreted by the liver. The bile emulsifies fats and neutralizes acids in partly digested food. A muscular valve in the common bile duct opens, and the bile flows from the gallbladder into the cystic duct, along the common bile duct, and into the duodenum (part of the small intestine).

4) Rank these digestive tract layers from 1-4 on their closeness to digested food and give 2-3 sentences explanation of their function:

1) Mucosa is the innermost layer of the gastrointestinal wall that is surrounding the lumen, or open space within the tube. This layer comes in direct contact with food called bolus, and is responsible for absorption, digestion and secretion, which are the important processes in digestion. The mucosa is made up of three layers: mucous epithelium - an inner layer, lamina propria - a layer of connective tissue and muscularis mucosae - a thin layer of smooth muscle.

2) Submucosa: In the gastrointestinal tract, the `submucosa` is the layer of loose connective tissue that supports the mucosa, as well as joins the mucosa to the bulk of underlying smooth muscle (fibers running circularly within layer of longitudinal muscle).

3) Muscularis: is the thin layer of smooth muscle found in most parts of the gastrointestinal tract, located outside the lamina propria and separating it from the submucosa.

4) Serosa: is the outmost layer of the colon and The is also called the adventitia and its main purpose is to make sure your colon stays put while you move around.