Digestive glands

Digestive glands include the major salivary glands, pancreas and liver.

Major salivary glands

In oral cavity except numerous minor salivary glands there are 3 pairs of major salivary glands: the parotid, submandibular (submaxillary) and sublingual glands.

The major salivary glands are paired exsocrine glands, whose ducts empty into the oral cavity to release saliva. Saliva has many functions, some of which are related to digestion.

The major salivary glands have similar organization. Their stromal component is represented by connective tissue capsule, surrounding gland outside and loose connective tissue trabeculae extending from capsule into parenchyma of organ to divide it into lobules. Parenchyma of major salivary glands is represented by epithelium, which is developed from the oral epithelium (ectodermal origin).

The major salivary glands are compound branched tubulo-alveolar or alveolar glands. They consist of secretory portions and ducts.

The duct system of major salivary glands includes:

I. Intralobular ducts:
   1) intercalated duct lining with a simple short cuboidal epithelium and outer dispose myoepithelial cells;
   2) striated duct – lining with a simple columnar epithelium and outer dispose myoepithelial cells.

II. Interlobular (excretory) ducts:
   3) small - lining with a pseudostratified epithelium;
   4) large - lining with a stratified cuboidal or columnar epithelium.

III. Main duct lining with a nonkeratinized stratified squamous epithelium.

Intercalated ducts are the smallest intralobular ducts lead from the secretory portions called acini and open into striated ducts.

Striated ducts are so called because columnar cells lining these ducts show the basal striations on their basal plasma membrane. The basal striations are deep infoldings of the epithelial cells plasma membrane, associating with elongate mitochondria. This

morphologic feature is evidence of cells activity to the reabsorption of fluid and electrolytes. The cells lining striated ducts reabsorb sodium and secrete potassium. Therefore, they regulate the water and electrolyte content of saliva to make it hypotonic.

Interlobular or excretory ducts are located in loose connective tissue trabeculae between lobules of salivary glands.

Main duct empties into the oral cavity to release here saliva.

Secretory acini of salivary glands

Secretory cells of the salivary glands are arranged into the secretory portions called acini. Secretory acini are organized into lobules.

In salivary glands three types of acini are described:

1) Serous acini, which contain only serous (protein secreting) cells and are generally spherical;
2) Mucous acini, which contain only mucous (mucin secreting) cells and are usually more tubular;
3) Mixed acini, which contain both serous and mucous cells.

In mixed acini, several serous cells form a cap, called a serous demilune, on the outer aspect of mucous cells.

Each acinus is surrounded by the contractile myoepithelial cells. They lie between the basal part of secretory acinar cells and the basal lamina of the epithelium. Myoepithelial cells also underlie the proximal portion of the duct system. In both locations, the myoepithelial cells provide the movement of saliva toward the excretory duct.

Structure and function of the parotid gland, submandibular and sublingual salivary glands

The paired parotid glands are the largest of the major salivary glands. They are located below and in front of the ear. The parotid gland is compound branched alveolar type. Main duct of parotid gland enter the oral cavity opposite the second upper molar tooth. The parotid glands are completely serous, because they contain only serous acini. Serous acini and intercalated and striated ducts form the lobules of parotid gland.

The submandibular glands are located under either side of the floor of the mouth,

close to the mandible. They are compound branched tubulo-alveolar type. Main duct of submandibular glands runs forward and medially to a papilla located on the floor of the mouth just lateral to the frenulum of the tongue. The submandibular glands are mixed glands but they are mostly serous because they contain mainly serous acini and some mixed acini in their lobules.

The sublingual glands are the smallest of the major salivary glands. They are located in the floor of the mouth. The sublingual glands are compound branched tubulo-alveolar type. Their multiple small sublingual ducts empty into the submandibular duct as well as directly onto the floor of the mouth. The sublingual glands are mixed glands but they are mostly mucous because they contain mainly mucous acini and some mixed acini in their lobules.

Pancreas

The pancreas is a digestive gland having three parts: head, body, and tail. The pancreas has stroma and parenchyma. The stromal component is represented by connective tissue capsule, surrounding pancreas outside and loose connective tissue trabeculae extending from capsule into parenchyma of organ to divide it into lobules. Parenchyma of pancreas is represented by epithelium, which is developed from the entoderm.

Functionally the pancreas is an exocrine and endocrine gland. In pancreas the exocrine part is predominated over the endocrine part.

The exocrine part of pancreas synthesizes and secretes pancreatic juice containing water, sodium, bicarbonate ions and inactive enzymes. These enzymes are released into the duodenum, where the main pancreatic duct opens. Pancreatic enzymes are essential for digestion in the intestine.

The endocrine part of pancreas synthesizes and secretes the hormones (insulin, glucagon) into the blood.

Exocrine part of pancreas

The exocrine part of pancreas is found throughout the organ to form the most content of pancreatic lobules. The exocrine pancreas is a serous (protein secreting), compound branched alveolar exocrine gland closely resembles the parotid gland.

Structural secretory units of the pancreas exocrine part are called pancreatic acini.

The pancreas does not have striated ducts and duct system of pancreas exocrine part includes:

1. Intercalated ducts;
2. Intralobular ducts;
3. Interlobular ducts;
4. Main duct.

The pancreatic acini consist of 2 types of epithelial cells: acinar and centroacinar.

Acinar cells are pyramidal shape serous cells, lying on the basement. Usually 8 to 12 acinar cells are grouped to produce rounded structures called pancreatic acinus. The acinar cells are polarized secretory cell containing the basal part towards the basement and the apical part towards the limen of pancreatic acinus.

The basal part or homogenic zone of acinar cells contains the nucleus and a large region of rER and is characterized by distinct basophilia. The apical part or zymogenic zone of acinar cells contains numerous acidophilically staining zymogen granules.

Zymogens are inactive enzymes. Zymogen granules of acinar cells contain inactive forms of trypsinogen, chyrmotrypsinogen, carboxypeptidase, lipase, phospholipase, cholesterol esterase, amylase and nucleases. They become active after they enter the duodenum.

The smallest intercalated duct begins within the pancreatic acinus. The intercalated duct cells within the acinus are called centroacinar cells. They are squamous epithelial cells, staining very lightly with eosin. Centroacinar cells produce a large volume of fluid rich in sodium and bicarbonate for neutralization the acidity of the chyme that enters the duodenum from the stomach.

Endocrine part of the pancreas

The endocrine part of the pancreas presenting by the islets of Langerhans is embedded within the exocrine part of the organ. The islets of Langerhans are vary in size and are the most numerous in the tail of the pancreas.

The islet of Langerhans is represented by a collection of endocrine cells and numerous fenestrated capillaries lying between them. In islet of Langerhans there

are three main types of endocrine cells:

1) The alpha cells or A-cells secreting the hormone called glucagon. These cells form about 15 to 20% of the islet cells;

2) The beta cells or B-cells secreting the hormone called insulin. These cells form about 70% of the islet cells;

3) The delta cells or D-cells producing the hormones called somatostatin. These cells form about 5% to 10% of the islet cells.

Somatostatin inhibits the secretion of both glucagon and insulin.

Glucagon and insulin have a direct opposite effect on the level of glucose in the blood. Insulin reduces the level glucose in bloodstream and glucagon elevates it.

In islets of the human pancreas the alpha and delta cells tend to be arranged towards the periphery of the islets. In contrast the beta cells tend to lie near the center of the islet.

Liver

Main functions of the liver:

The liver is the largest digestive gland. It performs next functions:

1. Plasma proteins synthesis;
2. Bile secretion;
3. Storage of fat soluble vitamins (A, D, K);
4. Storage of glycogen;
5. Detoxification and inactivation of drugs, toxins, and other proteins foreign to the body (xenobiotics);
6. Haemopoietic function during fetal life.

Classic liver lobules

The liver is a parenchymal organ, containing stroma and parenchyma.

The stromal component is represented by connective tissue capsule, surrounding liver outside and loose connective tissue trabeculae extending from capsule into parenchyma of organ to divide it into lobules.

The parenchyma of liver is represented by epithelial, entodermal origin cells called hepatocytes. The hepatocytes are grouped in plates that are interconnected with each

other to form the structural units of the liver called classic liver lobules.

Classic liver lobules are polyhedral prisms having a measures about 0.7 x 2.0 mm. In certain animals (e.g., the pig), lobules are separated from each other by a thick layer of connective tissue. In humans there is not prominent connective tissue between liver lobules making it difficult to establish the limits between classic liver lobules.

The hepatocytes form anastomosing plates of hepatocytes, 1 or 2 cells thick. Plates of hepatocytes are radially disposed in the liver lobule to form a sponge like structure.

In liver lobule the spaces between plates of hepatocytes is filled by sinusoidal capillaries. The sinusoids run radially and converge in the center of the classic liver lobule to enter the central or centrolobular vein.

Hepatocytes are large, polygonal epithelial cells, forming liver lobules. They constitute about 80% of the cell population of the liver.

Hepatocyte nuclei are large and spherical and occupy the center of the cell. Many hepatocyte in the adult liver are binucleate. Some of hepatocytes nuclei are tetraploid (they contain the 4c amount of DNA).

Hepatocytes are demonstrated all general organelles of cells and numerous inclusions (glycogen and lipids). They contain well developed sER, rER, free ribosomes, multiple Golgi complexes, a lot of peroxisomes, lysosomes and mitochondria.

Hepatocytes have numerous functions such as plasma proteins biosynthesis, bile secretion, storage of glycogen and detoxification and inactivation of drugs and toxins.

The hepatocytes have 3 surfaces. They are sinusoidal, canalicular and intercellular surfaces.

The sinusoidal surfaces of hepatocytes face the perisinusoidal space or space of Disse. Spaces of Disse lie between the sinusoidal endothelium and the hepatocytes. Sinusoidal surfaces of hepatocytes have numerous microvilli that are associated with active transfer of substances between sinusoids and hepatocytes.

The canalicular surfaces of hepatocytes face the bile canaliculi that are formed, as a result of similar depressions of the neighboring cells membranes. Thus, the bile canaliculi are intercellular spaces between two adjacent hepatocytes

The intercellular surfaces of hepatocytes are areas where adjacent hepatocytes communicate with each other as typical cells.

The bile canaliculi are the first portion of the bile duct system of the liver. They collect bile after it is produced by hepatocytes in the hepatocytes plates. The bile canaliculi are limited by only the plasma membranes of 2 neighboring hepatocytes. In bile canaliculi the bile flows from the center of liver lobule to its periphery and after the bile enters the interlobular bile ducts that is a part of the portal triad.

Blood supply in the liver

The liver has a dual blood supply consisting of a venous supply via the hepatic portal vein and an arterial supply via the hepatic artery. Both vessels enter the liver at a hilum which is the same site for common bile duct, carrying the bile secreted by the liver hepatocytes, and the lymphatic vessels leave the liver. Therefore, bile flows in a direction opposite to that of the blood.

The liver receives metabolic substrates and nutrients rich blood from the stomach, intestines and spleen through the portal vein and its branches called interlobular veins.

The liver also receives oxygenated blood through the hepatic artery and its branches called interlobular arteries.

In loose connective tissue of liver there is a portal tract or a portal triad between adjacent liver lobules. Each portal tract contains 3 types of structures: interlobular vein, interlobular artery and interlobular bile duct.

The interlobular veins and their branches give rise to the small inlet venules that empty into sinusoids of the liver lobule. The interlobular arteries and their branches empty directly in the sinusoids as arteriosinusoidal branches. Therefore the mixed (arterio-venous) blood is transported by the sinusoids from the peripheral part of classic liver lobule to a central vein.

From central vein, blood drains into the sublobular veins, lying solitary in loose

connective tissue between liver lobules. The sublobular veins empty into several larger hepatic veins, which leave the liver and, than empty into the inferior vena cava.

Hepatic sinusoids are lined with a thin discontinuous endothelium laying on a discontinuous basal lamina (it may be absent).

Cells of the liver

Except the most numerous hepatocytes the liver lobules contain other types of cells. They are Ito cells, Kupffer cells and Pit cells.

Ito cells or hepatic stellate cells are located in space of Disse. These cells have mesenchymal origin. Cytoplasm of Ito cells contain many lipid droplets, which store vitamin A. Vitamin A is released from the Ito cells as retinol and then transported from the liver to the retina, where its binds to the protein opsin to form visual pigment of rods and cones called rhodopsin.

Kupffer cells or stellate sinusoidal macrophages of the liver belong to the mononuclear phagocytotic system. Like other macrophages of the organism, Kupffer cells are derived from blood monocytes (mesenchymal origin). They are located on the luminal surface of the endothelial cells lining sinusoids. Principle function of Kupffer cells is phagocytosis of debris and damaged erythrocytes from the bloodstream.

Pit cells are liver-associated natural killer cells (lymphocytes). As all blood cells they have mesenchymal origin and are located in sinusoidal lumen. Pit cells have capacity to kill tumor cells in the liver.

Portal lobule and liver acini

The lobules of liver can be classified into three types based on their structure and function. They are classic liver lobule, portal lobule and liver acini.

Portal lobule has triangular shape where the one portal triad there is in center and three central veins there are at the tip of each of its angles. The portal lobule contains parts of 3 adjoining classic liver lobules.

Liver acinus has diamond shape, which includes two central veins and two portal triads in each lobule.