Chapter 12
The Digestive Glands

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Components of digestive glands

- large salivary glands, pancreas, liver, gallbladder.
- These organs are located outside the digestive tract and have ducts open into the digestive tract. (exocrine gland)
Functions of digestive glands

Salivary gland: produce saliva
Pancreas: produce digestive enzymes and hormones
Liver: produce bile, metabolism, synthesize blood proteins, et al.
Gallbladder: store and concentrate the bile.
The exocrine glands include two parts: the secretory part and the duct system. The part of the gland formed by secretory cells is shown in black; the remainder shows the ducts. The compound glands have branching ducts.
1. Salivary glands

- The salivary glands are compound tubuloacinar glands.
- Three pairs of large salivary glands: parotid, submandibular glands and sublingual glands.
1.1 General structure of salivary glands

Capsule and septa (CT) ➔ lobules
Parenchyma: secretory acinus and a duct system
1.2 Secretory acini of salivary glands

- Two types of secretory cells: serous and mucous cells
- Three types of acini: serous acini, mucous acini and mixed acini.
Serous cell

LM:
- Usually pyramidal in shape;
- cytoplasm is deep stained
- nucleus are spherical in shape and near the base.

EM:
- rich in RER, Golgi complex dark secretory granules.

Function:
- Protein-secreting cells (enzyme)
  (The secretion is washiness.)
- The serous cells form serous acini
**Mucous cell**

**LM:**
- Usually cuboidal to columnar in shape;
- cytoplasm are light stained
- nucleus are flattened ovoid in shape and close to the base.

**EM:**
- RER, Golgi complex, light secretory granules

Function: secrete mucoproteins.

(The secretion is viscid.)

The mucous cells form the mucous acini.
The mixed acinus is composed of both serous and mucous cells, mainly mucous acinus with a serous demilune.
**Myoepithelial cell**

- **Situation:** are found within the basal lamina of secretory acini and intercalated ducts.
- **Stellate or spindle in shape.**
- **Function:**
  - **contraction:** helping to squeeze out secretion.
  - **prevention:** prevent the end pieces of gland distention.
1.3 The duct system of salivary glands

- duct, striated duct, interlobular duct and major excretory duct. (Simple cuboidal epi stratified columnar epi)
- Intercalated ducts: Simple cuboidal epithelium or flat cells
**Striated duct (secretory duct)**

- **LM:** simple columnar epithelium; the nucleus is near the cell apex; cytoplasm is acidophilic; has basal striations.
- **EM:** The basal striations are created by membrane infolding and mitochondria.
- **Function:** transport water and ions reabsorbing sodium and excreting potassium.
1.3 three types of salivary glands

**Parotid gland**

- A branched acinar gland. entirely *serous acini*.
- longer *intercalated duct* and striated duct.
- secrete products mainly contain *salivary amylase*.
**Submandibular gland**

- A branched tubuloacinar gland.
- Mixed gland. More serous acini, less mixed or mucous acini.
- Short intercalated duct, longer striated duct.
- Secrete products contain less salivary amylase, more mucus.
Sublingual gland

- A branched tubuloacinar gland.
- Mixed gland, mainly mucous acini.
- Without intercalated duct, rare striated ducts.
- Secretes products are mainly composed of mucus.
2. Pancreas

- A capsule and septa (CT) parenchyma → lobules

- Exocrine portion
  It is a compound tubuloacinar gland which contains entirely serous acini.

- Endocrine portion
  islet of Langerhans
2.1 Exocrine portion

- It is a compound tubuloacinar gland which contains entirely serous acini.

- The serous cells have basophilic basal cytoplasm
  --rich in RER, Golgi complex;
  --Zymogen granules in apical cytoplasm.
The centroacinar cells are small, pale stained cells in the lumen of acini which are from cells of the intercalated ducts.

There are no myoepithelial cells.
Ducts

- Long intercalated ducts (simple squamous or cuboidal epithelium),
- Absent of striated ducts.

Intralobular ducts (cuboidal) → interlobular ducts (columnar) → main pancreatic duct (high columnar with goblet cells).
The functions of exocrine portion

- To secret pancreatic juice which contain water, ions, and several proteases (trypsinogen, chymotrypsinogen), amylase, lipase, etc.

  The majority of the enzymes are stored as proenzymes in the secretory granules of acinar cells.

- To synthesize the protease inhibitors.
Acute pancreatitis

In acute pancreatitis, the proenzymes may be abnormally activated and digest the whole pancreas, leading to very serious complications. Possible causes are alcoholism, gallstones, metabolic factors, infection, and drugs.

The proenzymes may be abnormally activated, which results in this disease.
2.2 Endocrine portion (islet of Langerhans)

- They appear as *rounded clusters of cells* embedded within exocrine portion, more abundant in the tail of pancreas.

  scattered, 1-2 million

- Cells are polygonal or rounded, lightly stained, arranged in cords separated by a network of fenestrated capillaries.
Using immunocytochemical methods, three major types of cells –A, B, and D—have been distinguished.

- **A cells**: 20%
- **B cells**: 70%
- **D cells**: 5%
- **Others**: 5%
# Cells in islet of Langerhans

<table>
<thead>
<tr>
<th>Cell type</th>
<th>Quantity</th>
<th>Distribution</th>
<th>Hormone produced</th>
<th>Function of hormones</th>
</tr>
</thead>
<tbody>
<tr>
<td>A cells</td>
<td>20%</td>
<td>Peripheral</td>
<td>Glucagon</td>
<td>Increases glucose content in blood.</td>
</tr>
<tr>
<td>B cells</td>
<td>70%</td>
<td>center</td>
<td>Insulin</td>
<td>Decrease glucose content in blood.</td>
</tr>
<tr>
<td>D cells</td>
<td>5%</td>
<td>Variable</td>
<td>Somatostatin</td>
<td>Inhibit hormones release by other islet cells.</td>
</tr>
<tr>
<td>PP cells</td>
<td>rare</td>
<td>variable</td>
<td>Pancreatic polypeptide</td>
<td>Control gastric secretion? Control secretion of the exocrine pancreas?</td>
</tr>
<tr>
<td>D1 cells</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
diabetes mellitus

- A disease in which the body's production and use of insulin is impaired. As a result, the level of blood glucose is too high (hyperglycemia).
- There are many types of diabetes, but the most common are type I, type II and gestational diabetes.
- The type I diabetes is insulin-dependent and results from partial or total destruction of B cells due to autoimmune disease. It occurs more in juvenile (juvenile diabetes).
- The type II diabetes is insulin-independent diabetes and is frequently associated with obesity. It occurs at a later stage in life.
3. Liver

Capsule (Glisson’s capsule) and hilum
- Central vein
- Liver plates formed by hepatocyte
- Liver sinusoid
- Others

Liver lobule

✓ Basic structural unit

Portal area
- Interlobular arteries
- Interlobular veins
- Interlobular bile ducts

General structure of Liver
Function:

--- *produce bile*, an important fluid in the digestion of fats;
--- play important roles in lipid, carbohydrate, and protein metabolism;
--- inactivate and metabolize many toxic substances and drugs
--- participate in the iron metabolites and the synthesis of plasma proteins (e.g., albumin, fibrinogen, lipoproteins)
3.1 hepatic lobule

- Basic structural unit of the liver
  - Polygon mass of tissue, 2x1x1 mm³, ~0.5~1 million
Compositions of Liver lobule

- **Central vein**: occupies the centre of the liver lobule.
- **liver plates**: are composed of a single row of hepatocytes
- **liver sinusoid**: situated between the liver plates
- **Perisinusoidal space (space of Disse)**: between endothelial cells and hepatocytes.
- **Bile canaliculi**: Formed by indented plasma membranes of opposing hepatocytes.

----- Polygonal prism, difficult to establish the exact limits

*Human liver*  
*pig liver*
(1). **Central vein**

---located in the axis of hepatic lobule

---lined by endothelium and a few of CT under epithelium.

---receive blood drainage from sinusoid
(2). Hepatocytes

LM

- Form liver plates (liver cords).
- Polyhedral in shape,
- Eosinophilic cytoplasm,
- One or two large rounded nuclei with one or two nucleoli.
Mi, RER, SER, Golgi complex, lysosomes, microbodies, and inclusions (glycogen, lipid droplets).

*Probably the most versatile cell*
Functions of hepatocyte

Mitochondria

provide the energy for the hepatocytes

Rough endoplasmic reticulum

synthesize plasma proteins

Golgi complex

participate in the formation of bile and lipoprotein

Smooth endoplasmic reticulum

- synthesize bile, triglyceride and LDL (Low Density Lipoprotein)
- metabolism of the lipid, hormones and bilirubin
- inactivate steroid hormone
- biotransformation of some materials
- detoxification of noxious substances
Lysosomes

- actively participate in the metabolism of hepatocyte and renewal of organelles
- play a role in metabolism and transport of bilirubin
- storage of iron

Microbodies

- Detoxification: catalase and peroxidase;
- Reduce the hydrogen peroxide ($\text{H}_2\text{O}_2$) into $\text{H}_2\text{O}$

Inclusions

- Include glycogen, lipid droplets, pigment etc;
- These contents vary according to physiologic status of human body
(3). Liver sinusoid

**LM:**
- Large and irregular sinusoidal capillaries between hepatic plates,
- Composed solely of endothelial cells
**EM:**

The endothelial cells of liver sinusoid are thin, discontinuous, fenestrated, and no basal lamina.
Kupffer cells located in the lumen of liver sinusoid, which belong to mononuclear phagocytic system. Kupffer cells are irregular, phagocytic, and contain a number of lysosomes.
(4). Space of Disse

The space is between endothelial cells and hepatocytes, about 0.4 um. It contains fluid similar to plasma, microvilli from the hepatocytes, reticular fibers and fat-storing cells.

Function:
the site of materials exchange between blood and hepatocytes.
Fat-storing cells are found in the space of Disse, which store vitamin A and produce type III collagen fibers (reticular fibers).

**IHC Staining (desmin)**
Hepatic cirrhosis
In chronically diseased liver, fat-storing cells are activated by factors released by hepatocytes and Kupffer cells. The activated fat-storing cells proliferate, and can produce many collagenous fibers and cause hepatic cirrhosis. The normal tissue of liver is replaced by fibrous tissue which lost the function of hepatocytes. Hepatic cirrhosis can result from alcohol abuse, or infection, especially by the hepatitis virus.
(5). Bile canaliculi

- Formed by indented plasma membranes of opposing hepatocytes.
- Microvilli extend into canalicular lumen which contains bile, secretion of liver.

Silver staining, LM

TEM
There are junctional complex including tight junctions and desmosomes around canaliculi.

The junctional complex isolates canaliculi from other portion of intercellular space, and prevents bile from entering spaces of Disse.
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Pathological condition:

The structure of canaliculi is broken up

Bile flow into perisinusoidal space

Blood

Cause jaundice (skin & sclera)
3.2 Portal area

Connective tissue at the corners among adjacent hepatic lobules, which contains interlobular veins (branches of the portal vein), interlobular arteries (branches of the hepatic artery), and interlobular bile ducts (intrahepatic branches of the hepatic duct).
3.3 Blood Supply of liver

portal V. → interlobular V. (functional vessel)
hepatic A. → interlobular A. (nutrient vessel)

sinusoids → central V. → sublobular V. → hepatic V. → Inferior vena cava

Schematic drawing of the structure of the liver
3.4 Discharge way of bile

Bile canaliculi

↓

Hering’s canals

↓

Interlobular bile ducts

↓

Hepatic duct

↓

Common bile duct

Cystic duct

↓

duodenum

↓

Gallbladder
Review: the Composition of hepatic lobules

1. Central vein
2. Hepatic plate
3. Sinusoid
5. Space of Disse
4. Bile canaliculi

Portal area

(3-dimensional diagram shows a portion of liver tissue)
REVIEW: hepatocyte

EM diagram shows the ultra-structure of hepatocyte and its surrounding structure.
4. Gallbladder

- **Mucosa**
  Simple columnar Epi., no Goblet cells
  Laminar propria: C.T.
- **muscle layer**
  Composed of smooth muscle
- **Adventitia**
  most are fibrosa, some are serosa

Function: store bile and concentrate it
KEY POINTS

- General structure of salivary gland
- Structure and function of exocrine portion of pancreas
- Endocrine portion of pancreas (islets): cell types and secretions
- Hepatic lobule: Structural unit of liver ------ its components and function
- Triads in portal space
Assignments

1. Describe cells types of pancreas islet and their function

2. Describe the compositions of hepatic lobule.