Organs Associated with the Digestive Tract

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March, 2016
Salivary Glands

Major
90% of saliva

- Parotid
- Submandibular
- Sublingual

Minor
10% of saliva

Scattered in the mucosa & submucosa
Salivary Glands (cont’d)

- Exocrine glands $\rightarrow$ saliva (pH 6.5-6.9)
- Their secretions may be serous, seromucous or mucous.
- Each major salivary gland is composed of:
  1. **Stroma**: C.T capsule surrounding the gland & sending septa into its interior. Many lymphocytes & plasma cells also present.
  2. **Parenchyma**: lobules made of secretory units & ducts.
Medical Application

- Inadequate saliva production, leading to dry mouth or xerostomia, can be caused by various factors affecting the major salivary glands, as:
  1. mumps viral infection,
  2. radiation of the glands, or
  3. normal side effect of drugs such as antihistamines.

- Excessive saliva production, or sialorrhea, is associated with the autonomic activity of nausea, inflammation within the oral cavity, and rabies viral infection.
Salivary Glands (cont’d)
Serous cells

- Usually **pyramidal** in shape with rounded nuclei.
- Broad base resting on the basal lamina.
- Narrow apical surface with short, irregular microvilli facing the lumen.
- They exhibit characteristics of polarized **protein-secreting** cells.
- Usually form a **spherical mass of cells** called **acinus** with very small central lumen.
Mucous cells

- Usually **cuboidal to columnar** in shape.
- Their **nuclei** are oval and pressed toward the bases of the cells.
- Secret **glycoprotein mucins**.
- Mucous cells are most often organized as **tubules**.
- The ends of mucous tubules are **capped by serous cells**, which constitute the **serous demilunes**.
Serous & Mucous Cells

- Ill-defined cell borders.
- Narrow lumen.

- Well-defined cell borders.
- Wide lumen.

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Myoepithelial cells

- Found between the basal lamina and the basal plasma membrane of the cells forming secretory end-pieces and intercalated ducts.

- Sometimes called basket cells
Myoepithelial cells (cont’d)
Myoepithelial cells (cont’d)
Duct System

- Acini
- Intercalated Ducts
- Striated Ducts
- Excretory Ducts
- Main Duct

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Duct System

1. Intralobular ducts
   - Intercalated ducts
   - Striated ducts

2. Interlobular (excretory) ducts
   - Lining range from simple cuboidal or columnar epithelia to stratified cuboidal or columnar epithelia.
   - Or even pseudostratified type.

3. The main duct
   - Non-keratinized stratified squamous epithelium.
Striated & Intercalated Ducts

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Striated Ducts, E.M
Salivary Glands

Major
- 90% of saliva
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I. Major Salivary Glands

- Parotid salivary gland
- Parotid duct
- Masseter muscle
- Mucosa (cut)
- Sublingual ducts
- Submandibular duct
- Sublingual salivary gland
- Mylohyoid muscle (cut)
- Submandibular salivary gland

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1. Parotid Gland

- Branched acinar gland.
- Its secretory portion is composed exclusively of serous cells.
- Secretory granules have abundant proline-rich proteins with antimicrobial & $\text{Ca}^{+2}$-binding activities and also have a high $\alpha$-amylase content.
- Intercalated and striated ducts are easily observed.
2. Submandibular Gland

- Branched **tubulo-acinar** gland formed of both **serous** and **mucous** cells.
- It produces **2/3** of total saliva.
- The **serous cells** are the main component (90%).
- Serous cells are mostly **serous demilunes**.
- Serous cells secrete the enzyme **lysozyme** in addition to amylase & proline-rich proteins.
- **Striated ducts** are easily observed but intercalated ducts are very short.
2. Submandibular Gland (cont’d)

Submandibular gland is a mixed serous (90%) and mucous (10%) gland and shows:
• well-stained cells in serous acini (A) and in serous demilunes (S) and
• pale-staining mucous cells (M) grouped as tubules in this tubuloacinar gland.
• Small intralobular ducts (ID) drain each lobule, but these are not composed of columnar cells with well-developed striations. X340. H&E.
2. Submandibular Gland (cont’d)
3. Sublingual Gland

- Branched tubuloacinlar gland formed of both serous and mucous cells.
- Mucous cells predominate in this gland.
- Intralobular ducts are not as well developed as in other major salivary glands.
3. Sublingual Gland (cont’d)

- Sublingual gland is a mixed but largely mucous gland with a tubuloacinarian arrangement of poorly stained mucous cells (M).
- Small intralobular ducts (ID) are seen in connective tissue, as well as small fascicles of lingual striated muscle (SM).
3. Sublingual Gland (cont’d)
3. Sublingual Gland (cont’d)
II. Minor Salivary Glands

- Non-encapsulated glands distributed throughout the oral mucosa and submucosa.
- Saliva is produced by secretory units into short ducts, with little modification of its content.
- Minor salivary glands are usually mucous except the small serous glands von Ebner's glands.
- Lymphocyte aggregates are commonly observed and are concerned with IgA secretion.
Pancreas

• The pancreas is a mixed exocrine-endocrine gland that produces digestive enzymes and hormones.
• Enzymes are stored and released by cells of the exocrine portion, arranged in acini.
• The hormones are synthesized in clusters of endocrine epithelial cells known as islets of Langerhans.
• It has a C.T capsule that sends septa.
Pancreas (cont’d)

Pancreatic acinus

Duodenum and pancreas, anterior view

Body of pancreas

Main pancreatic duct

Tail of pancreas

Common bile duct

Duodenum

Accessory pancreatic duct

Hepatopancreatic ampulla

Major duodenal papilla

Jejunum

Duodenojejunal flexure

Pancreatic acini

Pancreatic islet

Acinar cell
**Pancreatic Cancer**

- *Pancreatic cancer* is a carcinoma of duct cells that can arise anywhere in the gland.
- It occurs *most often in the head* of the organ near the duodenum.
- The tumor is *usually asymptomatic until growth and metastasis are well advanced*, leading to the low rate of early detection and subsequent high rate of mortality.
- *Metastasis* may be facilitated by the relatively sparse connective tissue around the ducts and vasculature of the pancreas.
Pancreatic acini (b): The diagram shows the arrangement of cells more clearly. Under the influence of secretin, the centroacinar and other cells of these small ducts secrete a copious $\text{HCO}_3^-$- rich fluid that hydrates and alkalinizes the enzymatic secretions of the acinar cells. Pancreatic acini lack myoepithelial cells and their intercalated ducts lack striations.
Pancreas (cont’d)

Exocrine part (compound acinar) is similar to parotid gland except:

1. Absence of striated ducts.
2. The initial portions of intercalated ducts penetrate the lumens of the acini (centroacinar cells).
3. No myoepithelial cells.
4. Presence of the islets of Langerhans in the pancreas.

N.B. Intercalated ducts are tributaries of larger interlobular ducts.
Pancreas (cont’d)

- The exocrine pancreatic acinus is composed of several serous cells surrounding a lumen.
- These cells are highly polarized, with a spherical basal nucleus, and are typical protein-secreting cells with apical zymogen granules.
Pancreas (cont’d)
Pancreas (cont’d)
Pancreas (cont’d)
Pancreas (cont’d)

- The exocrine pancreas secretes about 1500 ml of alkaline fluid / day containing:
  - Water
  - Ions
  - Proteases (Trypsinogen, chymotrypsinogen, ...)
  - $\alpha$- amylase
  - Lipases
  - Nucleases (DNAase & RNAase)

- The majority of the enzymes are stored as proenzymes in the secretory granules of acinar cells.
Pancreas (cont’d)

- Pancreatic tissue is protected against autodigestion by the following:
  1. Restricting protease activation to the duodenum.
  2. Trypsin inhibitor, which is co-packaged in the secretory granules with trypsinogen.
  3. The low pH in the acini and duct system due to HCO\textsubscript{3} –secreted by the centroacinar and intercalated duct cells, which helps keep all the enzymes inactive.
Pancreatitis

- In **acute pancreatitis**, the proenzymes may be activated and digest pancreatic tissues, leading to very serious complications.
  - Possible causes include infection, gallstones, alcoholism, drugs, and trauma.

- **Chronic pancreatitis** can produce progressive fibrosis and loss of pancreatic function.
Regulation of Pancreatic Secretion

Pancreatic secretion is controlled mainly through:

1. Two polypeptide hormones - secretin and cholecystokinin (CCK) - produced by enteroendocrine cells of the intestinal mucosa (duodenum and jejunum).

2. The vagus (parasympathetic) nerve: stimulates both duct and acinar cell secretions.
Regulation of Pancreatic Secretion

- **Secretin** promotes the secretion of an abundant alkaline fluid rich in electrolytes and poor in enzymes by the duct cells.

- **Cholecystokinin** promotes the secretion of a less abundant but enzyme-rich fluid acting mainly by extrusion of zymogen granules from acinar cells.
Liver (cont’d)

- Liver is the second-largest organ of the body and the largest gland.
- The liver is the organ in which nutrients absorbed in the digestive tract are processed and stored for use by other parts of the body.
- It has a dual blood supply:
  1. 75% comes from the portal vein, (nutrient-rich, O2-poor)
  2. 25% is supplied by the hepatic artery (O2-rich).
- Bile is an exocrine secretion of the liver that is important for lipid digestion and toxic substances elimination.
- The liver also has the very important function of producing plasma proteins, such as albumin, other carrier proteins, coagulation factors, and growth factors.
Hepatic Stroma

- The liver is covered by a thin connective tissue capsule (Glisson's capsule) that becomes thicker at the hilum, where the portal vein and the hepatic artery enter the organ and where the right and left hepatic ducts and lymphatics exit.
- These vessels and ducts are surrounded by connective tissue all the way to their termination (or origin) in the portal spaces between the liver lobules.
- At this point, a delicate reticular fiber network that supports the hepatocytes and sinusoidal endothelial cells of the liver lobules is formed.
Hepatic Stroma

- Silver stain used to view the reticular fiber network running between hepatocytes.

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Hepatic Parenchyma

- Is formed of anastomosing plates of hepatocytes radiating from a central vein & arranged in a polyhedral hepatic lobules.
- Each lobule has 3-6 peripheral portal areas.
- Portal areas = C.T + Portal triad (AVD).
- Hepatic sinusoids present between the plates of hepatocytes separated from them by perisinusoidal space (of Disse).
Hepatic Lobule

- Hepatocytes
- Central vein
- Bile canaliculi

Hepatic sinusoid

**a** Hepatic lobules

- Portal triad
  - Branch of bile duct
  - Branch of hepatic portal vein
  - Branch of hepatic artery

**b** Hepatocytes and sinusoids

- Bile canaliculi
- Reticuloendothelial cell
- Hepatic sinusoid
- Hepatocyte

**c** Portal triad

- Hepatic sinusoid
- Hepatocytes

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Hepatic Lobule

L.M

- **C**: central vein.
- **A**: hepatic artery.
- **V**: portal vein.
- **D**: bile duct.
Hepatic Lobule
The Hepatocyte, L.M

- Large polyhedral cells.
- Central rounded vesicular nucleus.
- Cells are frequently binucleated.
- Cytoplasm: eosinophilic.
The Hepatocyte, E.M
The Hepatocyte, E.M
The Hepatocyte Function

Protein synthesis & Carbohydrate storage

Secretion of bile acids

Synthesis of cholic acid and conjugation with glycine and taurine 
Bile acids reabsorbed in the intestines

90% of bile acids are recirculated 
10% of bile acids are synthesized de novo

Golgi secretory vesicle

Glycogen

Degradation

Protein synthesis

Exocytosis

Space of Disse

Endothelium

Sinusoid

Glucose

Amino acids

Albumin, fibrinogen, prothrombin, lipoproteins

Golgi canaliculus

Bile canaliculus

Space of Disse

Sinusoid

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The Hepatocyte Function (cont’d)

Secretion of bilirubin
Blood Supply of the Liver

Portal Vein 75% (Nutrient-rich, O2-poor)

Hepatic Artery 25% (O2-rich)

Portal Venules

Hepatic Sinusoids

Hepatic Arterioles

Hepatic Veins

Central Venules

Hepatic Sinusoids

Blood Supply

IVC

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Hepatic Sinusoids

- Have a large diameter.
- Discontinuous basal lamina.
- Lined by TWO types of cells:
  1. **Endothelial cells**: having fenestrated cytoplasm not covered by a diaphragm.
  2. **Kupffer cells**: large branching phagocytes that function to metabolize aged RBCs & digest hemoglobin.
Hepatic Sinusoids (cont’d)
Hepatic Sinusoids (cont’d)

Scanning electron micrograph of Kupffer cell spanning the diameter liver sinusoid

Note the fenestrations in the lining endothelial cells
Hepatic Sinusoids (cont’d)

- In the perisinusoidal space are hepatic stellate cells (or Ito cells) with small lipid droplets that store vitamin A and other fat-soluble vitamins.

- These mesenchymal cells, which are difficult to see in routine preparations, also produce extracellular matrix (ECM) components (becoming myofibroblasts after liver injury) and cytokines that help regulate Kupffer cell activity.
Internal organization of the liver

- **CLASSIC HEPATIC LOBULE**: Drains blood from the portal vein and the hepatic or the central vein.
- **PORTAL LOBULE**: Drains bile from hepatocytes to the bile duct.
- **PORTAL ACINUS**: Supplies oxygenated blood to hepatocytes.

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Liver Regeneration

- Despite its slow rate of cell renewal, the liver has an extraordinary capacity for regeneration.
- The loss of hepatic tissue by surgical removal or from the action of toxic substances triggers a mechanism by which hepatocytes begin to divide, continuing until the original mass of tissue is restored (compensatory hyperplasia).
Liver Cirrhosis

- The regenerated liver tissue is usually well organized, exhibiting the typical lobular arrangement and replacing the functions of the destroyed tissue.

- However, when there is continuous or repeated damage to hepatocytes over a long period of time, the multiplication of liver cells is followed by a pronounced increase in the amount of connective tissue.
Clinical features of liver disease

**TABLE 15.1 Clinical features of liver disease**

The normal liver has very diverse functions (see text). As a result, liver disease can produce a wide range of symptoms and signs affecting multiple body systems, some of which are detailed below.

<table>
<thead>
<tr>
<th>Sign/symptom</th>
<th>Clinical feature</th>
<th>Mechanism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jaundice</td>
<td>Yellow colouration of tissues due to bile pigments</td>
<td>Failure of metabolism or excretion of bile</td>
</tr>
<tr>
<td>Bleeding</td>
<td>Easy bruising and prolonged clotting time of blood</td>
<td>Failure of hepatic synthesis of clotting factors</td>
</tr>
<tr>
<td>Oedema</td>
<td>Swelling of dependent parts secondary to extracellular accumulation of water</td>
<td>Failure of hepatic synthesis of albumin, resulting in reduced plasma oncotic pressure</td>
</tr>
<tr>
<td>Ascites</td>
<td>Fluid in peritoneal cavity</td>
<td>Low serum albumin and/or portal hypertension</td>
</tr>
<tr>
<td>Gynaecomastia</td>
<td>Enlarged male breasts</td>
<td>Failure to detoxify endogenous oestrogens</td>
</tr>
<tr>
<td>Encephalopathy</td>
<td>Altered consciousness, lack of coordination, may lead to coma</td>
<td>Failure to detoxify ammonia and excitatory amino acids derived from protein breakdown</td>
</tr>
<tr>
<td>Haematemesis and/or melaena</td>
<td>Vomiting blood and passing blood</td>
<td>Bleeding from oesophageal varices or per rectum owing to portal hypertension</td>
</tr>
</tbody>
</table>
Bile Duct System

Canaliculi → Ductules → Ducts
**Biliary Tract & Gallbladder**

**FIGURE 16-19** Biliary tract and gallbladder.

1. Left and right hepatic ducts merge to form a common hepatic duct.
2. Common hepatic and cystic ducts merge to form a common bile duct.
3. Main pancreatic duct merges with common bile duct at the hepatopancreatic ampulla, which extends into the duodenum.
4. Bile and pancreatic juices enter duodenum at the major duodenal papilla.
Biliary Tract & Gallbladder

- **Canaliculi:** Lined only by plasma membranes of two adjacent hepatocytes.
- **Ductules:** Simple cuboidal epithelium.
- **Ducts:** Simple cuboidal or columnar epithelium + C.T.
- **The hepatic, cystic, and common bile ducts** are lined with a mucous membrane having a simple columnar epithelium of cholangiocytes + thin L.P & submucosa + thin muscularis.
Gallbladder

- The wall of the gallbladder consists of:
  - a mucosa composed of simple columnar epithelium and lamina propria.
  - a layer of smooth muscle.
  - a perimuscular connective tissue layer
  - a serous membrane.
Gallbladder

- The mucosa has abundant folds that are particularly evident when the gallbladder is empty.
- The epithelial cells are rich in mitochondria.
- All these cells are capable of secreting small amounts of mucus.
Tumors of the Digestive Glands

- Most primary malignant tumors of the liver derive from hepatic parenchyma or epithelial cells of the bile duct.
- It may be associated with a variety of acquired disorders, such as chronic viral hepatitis (B or C) and liver cirrhosis.
- In the exocrine pancreas, most tumors arise from ductal epithelial cells.
Medicine is An Ever-Changing Science

Thank You