Digestive system
Digestive system

Digestive tract
- Oral cavity
- Esophagus
- Stomach
- Small and large intestines
- Rectum and anus

Associated glands
- Salivary glands
- Liver
- Pancreas
General Structure of the Digestive Tract

- Mucosa
- Submucosa
- Muscularis
- Serosa
Abnormal innervation of the bowel

- Hirschsprung disease (congenital megacolon)
- Chagas' disease (*Trypanosoma cruzi*)
The Oral Cavity

Stratified squamous epithelium

Keratinized
- Gingiva
- Hard palate

Nonkeratinized
- Soft palate
- Lips
- Cheeks
- Floor of the mouth
Tongue
Papillae

- Filiform Papillae
- Fungiform Papillae
- Foliate Papillae
- Circumvallate Papillae
Circumvallate Papillae

- They are distributed in the V region in the posterior portion of the tongue.
- Numerous serous (von Ebner's) glands drain their contents into the deep groove that encircles the periphery of each papilla.
- The glands also secrete a lipase that probably prevents the formation of a hydrophobic layer over the taste buds that would hinder their function.
Taste bud

- Tastants dissolved in saliva contact the taste cells through the pore interacting with:
  - Taste receptors: (sweet and bitter tastes)
  - Ion channels (salty and sour tastes)
Pharynx

- A transitional space between the oral cavity and the respiratory and digestive systems.
- Lined by stratified nonkeratinized squamous epithelium in the region continuous with the esophagus.
- Lined by ciliated pseudostratified columnar epithelium containing goblet cells in the regions close to the nasal cavity.
- Contains the tonsils.
- The mucosa of also has many small mucous salivary glands in its lamina propria.
- The constrictor and longitudinal muscles of the pharynx are located outside this layer.
Teeth & Associated Structures

Deciduous (primary) usual age of eruption:
- Central incisor (3-10 months)
- Lateral incisor (8-10 months)
- Canine (cuspid) (16-20 months)
- 1st molar (15-21 months)
- 2nd molar (20-24 months)

Permanent (colored blue) usual age of eruption:
- Central incisor (7th year)
- Lateral incisor (8th year)
- Canine (cuspid) (11th-12th year)
- 1st premolar (9th year)
- 2nd premolar (10th year)
- 1st molar (6th year)
- 2nd molar (12th-13th year)
- 3rd molar (17th-25th year)
- 2nd molar (12th-13th year)
- 1st molar (8th year)
- 2nd premolar (10th year)
- 1st premolar (9th year)
- Canine (cuspid) (11th-12th year)
- Lateral incisor (9th year)
- Central incisor (7th year)
Teeth

Enamel
Crown
Dentin
Pulp
Alveolar bone
Periodontal ligament
Gingiva
Root canal
Cementum
Apical foramen
Dentin

- Calcified tissue
  - Type I collagen fibrils
  - Glycosaminoglycans
  - Phosphoproteins
  - Phospholipids
  - Calcium salts (hydroxyapatite)

- The organic matrix of dentin is secreted by odontoblasts
Odontoblast

- Polarized protein-secreting cells with secretion granules in the apical cytoplasm and a basal nucleus.
- Odontoblasts have slender, branched apical extensions the **odontoblast processes** (Tomes' fibers).
- The matrix produced by odontoblasts is initially unmineralized and is called predentin.
Odontoblast

- Odontoblast processes gradually become longer as the dentin becomes thicker.
- Running in small canals called dentinal tubules that are extensively branched near the junction between dentin and enamel.
Dentin Vs. Bone

- Dentin is a calcified tissue that is harder than bone because of its higher content of calcium salts (70% of dry weight).
- Unlike bone, dentin persists as a mineralized tissue long after destruction of the odontoblasts.
Enamel

- Enamel is the hardest component of the human body.
  - 96% mineral “hydroxyapatite crystals”
    - strontium, magnesium, lead, fluoride
  - 1% organic material “amelogenins and enamelins”
  - 3% water

- Enamel consists of elongated rods or columns—enamel rods (prisms)—that are bound together by interrod enamel.
Ameloblasts

- Enamel matrix is secreted by cells called **ameloblasts**.
- These tall columnar cells possess numerous mitochondria in the region below the nucleus.
- Rough endoplasmic reticulum and a well-developed Golgi complex are found above the nucleus.
- Each ameloblast has an apical extension, known as a **Tomes' process**, containing numerous secretory granules that contain the proteins that make up the enamel matrix.
Pulp

- Odontoblasts
- Fibroblasts
- Thin collagen fibrils
- Ground substance that contains glycosaminoglycans

- Pulp is a highly innervated and vascularized tissue.
Periodontium

- Cementum
- Periodontal ligament
- Alveolar bone
- Gingiva
Cementum

- Cementum covers the dentin of the root and is similar in composition to bone.
- Haversian systems and blood vessels are absent.

- It is thicker in the apical region of the root, where there are cementocytes cells with the appearance of osteocytes.
- Like osteocytes they are encased in lacunae
- Unlike those cells cementocytes do not communicate through canaliculi, and their nourishment comes from the periodontal ligament.

- Like bone tissue, cementum is labile and reacts to the stresses to which it is subjected by resorbing old tissue or producing new tissue.
Periodontal Ligament

- Special type of connective tissue whose fibers penetrate the cementum of the tooth and bind it to the bony walls of its socket while permitting limited movement of the tooth.
- It has high rate of collagen renewal.
Alveolar Bone

- It is an immature type of bone (primary bone).
- Many of the collagen fibers of the periodontal ligament are arranged in bundles that penetrate this bone and the cementum (Sharpey's fibers).
Gingiva

- Mucous membrane firmly bound to the periosteum.
- Composed of stratified squamous epithelium and lamina propria containing numerous connective tissue papillae.
- **Junctional epithelium** bound to the tooth enamel by means of a cuticle that resembles a thick basal lamina and forms the **epithelial attachment of Gottlieb**.
- The epithelial cells are attached to this cuticle by hemidesmosomes.
- Between the enamel and the epithelium is the **gingival sulcus**.
Esophagus
Junction of the esophagus with the stomach
Stomach

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Surface-lining cells

Bicarbonate
Mucous Neck Cells

Mucus secretion
Oxyntic (Parietal) Cells

- Hydrochloric acid
- Potassium chloride
- Gastric intrinsic factor
Atrophic gastritis

- Both parietal and chief cells are much less numerous, and the gastric juice has little or no acid or pepsin activity.
- Pernicious anemia
Oxyntic (Parietal) Cells
Chief (Zymogenic) Cells

Pepsinogen

Lipase
Enteroendocrine Cells

- Somatostatin
- Serotonin
- Gastrin
Pylorus

- Has deep gastric pits into which the branched, tubular pyloric glands open.
- Pyloric glands have longer pits and shorter coiled secretory portions.
- These glands secrete mucus as well as appreciable amounts of the enzyme lysozyme.
- **Gastrin (G) cells** which release **gastrin** are enteroendocrine cells intercalated among the mucous cells of pyloric glands.
- Other enteroendocrine cells **D cells** secrete **somatostatin**, which inhibits the release of some other hormones, including gastrin.
Junction of the stomach with the duodenum
Small Intestine
Absorptive cells or Enterocytes

Disaccharidases peptidases
Structure of a microvillus

- Villin
- Actin filament
- Fibrin
- Binding to cell membrane
- Binding to cell membrane
- Actin filament
- Intermediate filament
Goblet cells

- Interspersed between the absorptive cells.
- They are less abundant in the duodenum and increase in number as they approach the ileum.
- Produce acid glycoproteins of the mucin type
Paneth's cells

Lysozyme
Immunological protection of the intestine
M (microfold) cells
Endocrine Cells of the Intestine

Closed type

Open type
## Principal Enteroendocrine Cells in the Gastrointestinal Tract

<table>
<thead>
<tr>
<th>Cell Type and Location</th>
<th>Hormone Produced</th>
<th>Major Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>G—pylorus</td>
<td>Gastrin</td>
<td>Stimulation of gastric acid secretion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gastric mucosal growth</td>
</tr>
<tr>
<td>S—small intestine</td>
<td>Secretin</td>
<td>Pancreatic and biliary bicarbonate and water secretion</td>
</tr>
<tr>
<td>K—small intestine</td>
<td>Gastric inhibitory polypeptide</td>
<td>Inhibition of gastric acid secretion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stimulation of insulin release</td>
</tr>
<tr>
<td>L—small intestine</td>
<td>Glucagon-like peptide 1 (GLP-1)</td>
<td>Inhibition of gastric acid secretion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stimulation of insulin release</td>
</tr>
<tr>
<td>I—small intestine</td>
<td>Cholecystokinin</td>
<td>Pancreatic enzyme secretion, gallbladder contraction</td>
</tr>
<tr>
<td>D—gut</td>
<td>Somatostatin</td>
<td>Inhibition of endocrine, exocrine, and neuro transmitter secretion</td>
</tr>
<tr>
<td>Mo—small intestine</td>
<td>Motilin</td>
<td>Increased gut motility</td>
</tr>
<tr>
<td>EC—digestive tract</td>
<td>Serotonin, substance P</td>
<td>Increased gut motility</td>
</tr>
<tr>
<td>D₁—digestive tract</td>
<td>Vasoactive intestinal polypeptide</td>
<td>Ion and water secretion, increased gut motility</td>
</tr>
</tbody>
</table>
Lamina Propria Through Serosa
Duodenal or Brunner's Glands

Alkaline
Peyer's Patches
Large Intestine
Absorptive and mucous goblet cells
Large Intestine Muscularis
Rectoanal junction
Cell Renewal in the Gastrointestinal Tract

**Stomach**
- Rapid surface-cell renewal (4–7 days)
- Site of stem cells (isthmus and neck)
- Slow gland-cell renewal (weeks)

**Small intestine**
- Cell renewal (3–6 days)
- Cells sloughing off
- First appearance of goblet cells and absorptive cells
- Mitoses
- Stem cells
- Paneth's cells

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Appendix
Cancer of the Digestive Tract

- Approximately 90–95% of malignant tumors of the digestive system are derived from intestinal or gastric epithelial cells.
- Malignant tumors of the large bowel are derived almost exclusively from its glandular epithelium (adenocarcinomas).
- Some proteins such as the carcinoembryonic antigen produced exclusively by malign cells are very important for the diagnosis of cancer.
Dr. Sami Zaqout. IUG

Organs Associated with Digestive Tract

- Salivary glands
  - Wet and lubricate
  - Initiate the digestion
  - Secrete germicidal protective substances
  - Buffering function
- Pancreas
  - Produce digestive enzymes
  - Secrete hormones
- Liver
  - Produces bile
  - Metabolism and inactivation
  - Synthesis of blood proteins
- Gallbladder
  - Stores the bile
Salivary Glands
Serous cells

- Usually pyramidal in shape.
- 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.
Mucous cells

- Usually cuboidal to columnar in shape.
- Their nuclei are oval and pressed toward the bases of the cells.
- Secret glycoproteins mucins
- Mucous cells are most often organized as **tubules**.
- The mucous cells form tubules, but their ends are capped by serous cells, which constitute the **serous demilunes**.
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.
Duct system

- **Intralobular ducts**
  - Intercalated ducts
  - Striated ducts

- **Interlobular ducts**
  - Pseudostratified or stratified cuboidal epithelium
  - Stratified columnar epithelium

- **The main duct**
  - Nonkeratinized stratified squamous epithelium
Salivary Glands

Small salivary glands
- Parotid

Large salivary glands
- Submandibular
- Sublingual
Parotid Gland

- Branched acinar gland.
- Its secretory portion is composed exclusively of serous cells.
- Containing secretory granules that are rich in proteins and have a high amylase activity.
- Intercalated and striated ducts are easily observed.
Submandibular (Submaxillary) Gland

- Branched tubuloacinar gland formed of serous and mucous cells.
- The serous cells are the main component.
- Serous cells are responsible for the weak amylolytic activity.
- The cells that form the demilunes in the submandibular gland secrete the enzyme lysozyme.
- Striated ducts are easily observed but intercalated ducts are very short.
Sublingual Gland

- Branched tubuloacinar gland formed of serous and mucous cells.
- Mucous cells predominate in this gland.
- Intralobular ducts are not as well developed as in other major salivary glands.
Minor Salivary Glands

- Nonencapsulated glands distributed throughout the oral mucosa and submucosa.

- Saliva is produced by small groups of secretory units and is conducted to the oral cavity by short ducts, with little modification of its content.

- Minor salivary glands are usually mucous.
- The small serous glands present in the posterior region of the tongue (von Ebner's glands) are the only exception.

- Lymphocyte aggregates are commonly observed within minor salivary glands, associated 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.
Pancreas

- Absence of striated ducts
- Presence of the islets of Langerhans in the pancreas.
- The initial portions of intercalated ducts penetrate the lumens of the acini.
- Intercalated ducts are tributaries of larger intralobular ducts that form larger interlobular ducts.
Pancreas

- The exocrine pancreatic acinus is composed of several serous cells surrounding a lumen.
- These cells are highly polarized, with a spherical nucleus, and are typical protein-secreting cells.
Pancreas secretions

- The exocrine pancreas secretes 1500-3000 mL of isosmotic alkaline fluid per day containing:
  - Water
  - Ions
  - Proteases
  - Amylase
  - Lipases
  - Phospholipase A2
  - Nucleases
- The majority of the enzymes are stored as proenzymes in the secretory granules of acinar cells.
Pancreas Secretions Regulation

- Gastric acid in the intestinal lumen is a strong stimulus for secretin release.
- Secretin promoting the secretion of an abundant alkaline fluid rich in electrolytes and poor in enzyme activity.

- The release of cholecystokinin is triggered by the presence of long-chain fatty acids, gastric acid, and certain essential amino acids in the intestinal lumen.
- Cholecystokinin promotes secretion of a less abundant but enzyme-rich fluid acting mainly in the extrusion of zymogen granules.
Liver

- The 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.
- Most of its blood (70-80%) comes from the portal vein, arising from the stomach, intestines, and spleen; the smaller percentage (20-30%) is supplied by the hepatic artery.
- Bile is an exocrine secretion of the liver that is important for toxic substances elimination and lipid digestion.
- The liver also has the very important function of producing plasma proteins, such as albumin, other carrier proteins, coagulation factors, and growth factors.
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.
The Liver Lobule
The Liver Lobule

- Hepatocyte
- Portal spaces
- Central vein
- Liver sinusoids
- Space of Disse
- Kupffer cells
- Fat-storing cells
- Portal Vein System
- Arterial System
The Liver Lobule

A
- Central vein
- Hepatocytes
- Sinusoid

B
- Branch of hepatic artery
- Branch of portal vein
- Biliary duct
The Heterogeneity of Hepatocytes
The Hepatocyte
The Hepatocyte

Protein synthesis and Carbohydrate storage

Secretion of bile acids
The Hepatocyte

Secretion of bilirubin
Bile Duct System
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.
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.
Biliary Tract
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 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 cirrhosis.

- In the exocrine pancreas, most tumors arise from ductal epithelial cells.
Thank you