Connective tissue

The Digestive System

Part 1
Structure of digestive system

Organs of the Alimentary Canal
- Mouth
- Pharynx
- Esophagus
- Stomach
- Small intestine
- Large intestine
- Anus

Accessory Digestive Organs
- Salivary glands
- Teeth
- Pancreas
- Liver
- Gall bladder
Functions

ORAL CAVITY, TEETH, TONGUE
- Mechanical processing, moistening, mixing with salivary secretions

LIVER
- Secretion of bile (important for lipid digestion), storage of nutrients, many other vital functions

GALLBLADDER
- Storage and concentration of bile

SALIVARY GLANDS
- Secretion of lubricating fluid containing enzymes that break down carbohydrates

PHARYNX
- Pharyngeal muscles propel materials into the esophagus

ESOPHAGUS
- Transport of materials to the stomach

STOMACH
- Chemical breakdown of materials via acid and enzymes; mechanical processing through muscular contractions

PANCREAS
- Exocrine cells secrete buffers and digestive enzymes; endocrine cells secrete hormones

SMALL INTESTINE
- Enzymatic digestion and absorption of water, organic substrates, vitamins, and ions

LARGE INTESTINE
- Dehydration and compaction of undigestible materials in preparation for elimination
Basic Structure of the Alimentary Canal Wall

Tube is made up of four layers:

1. Mucosa
2. Submucosa
3. Muscularis externa
4. Serosa (Peritoneum) or Adventitia
Mucosa

The innermost wall of the alimentary tube. Consists of:

- **Epithelium** - usually simple columnar epithelium with goblet cells; may be stratified squamous if protection is needed (e.g. esophagus)

- **Lamina propria** – loose connective tissue

- **Muscularis mucosae** – takes part in the formation of folds
Submucosa

Made up of dense irregular connective tissue. Contains submucosal nervous plexus and blood vessels.
Muscularis externa

Usually two layers of smooth muscle:
• inner circular layer
• outer longitudinal layer.

Responsible for peristalsis (controlled by the nerve plexus)
Outer membrane

- A serous membrane/\textit{peritoneum} consisting of the mesothelium (simple squamous epithelium), and a small amount of underlying loose connective tissue.
- Or \textit{adventitia} consisting only of connective tissue is found where the wall of the tube is directly attached or fixed to adjoining structures (i.e., body wall and certain organs).
Pharynx

• Common respiratory and digestive pathway (both air and swallowed food and drinks pass through)
The esophagus is a fixed muscular tube that delivers food and liquid from the pharynx to the stomach.
Mucosal and submucosal glands of the esophagus secrete mucus to lubricate and protect the luminal wall.

Esophageal glands proper lie in the submucosa. These glands are scattered along the length of the esophagus but are somewhat more concentrated in the upper half.

Esophageal cardiac glands are named for their similarity to the cardiac glands of the stomach and are found in the lamina propria of the mucosa.

Those glands near the stomach tend to protect the esophagus from regurgitated gastric contents. Under certain conditions, however, they are not fully effective, and excessive reflux results in pyrosis, a condition more commonly known as heartburn. This condition may progress to fully developed gastroesophageal reflux disease (GERD).
Stomach Diagram

- esophagus
- circular muscle layer
- longitudinal muscle layer
- serosa
- lesser curvature
- greater curvature
- lumen
- duodenum
- rugae
- pyloric sphincter
- gastric pits (foveolae gastricae)
- gastric glands
- muscularis mucosae
- blood vessels
- submucosa
- oblique muscle layer
- circular muscle layer
- longitudinal muscle layer
- connective tissue layer
- serosa
- visceral peritoneum

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Surface mucous cells line the inner surface of the stomach and the gastric pits.

Each cell possesses a large, apical cup of mucinogen granules, creating a glandular sheet of cells.

The mucous protects against abrasion from rougher components of the chyme.

Additionally, its high bicarbonate and potassium concentration protects the epithelium from the acidic content of the gastric juice.

Surface mucous cells are renewed approximately every 3 to 5 days.
The fundic glands produce the gastric juice of the stomach.

Fundic glands are composed of functionally different cell types.

- Mucous neck cells
- Chief cells
- Parietal cells
- Enteroendocrine cells
- Undifferentiated adult stem cells
The fundic glands produce the gastric juice of the stomach.

Gastric juice contains four major components:

- Mucus
- Hydrochloric acid (HCl)
- Pepsin
- Intrinsic factor
Mucus, an acid-protective coating for the stomach secreted by several types of mucus-producing cells.

mucus + bicarbonates = physiologic gastric mucosa barrier
Hydrochloric acid (HCl)

Hydrochloric acid (HCl), which gives the gastric juice a low pH (1.0 to 2.0). It is produced by parietal cells.

Because HCl is bacteriostatic, most of the bacteria entering the stomach with the ingested food are destroyed. However, some bacteria can adapt to the low pH of the gastric contents (Helicobacter pylori).
Pepsin, a potent proteolytic enzyme. It is converted from **pepsinogen** produced by the **chief cells** by HCl at a pH lower than 5.
Intrinsic factor, a glycoprotein secreted by parietal cells that binds to vitamin B12.

Lack of intrinsic factor leads to pernicious anemia and vitamin B-12 deficiency.
Enteroendocrine cells secrete their products into either the lamina propria or underlying blood vessels.
Pyloric Gastric Gland stained for Gastrin Cells
Hormones produced by enteroendocrine cells

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Pyloric Stomach

Long pits (P)

Short Glands

Glandulae pyloricae

Fundic Stomach

Short pits (P)

Long Glands

Glandulae gastricae
The Small Intestine

(a) Gross anatomy of the intestinal wall
- Plica circulares
- Villi
- Mucosa
  - Muscularis mucosae
  - Submucosa
- Muscularis externa
- Serosa

(b) Intestinal villi and intestinal crypts
- Lacteal
- Lymphoid nodule
- Intestinal gland
- Lymphatic vessel
- Submucosal plexus
- Circular layer of smooth muscle
- Myenteric plexus
- Longitudinal layer of smooth muscle
- Submucosal artery and vein
✓ Plicae circulares,
✓ villi,
✓ and microvilli
increase the absorptive surface area of the small intestine.
The **intestinal glands**, or **crypts of Lieberkühn**, are simple tubular structures that extend from the muscularis mucosae through the thickness of the lamina propria, where they open onto the luminal surface of the intestine at the base of the villi.
At least five types of cells are found in intestinal mucosal epithelium.

- **Enterocytes**, whose primary function is absorption
- **Goblet cells**, unicellular mucin-secreting glands
- **Paneth cells**, whose primary function is to maintain mucosal innate immunity by secreting antimicrobial substances
- **Enteroendocrine cells**, which produce various paracrine and endocrine hormones
- **M cells (microfold cells)**, modified enterocytes that cover enlarged lymphatic nodules in the lamina propria
Enterocytes

Goblet cells represent unicellular glands
Paneth cells play a role in regulation of normal bacterial flora of the small intestine.

The secretory vesicles of Paneth cell contain the antibacterial enzyme lysozyme, -defensins, other glycoproteins, an arginine-rich protein (probably responsible for the intense acidophilia), and zinc.

Lysozyme digests the cell walls of certain groups of bacteria. Defensins are homologs of peptides that function as mediators in cytotoxic CD8 T lymphocytes.
M cells (microfold cells), modified enterocytes that cover enlarged lymphatic nodules

Ileum – Peyer’s Patches in the Submucosa
Comparative histology of Small Intestine

(a) Regional characteristics

DUODENUM

JEJUNUM

ILEUM
The large intestine

The principal functions of the large intestine are reabsorption of electrolytes and water and elimination of undigested food and waste.

The mucosal epithelium of the large intestine contains the same cell types as the small intestine except Paneth cells, which are normally absent in humans.

The mucosa of the large intestine has a “smooth” surface; neither plicae circulares nor villi are present. It contains numerous straight tubular intestinal glands (crypts of Lieberkühn) that extend through the full thickness of the mucosa.
Accessory digestive organs

Oral Cavity
Salivary glands
Liver and gallbladder
The pancreas
The Tongue
Filiform papillae are the smallest and most numerous in humans. They are conical, elongated projections of connective tissue that are covered with highly keratinized stratified squamous epithelium. This epithelium does not contain taste buds. The papillae serve only a mechanical role.

Fungiform papillae, as the name implies, are mushroom-shaped projections located on the dorsal surface of the tongue. They project above the filiform papillae. They tend to be more numerous near the tip of the tongue. Taste buds are present in the stratified squamous epithelium on the dorsal surface of these papillae.
**Foliate papillae** consist of parallel low ridges separated by deep mucosal clefts, which are aligned at right angles to the long axis of the tongue. They occur on the lateral edge of the tongue. *In aged individuals, the foliate papillae may not be recognized; in younger individuals, they are easily found on the posterior lateral surface of the tongue.* **Taste buds are present**

**Circumvallate papillae** are the large, dome-shaped structures that reside in the mucosa just anterior to the sulcus terminalis. The human tongue has 8 to 12 of these papillae. Each papilla is surrounded by a moatlike invagination lined with stratified squamous epithelium that contains numerous taste buds.
Taste buds are present on fungiform, foliate, and circumvallate papillae.

**Taste buds** appear as oval, pale-staining bodies. A small opening onto the epithelial surface at the apex of the taste bud is called the **taste pore**.

Three principal cell types are found in taste buds:

- **Neuroepithelial (sensory) cells** are the most numerous cells in the taste bud.
- **Supporting cells** are less numerous.
- **Basal cells** are small cells located in the basal portion of the taste bud.
Structure of Teeth

Crown - exposed surface of tooth
Neck - boundary between root and crown
Root – inside the alveolar fossa
Pulp cavity - hollow with blood vessels and nerves
Root canal - canal length of root
Gingival sulcus - where gum and tooth meet
Periodontal Ligament
Teeth consist of three layers of specialized tissues

- **Enamel**, a hard, thin, translucent layer of acellular mineralized tissue that covers the crown of the tooth.

- **Dentin**, the most abundant dental tissue; it lies deep to the enamel in the crown and cementum in the root. Its unique tubular structure and biochemical composition support the more rigid enamel and cementum overlying the surface of the tooth.

- **Cementum**, is a thin layer of bonelike material that is secreted by cementocytes, cells that closely resemble osteocytes.
Enamel is the hardest substance in the body; it consists of 96 to 98% calcium hydroxyapatite.

Enamel is composed of enamel rods that span the entire thickness of the enamel layer.
Dentin is a calcified material that forms most of the tooth substance. Dentin contains less hydroxyapatite than enamel, about 70%, but more than is found in bone and cementum. Dentin is secreted by odontoblasts that form an epithelial layer over the inner surface of the dentin
Enamel is produced by ameloblasts of the enamel organ, and dentin is produced by neural crest–derived odontoblasts of the adjacent mesenchyme.
Dental Pulp and Central Pulp Cavity (Pulp Chamber)

The dental pulp cavity is a connective tissue compartment bounded by the tooth dentin. The **central pulp cavity** is the space within a tooth that is occupied by **dental pulp**, a loose connective tissue that is richly vascularized and supplied by abundant nerves. The blood vessels and nerves enter the pulp cavity at the tip (apex) of the root, at a site called the **apical foramen**.
Salivary glands

- Three pairs, **parotid, submandibular, sublingual.**
- Saliva is a mixture of **mucus** and **serous fluids**, each produced to various extents in various glands. Also contains salivary amylase, (starts to break down starch) lysozyme (antibacterial) and IgA antibodies. In some mammals (and snakes!) saliva may be poisonous.
The parotid glands are completely **serous**.

The submandibular glands are **mixed** glands that are **mostly serous** in humans.

The small sublingual glands are **mixed** glands that are **mostly mucous** secreting in humans.
Serous cells are protein-secreting cells.

Mucous cells are mucin-secreting cells.

Myoepithelial cells are contractile cells with numerous processes. They lie between the basal plasma membrane of the epithelial cells and the basal lamina of the epithelium.
The lumen of the salivary acinus is continuous with that of a **duct system** that may have as many as three sequential segments:

- **Intercalated duct**, which leads from the acinus
- **Striated duct**, so-called because of the presence of “striations,” the infoldings of the basal plasma membrane of the columnar cells that form the duct
- **Excretory ducts**, which are the larger ducts that empty into the oral cavity
Mumps

Mumps begins as infectious parotitis in the parotid glands in the cheek.

Swollen, painful parotid salivary glands (parotitis) on one or both sides of the face
Etiology: Mumps virus (Myxovirus)
Fever and sometimes orchitis, pancreatitis etc.
About 1/3 of infected people do not show symptoms
Effective vaccine (MMR) since 1967!
Liver is the biggest gland

- **Bile**, a watery greenish fluid is produced by the liver and secreted via the **hepatic duct** and **cystic duct** to the **gall bladder** for storage, and thence on demand via the **common bile duct** to an opening near the pancreatic duct in the duodenum.
Liver function

The liver plays an active role in the process of digestion through the production of bile.

Bilirubin present in bile is a product of the liver’s digestion of worn out red blood cells.

The liver monitors the contents of the blood and removes many potentially toxic substances before they can reach the rest of the body.

The liver provides storage of many essential nutrients, vitamins, and minerals obtained from blood passing through the hepatic portal system.

The liver is responsible for the production of several vital protein components of blood plasma: prothrombin, fibrinogen, and albumins.
Histology: Liver Lobule and Portal Tract

- Portal vein
- Hepatic artery
- Bile duct
- Lobule boundary
- Central vein
- Portal area
Liver Portal Tract

-Portal vein (PV)
-Hepatic artery (A)
-Bile Duct (B)
-Lymphatic vessels (L)

S = sinusoids
Epithelial and sinusoidal cells

- portal venule
- bile ductule
- Bile duct cell
- Kupffer cell
- sinusoid
- central vein
- stellate cell
- space of Disse
- hepatic arteriole
- hepatocyte
- endothelial cell
The pancreas performs both exocrine and endocrine functions.

• The exocrine secretory glands drain pancreatic juice into the pancreatic ducts and, from there, ultimately into the duodenum. The secretion is essential for the digestion and absorption of proteins, fats and carbohydrates.
Pancreas – Secretory acini & Islet of Langerhans
Exocrine part

Acinar cells – Several types of digestive enzymes e.g., trypsin

Centroacinar cells – produce bicarbonate rich fluid.
Pancreas – Secretory acini w/ zymogen granules
Pancreas

Intercalating Duct (D)

C – centroacinar cell
Pancreas - Intercalating Duct (arrow)
Pancreas – Interlobular Duct
Pancreas – Intralobular Duct
• The endocrine pancreas is responsible for the production and secretion of glucagon and insulin, which take place in specialized cells of the islets of Langerhans.
Thank you for attention

when I see you smile