Histology and Structure of the upper Gastrointestinal (GI) Tract

The gastrointestinal (GI) tract is a continuous tube extending from the oral cavity to the anal canal. A cross-section of the GI tract reveals four layers:

1. Mucosa
2. Submucosa
3. Muscular layer
4. Serosa (or adventitia, depending on the location)

Mucosa

The mucosa itself has three sublayers:

- Lining epithelium
- Lamina propria
- Muscularis mucosae

Each segment of the GI tract has specific epithelial features:

- Oral cavity, pharynx, and esophagus: lined by non-keratinized stratified squamous epithelium.
- Stomach: lined by simple columnar epithelium, without goblet cells, adapted for secretion.
    - The lamina propria in the stomach is densely packed with gastric glands, essential for digestion.

Small Intestine

The small intestine consists of the duodenum, jejunum, and ileum. It is lined by simple columnar epithelium with goblet cells. The mucosa contains finger-like projections called villi, which significantly increase the surface area for nutrient absorption.

- The duodenum, located immediately after the stomach, receives highly acidic chyme. To neutralize this, the **submucosa** of the duodenum contains Brunner's glands, which secrete alkaline mucus. This feature is unique among most segments of the GI tract.
- Due to this acidity, peptic ulcers commonly occur in the first inch of the duodenum if the acid is not sufficiently neutralized.

Large Intestine

The large intestine is lined with simple columnar epithelium containing a high density (numerous) of goblet cells. These goblet cells help lubricate the passage of feces, which may be hard.

Smoking and GI Health: Smoking adversely affects nearly every organ, including the gastrointestinal system. It compromises blood supply to the stomach, potentially leading to ischemia and an increased risk of peptic ulcers.

Digestive System

The digestive system begins at the oral cavity and includes the esophagus, stomach, small intestine, large intestine, rectum, and anal canal. It also involves several accessory organs: Liver, Pancreas, Salivary glands and Gallbladder.

Functions of the Digestive System

The digestive system is responsible for breaking down complex food materials into simpler, absorbable forms:

- Carbohydrates → Glucose / Proteins → Amino acids / Fats → Fatty acids

In addition to macronutrients, the system also absorbs: Water, Vitamins and Minerals. These are important for body functions and are involved in the synthesis of hormones and enzymes.

After digestion, nutrients are absorbed into the bloodstream and transported to the liver via the **portal vein.**

Functions of the Liver

The liver plays multiple key roles:

- Metabolism of nutrients
- Synthesis of bile salts (essential for fat digestion)
- Production of various enzymes and hormones
- Storage of glycogen (a storage form of glucose)
- Detoxification of harmful substances

Histological Structure of the GI Tract

A cross-section of the gastrointestinal (GI) tract shows four main layers:

1. Mucosa
    - Lining epithelium: varies between organs
    - Lamina propria: loose connective tissue containing glands
    - Muscularis mucosae: thin smooth muscle layer affecting mucosal folding

The type of epithelium and the presence of glands in the lamina propria differ depending on the specific organ.

2. Submucosa
    - Dense connective tissue containing blood vessels, lymphatics, and nerve plexuses
    - Glands in the submucosa are found only in two regions:
        - **Duodenum**: contains Brunner's glands that secrete alkaline mucus to neutralize gastric acid
        - **Esophagus**: especially the lower part, contains mucus-secreting glands to protect against gastric reflux
3. Muscularis layer
    - Composed of two layers of smooth muscle:
        - Inner circular layer
        - Outer longitudinal layer
    - Responsible for peristalsis and controlled by the nervous system
4. Outer Layer: Serosa or Adventitia
    - **Serosa**: found where the organ is surrounded by peritoneum; composed of simple squamous epithelium (mesothelium)
    - **Adventitia**: found where the organ is attached to surrounding connective tissue

Example: Esophagus

- Cervical (neck) and thoracic (chest) parts: covered by **adventitia**
- Abdominal portion (approximately 1.3 cm): lies below the diaphragm and is covered by **serosa**

Nervous System in the GI Tract

1. Submucosal (Meissner's) Plexus

- Located in the submucosa
- Contains both sympathetic and parasympathetic fibers
- The parasympathetic component is more dominant and secretomotor in function:
    - Stimulates glandular secretion
    - Regulates local muscular contractions

2. Myenteric (Auerbach's or Orbuc's) Plexus

- Located between the inner circular and outer longitudinal layers
- Mainly motor in function
    - Coordinates peristaltic movements along the GI tract
    - Also plays a role in glandular regulation

Innervation:

- Parasympathetic fibers (from the vagus nerve) are preganglionic, synapsing in ganglia and has postganglionic fibers
- Sympathetic fibers are usually postganglionic (pass without synapsing).

Histological Functions by GI Region

Each part of the GI tract exhibits a different histological structure and function, tailored to its role:

1. Protective Epithelium

- Found in the:
    - Oral cavity, Pharynx, Esophagus and Anal canal
- Lined with stratified squamous non-keratinized epithelium
    - Offers protection against abrasion
    - Designed (stratified) for regeneration, especially important where mechanical injury is frequent (rough food, hard stool)

2. Secretory Epithelium

- Found in the stomach
- Lined with simple columnar epithelium (without goblet cells)
- The lamina propria of the mucosa is packed with gastric glands containing four cell types.

3. Absorptive Function

- Found in the small intestine
- Lined with simple columnar epithelium with goblet cells (finger-like projections)
- Lamina propria contains intestinal glands known as **crypts of Lieberkühn** (instead of gastric)
- Duodenum also contains Brunner's glands in the submucosa
    - These glands secrete alkaline mucus to neutralize gastric acid
    - Thus, the duodenum has two types of glands: Brunner's (submucosa) and crypts of Lieberkühn (lamina propria)

4. Absorption and Protection in the Large Intestine

- Function: Water reabsorption and feces formation
- Lined with simple columnar epithelium rich in goblet cells
    - Goblet cells secrete mucus for lubrication due to the hardness of feces
- Lamina propria glands are filled with mucous-secreting cells

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Histology of the Oral Cavity

The oral cavity is lined by stratified squamous epithelium, with keratinization varying based on location and function:

Types of Epithelium:

- Keratinized epithelium: Found in areas exposed to friction or mechanical stress
    - Hard palate
    - Gingiva (gums)
    - Dorsal surface of the tongue (specifically parakeratinized)
- Non-keratinized epithelium: Found in softer, more mobile areas
    - Inner cheeks (buccal mucosa)
    - Soft palate
    - Ventral (underside) of the tongue
    - Floor of the mouth

Gingiva (Gums):

- Dense connective tissue
- Covered by keratinized epithelium for protection

Soft Palate:

- Covered by non-keratinized stratified squamous epithelium
- More flexible and contains soft connective tissue

Lamina Propria & Submucosa:

- Lamina propria interdigitates with the submucosa, forming invaginations that enhance structural integrity and nutrient diffusion

Tongue Structure and Papillae

The tongue has distinct regions, with specialized structures for taste and mechanical functions:

Types of Lingual Papillae (on dorsal surface):

1. Filiform papillae:
    - Most numerous
    - Projections
    - No taste buds
2. Fungiform papillae:
    - Mushroom-shaped
    - Contain taste buds
3. Circumvallate papillae:

    - Structure: Circumvallate papillae are circular in shape and are surrounded by a groove known as the **circular sulcus.**
    - Sulcus Walls: This sulcus has two walls — medial and lateral.
    - Glands: Beneath the papillae are von **Ebner's glands**, which are mucoserous glands. These glands secrete fluid through ducts that open into the base of the cleft of the sulcus.
    - Taste Buds: Taste buds are located on the medial wall of the sulcus, just lateral to the body of the circumvallate papilla.

4. Foliate papillae:
    - Poorly developed in humans but prominent in animals

Structure of a Taste Bud

1. Taste Pore

- A small opening on the surface of the papilla (visible on the dorsal surface of the tongue)
- This is the entry point through which dissolved food molecules enter the taste bud

2. Microvilli (Taste Hairlets)

- Fine, hair-like projections (microvilli) extend from the apical end of the taste receptor cells into the taste pore
- These microvilli interact with dissolved chemicals in food, initiating the taste sensation

3. Taste Receptor Cells (Gustatory Cells)

- These are bipolar sensory cells
    - Apical end: contains microvilli in the taste pore to detect tastants
    - Basal end: forms synaptic connections with afferent nerve fibers
        - Especially the chorda tympani branch of the facial nerve

4. Supporting (Sustentacular) Cells

5. Basal (Stem) Cells: Located at the base of the taste bud. Differentiate into new taste cells

Salivary Glands Overview

Salivary glands are classified into:

- Major salivary glands (three paired glands)
- Minor salivary glands

Major Salivary Glands

1. Parotid gland:
    - Type: Purely serous (protein-rich, watery secretion)
    - Duct: Parotid duct opens into the vestibule opposite the second upper molar
2. Submandibular gland:
    - Type: Mixed (serous and mucous)
    - Duct: Submandibular duct opens into the floor of the mouth
3. Sublingual gland:
    - Type: Mixed, but predominantly mucous

Histological Features

General Gland Structure

- Surrounded by a fibrous connective tissue capsule
- Septa extend from the capsule to divide the gland into lobes and lobules
- Between lobes and lobules as connective tissue, there are blood vessels, lymphatics, and nerves to reach every cells

Acini (Secretory Units)

- Serous acini:
    - Rounded nuclei at the base
    - Ill-defined boundaries between cells
    - Narrow lumen
    - Found in parotid gland
- Mucous acini:
    - Flattened nuclei at the base
    - Well-defined boundaries
    - Wide lumen
    - Found in sublingual gland (and part of submandibular)
- Serous demilunes: (IMPORTANT)
    - Seen in submandibular gland
    - Crescent-shaped serous cells capping mucous acini
    - A minor feature in sublingual gland
- Myoepithelial (basket) cells:
    - Located beneath the basement membrane
    - Contractile function (muscle), aiding in squeezing (تزيد) secretions
    - More prominent in serous glands

Duct System

Saliva produced by acini flows through a series of ducts:

1. Intercalated ducts:
    - From lumen
    - Small ducts lined by cuboidal cells
    - Found within lobules
    - Small number of cells (5-8)
2. Striated ducts:
    - Lined by columnar cells with basal striations
    - Also within lobules
    - Larger, with more than 10 cells
3. Interlobular / Interlobar ducts:
    - Located in the connective tissue between lobules
    - Lined by stratified cuboidal or stratified columnar epithelium
4. Main excretory duct:
    - Lined by stratified squamous non-keratinized epithelium

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Histological Differences Between Glands

Parotid Gland

- Composed entirely of serous acini
- Both striated and intercalated ducts are present
- No mucous acini or serous demilunes

Submandibular Gland

- Mixed gland
- Contains serous demilunes (serous caps over mucous acini)
- Striated ducts are abundant

Sublingual Gland

- Mixed, but predominantly mucous (foamy appearance)
- Few serous acini and minimal serous demilunes
- Has striated and intercalated ducts

Minor Salivary Glands

- Mostly mucous

For any feedback, please click HERE

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V1: The information regarding the circumvallate papillae in Page 5 has been reorganized. Page 7 edited