Histology of the lower GI tract

Histology of the Esophegus

The esophagus is a muscular tube that forms a continuation of the pharynx, beginning at the level of the sixth cervical vertebra (C6) and ending at the cardia of the stomach. It measures approximately 25 cm in length, though the distance from the incisors to the stomach is around 45 cm. Its main function is the propulsion of the food bolus from the pharynx to the stomach, facilitated by peristaltic movements of the esophagus.

Wall Structure

The wall of the esophagus is composed of four concentric layers (from inner to outer):

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

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1. Mucosa

The mucosa is the innermost layer and consists of three sub-layers:

- Lining Epithelium:
  - Stratified squamous non-keratinized epithelium, similar to that found in the oral cavity, pharynx, and anal canal.
  - This type of epithelium is characterized by high mitotic activity, enabling rapid regeneration in response to injury.
- Lamina Propria:
  - A loose connective tissue layer rich in lymphatic vessels, nodes, capillaries, and immune cells.
  - Contains cardiac glands, which become more numerous in the lower esophagus as it approaches the stomach.
- Muscularis Mucosae:
  - A thin layer of smooth muscle fibers, organized into inner circular and outer longitudinal layers.

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2. Submucosa

- Composed of dense connective tissue containing:
  - Blood vessels
  - Lymphatic vessels
  - **Esophageal glands proper**, which secrete mucus for lubrication.
- Also contains the Meissner's plexus (submucosal plexus)

Note: Only two parts of the GI tract have glands in the submucosa: the esophagus and the duodenum.

3. Muscularis Externa

This layer consists of two muscle layers:

- Inner circular
- Outer longitudinal

Between these layers lies the myenteric plexus (Auerbach's plexus), which provides parasympathetic secretomotor innervation to the glands and coordinates peristaltic movements via smooth muscle stimulation.

Muscle Composition by Region:

- Upper third: Skeletal muscle (voluntary control; somatic innervation)
- Middle third: Mixed skeletal and smooth muscle
- Lower third: Smooth muscle only (autonomic innervation including both sympathetic and parasympathetic fibers)

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4. Adventitia or Serosa

- Most of the esophagus, located in the neck and thoracic cavity, is surrounded by adventitia—a connective tissue layer that anchors it to surrounding structures.
- The abdominal portion (approximately 1.3 cm below the diaphragm) is the only part covered by serosa (a visceral peritoneal layer).

Histology of the Stomach

The stomach plays a vital role in digestion by converting ingested food into a semi-fluid viscous mixture known as **chyme**. It typically empties its contents into the duodenum through the pyloric sphincter within 2–4 hours after ingestion.

Anatomical Regions

The stomach is anatomically divided into the following regions:

- Cardia: Area surrounding the esophageal (cardiac) opening.
- Fundus
- Body
- Incisura angularis: A notch on the lesser curvature that demarcates the body from the pyloric region.
- Pyloric Part: Divided into:
    - Pyloric antrum
    - Pyloric canal
    - Pyloric sphincter

Wall Structure: The stomach wall is composed of four layers:

1. Mucosa
2. Submucosa

3. Muscularis externa
4. Serosa (since the stomach is entirely covered by peritoneum)

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1. Mucosa

The mucosa consists of:

- Epithelium:
  - Simple columnar epithelium without goblet cells.
  - Rugae: Folds of submucosa through mucosa that allow stomach expansion.
- Lamina Propria:
  - Loose connective tissue filled with **gastric glands**, which vary by stomach region.
  - These glands lined by simple columnar epithelium without goblet cells, which secrete mucus, which is rich in water (95%), lipids, and glycoproteins, forming a **protective, hydrophobic gel** layer that guards against self-digestion.
  - Depending on the plane of section, the gastric glands may appear circular, oblique, or coiled.
  - Their ducts open onto the surface through structures known as **gastric pits**, and these glands occupy most of the lamina propria.
  - Immune cells like lymphocytes and lymphatic nodules may be present, particularly in the pylorus.
- Muscularis Mucosae:
  - Thin layer of smooth muscle.

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2. Submucosa

- Composed of dense connective tissue, blood vessels, lymphatics, and the Meissner's (submucosal) plexus.

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3. Muscularis Externa

- Uniquely composed of three smooth muscle layers:
  - Innermost oblique
  - Middle circular
  - Outer longitudinal
- This inner oblique layer is found in the stomach wall but is absent in the pyloric canal and sphincter so the pyloric sphincter is a thickening of the circular layer.
- The myenteric (Auerbach's) plexus lies between the circular and longitudinal layers, regulating peristalsis and secretion.
- Sympathetic stimulation: contractatiob of the sphincter.
- When the sympathetic nervous system is inhibited, the parasympathetic nervous system increases the peristaltic movements therefore causing drainage.

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4. Serosa

Histological Differences Between Stomach Regions

Distinguishing between sections of the cardiac, body, or pyloric regions of the stomach is based on the relative thickness of the mucosa. This includes the glands filling the lamina propria and the depth of the gastric pits.

Cardia (1.5–3 cm wide)

- Gastric pits and glands are of equal length (1:1) .
- Glands lined by simple columnar epithelium without goblet cells.
- Contains:
    - Mucous cells
    - Few parietal cells (HCl)
    - Few chief cells (pepsinogen)
    - Enteroendocrine cells (gastrin)
    - Stem cells for regeneration
- Parietal and chief cells are present in smaller numbers, but are abundant in the body.

Body and Fundus

- 3/5 glands, 2/5 pits (pits are short and wide).
- Glands are numerous to serve the function (digestion) and composed of:
    - Isthmus (and neck): Rich in parietal cells and mucous neck cells.
    - Body: Mainly parietal cells (in the upper part).
    - Base: Contains chief (zymogenic) cells, enteroendocrine cells.
- Stem cells are located in the middle part of the gastric glands, where they divide and can migrate either upward or downward to replace dead or damaged cells

Cell Types

- Parietal (oxyntic) cells:
    - Secrete HCl
    - Acidophilic (appear faint),
    - Central, binucleated nucleus.
    - Active phase (formation of HCl): Shows **intracellular canaliculi**.
    - Resting phase: Contains **tubulovesicular** structures in the apical region of the cells.
- Chief (zymogenic) cells:
    - Basophilic appearance (appear dark)
    - Secrete pepsinogen, which converts to pepsin.
    - Located in the base of the gastric gland containing zymogen granules
- Mucous neck cells:
    - Foamy appearance due to mucus dissolution during preparation of the section.
    - Scattered between parietal cells (neck of the gastric gland).
- Enteroendocrine cells:
    - Have large nucleus
    - At gland base.
    - Secrete hormones like gastrin and serotonin as granules.
- Stem cells:
    - Located in the middle, migrate upward or downward.
    - Renew epithelium every 4–7 days.

Pylorus

- Characterized by long, narrow gastric pits and short glands (minor role in digestion).
- Glands are primarily composed of:
  - Mucous cells: Neutralize acid before chyme enters the duodenum.
  - Enteroendocrine cells (gastrin)
- No parietal or chief cells.
- Lamina propria often contains **aggregated** lymphatic nodules (while being scattered in other parts of the GI Tract).
- Meissner's and myenteric plexuses are present and regulate glandular secretion and motility.

Histology of the Small Intestine

The small intestine is divided into three parts: the duodenum, jejunum, and ileum.

General Structure

- The lining epithelium is simple columnar epithelium with goblet cells, which increase in number distally and become very numerous in the large intestine.
- Crypts of Lieberkühn (intestinal glands) are present in the lamina propria.
- The small intestine is characterized by finger-like projections called **intestinal villi**, located on the lateral side of the plicae circularis (to be discussed). The mucosa (finger-like projection) consists of:
  - Upper half: villi
  - Lower half: glands
  - The villi has lining epithelium and contain lamina propria. They measure 0.5–1.5 mm in length.

Lamina Propria

Contains:

- Crypts of Lieberkühn (intestinal glands) contain:
  - Lined with Simple columnar epithelium glands with Goblet cells
  - Mucus
  - Stem cells: Undergo mitosis
  - Enteroendocrine cells: Secrete hormones like gastrin.
  - **Paneth cells**: Acidophilic, located at the crypt bases, secrete lysozyme (antibacterial and control the intestinal flora).
  - There are no parietal or chief cells

- Smooth muscle fibers
- Blood vessels
- **Lacteals** (blind-ended lymphatic vessels for fat absorption)
- Fibroblasts, fibrocytes, and macrophages (as part of the loose connective tissue)

Submucosa:

Contains the Meissner's plexus.

Cell Types and Features

- **Enterocytes** (tall columnar absorptive cells) are the most abundant. Their apical surfaces contain:
    - Microvilli (forming the brush surface): Each enterocyte has ~3000 microvilli, each 1–2 μm long. Collectively, the microvilli contribute to an absorption area of ~200 m^2
    - Villi cntain actin filaments, fibrin, and villin
- **Goblet cells:** Secrete mucus for lubrication and aid in absorption.
- **Paneth cells**: Acidophilic, located at the crypt bases, secrete lysozyme (antibacterial and control the intestinal flora).
- **Mucus** in the intestines is primarily for absorption (unlike in the stomach, where it is for protection).
- **Peyer's patches** (lymphatic nodules) a key component of GALT (gut-associated lymphoid tissue).
- **M cells (microfold cells)** are specialized epithelial cells. It is a component of GALT (gut-associated lymphoid tissue) overlying Peyer's patches. They have discontinuous basal membranes, allowing lymphocytes and macrophages to access the surface and engulf bacteria (or viruses, presenting them to lymphocytes for antibody production).

Duodenum

- The villi are leaf-like projections.
- Surface cells have microvilli that form a **brush surface**, significantly increasing the surface area for absorption. While microvilli are present in all parts of the small intestine, they are most prominent in the duodenum.
- Contains crypts of Lieberkühn (intestinal glands) in the lamina propria
- The submucosa contains **Brunner's glands**, which help prevent peptic ulcers.

Jejunum

- The submucosa invaginates into the mucosa forming **plicae circularis or Kerckring's valves** (similar to stomach rugae), enhancing the surface area for absorption.
- Prominent **Paneth cells**

Ileum

- Characterized by the presence of **Peyer's patches**
- Prominent M cells (microfold cells)

Muscularis Externa

- Composed of:
    - Inner circular layer
    - Outer longitudinal layer
    - Myenteric (Auerbach's) plexus located between the two layers, composed of nerve cells, axons, and Schwann cells
    - The parasympathetic innervation (via the vagus nerve) synapses here with very short postganglionic fibers to the smooth muscle and glands.
    - The sympathetic innervation is postganglionic, originating from the celiac and superior mesenteric ganglia.

Nerve innervation, both sympathetic and parasympathetic, is distributed with the blood supply to the organs.

Surface Area Amplification

- The surface area for absorption is increased by:
  - Microvilli (20-fold increase)
  - Villi (10-fold increase)
  - Plicae circularis (especially in the jejunum) (3-fold increase)
- Total absorption area is approximately 200 m^2.

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1. The gastric gland of the pylorus contains all of the following cells except:

- Mucous cells
- Parietal cells
- Chief cells ← Correct answer
- Endocrine cells

I think it should be parietal, but that's was the answer on E-learning

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2. The villi of the small intestine contain all of the following except: (IMPORTANT)

- Lacteals
- Smooth muscle
- Capillaries
- Paneth cells ← Correct answer
- Goblet cells

For any feedback, please click HERE

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V1:

Page 3 : second point removed from Epithelium and added to lamina propria

Page 4 : enteroendocrine cells have large nucleus

Page 5 : underlined

Page 7 : Questions added