HISTOLOGY OF THE STOMACH

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The wall of the stomach has the same general layout seen in the rest of the alimentary tract.
• The inner surface of an empty stomach shows several longitudinal folds of *mucosa and submucosa* called *Rugae*.

• These disappear when the stomach is distended, thus allowing the stomach to increase in size.
Mucosa - Epithelium

- The stomach is lined by simple columnar epithelium.
- This simple columnar epithelium begins *Abruptly* at the gastro-esophageal junction (GEJ).

GP = gastric pit. CG = cardiac glands.
# Endoscopic difference between the *Esophageal* and *Gastric* mucosa

<table>
<thead>
<tr>
<th></th>
<th>Esophagus</th>
<th>Stomach</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Color</strong></td>
<td>Pink in color</td>
<td>Red in color <em>(Why?)</em></td>
</tr>
<tr>
<td><strong>Brightness</strong></td>
<td>Not shiny</td>
<td>Shiny – due to the presence of mucous layer</td>
</tr>
<tr>
<td><strong>Surface</strong></td>
<td>Smooth - No folds</td>
<td>Presence of folds – Rugae</td>
</tr>
<tr>
<td></td>
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<td><em>(unless the stomach is inflated during procedure)</em></td>
</tr>
</tbody>
</table>

- **Esophagus**
- **GE Junction**
- **Stomach**
- The epithelium invaginates the lamina propria to form **Gastric Pits**

- Branched tubular **Gastric Glands** open into these pits
• Each gastric gland is divided into the following regions:

1. **Isthmus** - at its junction with the pit
2. **Neck** - next to the isthmus
3. **Base** - the deepest part

Are the gastric glands simple or compound?
Cells of the Gastric Epithelium

1. Surface mucous cell (secretes mucus)
2. Mucous neck cell (secretes mucus)
3. Parietal cell (secretes hydrochloric acid and intrinsic factor)
4. Chief cell (secretes pepsinogen and gastric lipase)
5. G cell (secretes the hormone gastrin)
6. Stem Cells
1) **Surface Mucous Cells:**

- Line the lumen of the stomach and the gastric pits.
- Columnar cells. Apical part filled with mucinogen granules. Below it, we have Golgi apparatus and an oval nucleus. The basal part the rough endoplasmic reticulum.
- The mucus secreted by these cells:
  - Forms a thick, viscous, gel-like coat on the surface of the stomach that can be easily seen. This coat acts as a physical barrier against microorganisms and the abrasive effects of food in the stomach.
  - Contains bicarbonate ions that neutralize the acid in the lumen thus protecting the wall of the stomach.

Prostaglandins increase the thickness of the mucus and the amount of bicarbonate ions produced by these cells thus enhancing their protective property. Aspirin (and other NSAIDs) reduces the production of prostaglandins thus reducing the protection provided by surface mucous cells.
2) **Neck Mucous cells:**
These are present in the neck region of the gastric glands. They produce thin mucus that doesn’t form a visible coat over the mucosa.

<table>
<thead>
<tr>
<th>Cell Feature</th>
<th>Surface Mucous Cells</th>
<th>Neck Mucous Cells</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Surface of stomach</td>
<td>Neck region of</td>
</tr>
<tr>
<td></td>
<td>Gastric pits</td>
<td>gastric glands</td>
</tr>
<tr>
<td>Size</td>
<td>Longer</td>
<td>Shorter</td>
</tr>
<tr>
<td>Mucinogen granules</td>
<td>More</td>
<td>Less</td>
</tr>
<tr>
<td>Nucleus</td>
<td>Oval</td>
<td>Round</td>
</tr>
<tr>
<td>Mucus</td>
<td>Thick</td>
<td>Thin</td>
</tr>
</tbody>
</table>
3) **Stem cells:**
Undifferentiated highly mitotic cells that are usually present in the isthmus region of the gastric glands. They divide and differentiate to form the surface epithelial cells and the various cells of the gastric glands.

4) **Chief cells:**
- Lower part of the gland.
- Abundant rough endoplasmic reticulum in the basal part → Basophilic.
- Acidophilic secretory vesicles in apical part.
- Secrete Pepsinogen and Gastric Lipase.
5) **Parietal (Oxyntic) Cells:**

- In upper part of gland
- Large pyramidal cells
- Central nucleus
- Abundant mitochondria → Eosinophilic
- *Special features depending on activity*
- Long life span → about 200 days (?)

- **Function:**
  a) Secretion of HCl
  b) Secretion of Intrinsic Factor (Important for the absorption of Vitamin B\textsubscript{12})
**Active phase:**

the cell has a deep circular invagination, **the intracellular canaliculus**, into which protrude numerous microvilli. This provides an increased surface area for secretion.

**Resting phase:**

the canaliculus is short and the microvilli are absent; however, the cytoplasm is filled with **tubulovesicular structures** that fuse with the cell membrane when the cell is activated producing the deep canaliculus and the microvilli.
### Differences between Parietal and Chief cells of the gastric epithelium

<table>
<thead>
<tr>
<th>Feature</th>
<th>Parietal</th>
<th>Chief</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Upper part of gastric glands</td>
<td>Lower part of gastric gland</td>
</tr>
<tr>
<td>Size</td>
<td>Larger</td>
<td>Smaller</td>
</tr>
<tr>
<td>Cytoplasm</td>
<td>Acidophilic</td>
<td>Mostly basophilic</td>
</tr>
<tr>
<td>Vesicles</td>
<td>Tubulovesicles</td>
<td>Secretory vesicles in the apical part of the cell</td>
</tr>
<tr>
<td>Secretes</td>
<td>Hydrochloric acid Intrinsic Factor</td>
<td>Pepsinogen Gastric Lipase</td>
</tr>
</tbody>
</table>
Factors protecting gastric mucosa against HCl:

1. Mucus and bicarbonate secreted by the surface epithelium.
2. The surface epithelial cells have tight intercellular junctions and ion transporters that maintain the H$^+$ and HCO$_3^-$ concentrations.
3. Rapid turnover of the surface epithelial cells: about 5 days.
4. Extensive blood vessels in the lamina propria that provide nutrients, remove toxic material and help replace damaged cells.

Failure of these factors will make the gastric mucosa susceptible to damage by HCl and this will ultimately lead to ulceration. Damage to parietal cells will also lead to Vitamin B$_{12}$ deficiency (due to lack of intrinsic factor), which causes pernicious anemia.
6) **Enteroendocrine cells:**

- Found in the lower part of the gland.
- Secrete hormones.
- Secretory granules are usually found in the lower part of the cell. Example: G-cells (open type) which secrete gastrin.
- They could of two types:
  1. **Closed type** in which the cell is not in contact with lumen.
  2. **Open type**: the cell has a wide basal region with a thin apical process that reaches the lumen. The process ends in several microvilli which act as chemoreceptors that detect the contents of the lumen.
Regional differences in mucosa

1) **The Cardia**: simple branched spiral gland. Mainly mucus secreting.

2) **Pylorus**: Deep pit. 2-3 spiral glands open into pit. Mucus and Gastrin secreting.

3) **Fundus/Body**: Pit not deep. 5-7 tubular glands open into pit. All cell types, mainly Parietal and Chief cells, are present.
• **Mucosa:** *lamina propria* is a loose connective tissue layer that surrounds and supports the gastric pits and glands. It’s highly vascular and contains smooth muscle cells and some lymphoid cells. The *muscularis mucosae* is a smooth muscle cell layer (could be two) that separates the mucosa from the submucosa.

• **Submucosa** is a dense connective tissue layer present under the mucosa. It contains the submucosal plexus of nerves that innervates the blood vessels of this layer and the smooth muscles of the muscularis mucosae.
• **Muscularis externa** has 3 layers: outer *Longitudinal*, middle *Circular* and inner *Oblique*. Help mix food well with gastric juice. Circular layer in pylorus thickens to form the pyloric sphincter. The myenteric plexus of nerves is located between these layers and innervates them.

• **Serosa** (visceral peritoneum): areolar connective tissue and mesothelium. Continuous with the lesser and greater omenta.
HISTOLOGY OF THE SMALL AND LARGE INTESTINES

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(2021)
Histology of the Small Intestine

- Has the same general layout seen in the rest of the GIT
- The outermost layer, however, could be either serosa (formed of connective tissue and epithelium) or adventitia (formed of connective tissue only). This depends on whether that part of the small intestine is covered by peritoneum or not.
Permanent circular folds of mucosa and submucosa are present in the wall of the small intestine; these are called *plicae circulares*. They start in the duodenum, are most numerous in the jejunum and are few/absent in the ileum.

These folds increase the surface area of absorption and slow the passage of food through the intestine allowing more time for the intestine to absorb nutrients.
Mucosa

- Formed of epithelium, lamina propria and muscularis mucosae.

- Epithelium and lamina propria project into the lumen forming ‘**Villi**’ which increase surface area of absorption.

- Simple tubular glands open between the villi. These are called: *Intestinal Crypts* (of Lieberkuhn).
Cells of the Villi

1) **Enterocytes**: are tall columnar cells with an oval nucleus in the basal half of the cell. The apical surface of the cell has a brush border formed of numerous microvilli that contain the digestive enzymes. The microvilli increase the surface area of absorption.

- Plicae circulares, villi, and microvilli all participate in increasing the surface area of absorption.
2) **Goblet cells:**

- **Mucus secreting cells.**
- Found between the epithelial cell.
- Less in duodenum, more in ileum.
- Apical part is distended with mucinogen granules.
- Golgi apparatus forms a wide cup just below the granules.

- The stem shaped basal part contains the nucleus, numerous rough endoplasmic reticula, and mitochondria.
- Microvilli are restricted to a thin rim of cytoplasm that surrounds the apical part.
Core of the Villi

• The core of the villus is formed of:

1. The connective tissue of the lamina propria.
2. An arteriole, a venule and a lymphatic vessel (lacteal) that are connected to submucosal plexuses.
3. Smooth muscle fibers derived from the muscularis mucosae that pass into the villus and play an important role in its rhythmic movement.
Cells of the Crypts

1) Enterocytes
2) Goblet cells
3) Enteroendocrine cells (these release cholycystokinin, secretin, motilin, and others)

4) **Stem cells**: replace all the other cells. Enterocyte produced thus migrate from the crypt to the tip of the villus where they die. This process (cell turnover) takes about 5 days.

5) **Paneth cells**: produce various substances into the lumen of the intestine for the non-specific resistance against organisms.
6) **M (Microfold) cells**

- Present in the ileum overlying Peyer’s Patches.
- Apical surface has microfolds.
- Basal surface has a membrane invagination that produces a pocket which contains lymphocytes and macrophages.
- Their function is the **non-specific uptake of antigens from the intestinal lumen**. These antigens are, then, transported to the macrophages and lymphocytes present in the subcellular pockets where they are processed to activate the immune system.
Where is the lumen in the villus and crypt? Where are the secretory granules usually located in each?
Other layers

- Submucosa of the duodenum has duodenal (Brunner) glands. These secrete mucus which lubricates intestinal wall, neutralizes gastric acid, and provides optimal pH for the action of the enzymes.

- Submucosa of the ileum has a collection of lymphoid tissue called **Peyer’s Patches**. These play an important immune role.

- The submucosa has the submucosal plexus.
• The muscularis externa is formed of two layers. Outer longitudinal and inner circular between which we have the myenteric plexus.

• Serosa is continuous with the mesentry. The retroperitoneal parts of the small intestine (parts of the duodenum) are covered only by connective tissue adventitia.
Histology of the Large Intestine

**Mucosa**

- The large intestine is lined by a simple columnar epithelium which passes into the lamina propria to form tubular intestinal glands.

- This epithelium is formed of:
  1. *Colonocytes*
  2. *Goblet cells*: these become more numerous as we go distally along the large intestine
  3. *Stem cells*: which are located in the bottom third of each gland.
(a) Large intestine tunics

- Opening to intestinal gland
- Simple columnar epithelium
- Intestinal gland
- Lamina propria
- Lymphatic nodule
- Muscularis mucosae
- Nerves
- Arteriole
- Venule
- Serosa

(b) Large intestine mucosa and submucosa

- Opening to intestinal gland
- Goblet cells
- Simple columnar epithelium
- Intestinal gland
- Muscularis mucosae
- Circular layer
- Longitudinal layer (tania coli)
Colonocytes
- Columnar cells.
- Short microvilli at the apical surface.
- Large intercellular spaces between the cells.
- *Function:* Absorption of water.

Lamina propria
- Rich in lymphatic nodules that extend into the submucosa. This is due to the large bacterial content of the large bowel. This is most prominently seen in the appendix.

Mucularis mucosae
- A layer of smooth muscle cells
Muscularis externa

- Formed of two layers
  1. Inner circular
  2. Outer longitudinal: in the colon, the muscle cells of this layer aggregate in three bundles called *taenia coli*.

- Taenia coli are shorter than the large intestine. This results in puckering of the colon into large sacs called haustra.

Serosa/Adventitia

- The intraperitoneal parts of the large intestine are covered by serosa.

- The serosa of the colon forms several pendulous fat-filled sacs called *appendices epiploicae* (omental appendices).
The Appendix

- Has the same general layout of the large intestine.

- The mucosa and submucosa are filled with a large number of lymphatic nodules with distinct germinal centers.

- The outer longitudinal layer of the muscularis externa is continuous (not divided into bundles).

- The outer serosa is continuous with the mesentery of the appendix.
The Anal Canal

- The anal canal shows several longitudinal folds of mucosa and submucosa called *anal columns*.
- The rectum shows 3 prominent transverse rectal folds caused by enlargement of the muscle layer of the wall. The rest of the large intestine shows only few transverse semi-lunar folds.

- In the lamina propria and the submucosa of the anal columns, sinuses of the anal venous plexuses are located. When these sinuses are enlarged, they are called *haemorrhoids*.

- In the lower part of the anal canal, the circular muscle layer is thickened to form the *internal (involuntary) anal sphincter*. 
- At the pectinate (dentate) line (at the lower end of the anal columns), the simple columnar epithelium is changed into stratified squamous (non-keratinized) epithelium.

- Approximately at the level of the interval between the internal and external anal sphincters, at a line visible in the living person called the ‘white line’, the epithelium becomes stratified squamous keratinized.
Rectal mucosa

Levator ani muscle

External anal sphincter muscle

Internal anal sphincter muscle

Dentate (pectinate) line

Perianal skin

Squamous mucosa

Anal columns

Anocutaneous line (White line of Hilton)
Thank You