Gastrointestinal System Lecture Objectives

• Describe the general layered organization of the GI system, including the location and appearance of:
  • Mucosa with epithelium, lamina propria, glands, and muscularis mucosae
  • Submucosa with glands and Meissner’s submucosal nerve plexus
  • Muscularis (externa) with Auerbach’s myenteric nerve plexus
  • Serosa or adventitia

• Describe how each layer changes as one moves through the entire digestive tract.
Describe the structure and function of the cells that are present in:

- Esophageal glands and esophageal cardiac glands
- Gastric pits and gastric glands
- Intestinal glands or crypts (glands of Lieberkuhn) of the small intestine and the large intestine
- Duodenal glands (mucous glands of Brunner)
Gastrointestinal System Lecture Outline

• Introduction
• Esophagus
• Stomach
• Small intestine
• Large intestine
Gastrointestinal System Lecture Outline

• Introduction
Components of the GI System

The digestive tract consists of:

- Oral cavity
- Esophagus
- Stomach
- Small and large intestine

Organs associated with the digestive tract include:

- Salivary glands
- Pancreas
- Liver
- Gallbladder
Layers in the GI System

- **Mucosa** with epithelium, loose connective tissue of lamina propria, and muscularis mucosae
- **Submucosa** with glands, denser connective tissue, and Meissner’s submucosal nerve plexus
- **Muscularis** with Auerbach’s myenteric nerve plexus
- **Adventitia** or serosa
General Structure of the GI Tract
General Structure of the GI Tract

- Mucosa
  - Epithelium
  - Lamina propria
  - Muscularis mucosae

- Submucosa
  - Submucosal gland
  - Blood vessel
  - Submucosal nerve plexus

- Muscularis
  - Inner circular layer
  - Myenteric nerve plexus
  - Outer longitudinal layer

- Serosa
Gastrointestinal System Lecture Outline

• Introduction
• Esophagus
Esophagus: Mucosa

- Epithelium: non-keratinized stratified squamous
- Lamina propria:
  - May have lymphoid tissue (MALT)
  - Esophageal mucous (cardiac) glands located close to stomach
- Muscularis mucosae: typical
Differences between upper, middle lower esophagus
Esophagus: very low power view
Esophagus: Other Layers

- Submucosa: glands and MALT
- Muscularis externa:
  - Upper third: all skeletal muscle
  - Middle third: mixed skeletal and smooth muscle
  - Lower third: all smooth muscle
- Adventitia surrounds almost all of the esophagus
Esophagus: submucosa with glands
Esophagus: muscularis externa
Esophagus: Myenteric plexus
Esophagus: adventitia
Gastrointestinal System Lecture Outline

• Introduction
• Esophagus
• Stomach
Functions of the Stomach

- Mixes food to produce chyme
- Begins digestion process
- Produces intrinsic factor for absorption of vitamin B12 from the ileum
- Absorbs a few nutrients
Stomach: Mucosa

• The epithelium of the stomach consists of simple columnar mucous epithelial cells which invaginate into lamina propria to form gastric pits or foveolae.

• Rest of lamina propria contains gastric glands.

• Muscularis mucosae is typical.
Stomach histology

Mucosa
- Surface epithelium
- Gastric pit or foveolae
  - Simple columnar epithelium
- Gastric gland
- Lamina propria
- Muscularis mucosae

Submucosa
- Muscularis
- Serosa

Stomach histology
Mucosa of Body and Fundus

• Surface epithelium forms short pits (1/4 of the mucosal thickness).
• 2-4 straight-ish, long glands empty into each pit.
• Cells present include mucous neck cells, stem cells, parietal cells, chief cells, enteroendocrine cells.
Mucosa of body and fundus
Mucosa of body and fundus

- short pits
- long straight glands
- parietal cells
Stomach: fundic mucosa
Fundic mucosa: gastric pits
Fundic mucosa: gastric glands
Cells of Gastric Glands in Body/Fundus

- Mucous neck cells
- Parietal cells
- Chief cells
- Stem cells
- Enteroendocrine cells
Cells of Gastric Glands in Body/Fundus

- Mucous neck cells: make protective mucus
Cells of Gastric Glands in Body/Fundus

- Mucous neck cells
- Parietal cells
  - Make intrinsic factor (necessary for B12 absorption) and HCl
  - Have intracellular canaliculi and microvilli
  - Located mostly in neck and body of gland
  - Intensely eosinophilic (lots of mitochondria)
Cells of Gastric Glands in Body/Fundus

- Mucous neck cells
- Parietal cells
- Chief (or zymogenic) cells
  - Secrete pepsinogen, which is converted into pepsin by HCl
  - Pepsin hydrolyzes proteins
  - Located in base of glands
  - Very basophilic due to rough ER
Cells of Gastric Glands in Body/Fundus

- Mucous neck cells
- Parietal cells
- Chief cells
- Stem cells
  - Replenish epithelium
  - Located mostly in isthmus
Cells of Gastric Glands in Body/Fundus

- Mucous neck cells
- Parietal cells
- Chief cells
- Stem cells
- Enteroendocrine cells
  - Secrete hormones related to digestion (like gastrin)
Mucosa of Pyloric Region

- Surface epithelium forms long pits (2/3 of the mucosal thickness).
- 2-4 branched, coiled glands empty into each pit.
- Cells present include mucous neck cells and stem cells.
Mucosa of pyloric region
Mucosa of pyloric region

- long pits
- short, branched glands

Mucosa of pyloric region
Stomach: pyloric mucosa
Mucosa of Cardiac Region

• Similar to mucosa of pyloric region, except pits are short (1/4 of the mucosal thickness).

• Glands (coiled) and cells (mucous neck and stem cells) are same as pyloric region.
## Summary: Pits and Cells

<table>
<thead>
<tr>
<th></th>
<th>Cardia</th>
<th>Fundus/Body</th>
<th>Pylorus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pit</td>
<td>short</td>
<td>short</td>
<td>long</td>
</tr>
<tr>
<td>Cells</td>
<td>Mucous, stem</td>
<td>Mucous, stem, parietal, chief, enteroendocrine</td>
<td>Mucous, stem</td>
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</table>
Stomach: Remaining Layers

- Submucosa
  - Connective tissue with blood vessels and lymphatics
  - Meissner’s autonomic plexus
- Muscularis externa
  - 3 layers of smooth muscle (inner oblique, middle circular, outer longitudinal)
  - Myenteric nerve plexus between middle and outer layers
- Serosa
Muscularis externa

Inner oblique(ish)

Middle circular

Nerve plexus

Outer longitudinal

Muscularis externa
Gastrointestinal System Lecture Outline

• Introduction
• Esophagus
• Stomach
• Small intestine
Functions of Small Intestine

- Complete digestion of food
- Absorb final products of digestion (amino acids, monosaccharides, fatty acids, etc.)
- Secrete protective mucus
- Secrete hormones
Proximal

Distal

Plicae circulares or valves of Kerckring
Plicae circulares

Villus

Mucosa

Submucosa

Muscularis

Serosa

Mesothelium
Small Intestine: Anatomic Regions

- Duodenum: immediately distal to pylorus of stomach (12 inches)
- Jejunum: distal to duodenum (8 feet)
- Ileum: most distal region (12 feet)
Your small intestine is basically a 22-foot-long pipe that has a diameter of an inch or so. What’s the total surface area?
This is the actual surface area (2700 square feet)!
How can the surface area be so large? Folds, folds and more folds.

- **Plicae circulares**: circular infoldings of mucosa and submucosa in duodenum and upper jejunum
- **Villi**: mucosal folds
- **Microvilli**: tiny folds on cell surface
Small intestine: plicae circulares
Small intestine: layers

- Epithelium
- Lamina propria
- Muscularis mucosa
- Submucosa
- Muscularis externa
- Auerbach’s plexus
- Serosa

Small intestine: layers
Small intestine: plicum and villi
Small Intestine: Villi and Glands

• Villi are fingerlike processes of epithelium (with a core of lamina propria) projecting into the lumen. There is smooth muscle in the lamina propria which helps the villi move.

• Intestinal glands (Crypts of Lieberkühn) are invaginations of epithelium into the lamina propria.

• Epithelium covering the villi and lining the crypts is continuous (but there are different cell types in different parts).
Goblet cells
Lamina propria
Lacteal or central lymphatic
Capillary network with an artery and vein
Smooth muscle
Undifferentiated columnar cells
Paneth cells
Muscularis mucosae

Simple columnar epithelium
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Crypt of Lieberkuhn (intestinal gland)
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Undiffere
Intestinal villi

Crypts of Lieberkühn
Small intestine: villi and glands (crypts)
Cells of Epithelium Covering Villi

- Simple columnar absorptive cells
  - Most numerous
  - Have nice microvilli ("brush border")
  - Function: absorb nutrients

- Mucous goblet cells
  - Produce mucus for protection
  - Increase in number as you move down the intestinal tract
Small intestine: epithelial cells and goblet cells
Cells in Epithelium of Glands (Crypts)

- Simple columnar absorptive cells
- Mucous goblet cells
Cells in Epithelium of Glands (Crypts)

- Simple columnar absorptive cells
- Mucous goblet cells
- Enteroendocrine cells
  - Secrete a bunch of hormones related to digestion (like cholecystokinin)
Cells in Epithelium of Glands (Crypts)

- Simple columnar absorptive cells
- Mucous goblet cells
- Enteroendocrine cells
- Paneth cells
  - Deep in crypts
  - Produce lysozyme and defensins (antibacterial substances)
Cells in Epithelium of Glands (Crypts)

- Simple columnar absorptive cells
- Mucous goblet cells
- Enteroendocrine cells
- Paneth cells
- M (microfold) cells
  - Eat bugs/foreign stuff and present antigens to immune cells
Cells in Epithelium of Glands (Crypts)

- Simple columnar absorptive cells
- Mucous goblet cells
- Enteroendocrine cells
- Paneth cells
- M (microfold) cells
- Stem cells
  - Replenish cells of epithelium
Small intestine: glands
Small intestine: Paneth cells
How to Tell Apart Small Intestine from Stomach

- **Villi.** Small intestine has them; stomach does not.

- **Epithelium.** Small intestine has alternating absorptive cells (with microvilli) and goblet cells. Stomach has simple columnar mucous cells (no microvilli) and no goblet cells.

- **Paneth cells.** Small intestine has them; stomach does not.
Duodenum, Jejunum and Ileum

- All have similar epithelium and glands (crypts).
- All have villi.
- All have similar muscularis mucosae and externa.
- Differences lie in lamina propria and submucosa!
Duodenum

- Coolest feature of duodenum: Brunner’s glands.
- Present in submucosa; extend into lamina propria.
- Secrete alkaline mucous.
Duodenum: low power
Duodenum: Brunner’s glands
Ileum

• Coolest feature of ileum: Peyer’s patches.
• Lymphoid tissue present in submucosa, usually in nodules (follicles).
• Good example of mucosa-associated lymphoid tissue (MALT).
• Good idea to have additional, special lymphoid tissue. The gut is basically a tube open to the outside – think of all the bugs and foreign material it is exposed to!
Ileum: Peyer’s patch
Jejunum

• Coolest feature of jejunum: well, there isn’t a particularly cool feature unique to the jejunum. Sorry jejunum.

• To distinguish it from the duodenum and ileum, though, note that it does NOT have either Brunner’s glands (like the duodenum) or Peyer’s patches (like the ileum).
Jejunum: Submucosa without Brunner’s glands or Peyer’s patches
### Summary: Features of Small Intestine

<table>
<thead>
<tr>
<th></th>
<th>Duodenum</th>
<th>Jejunum</th>
<th>Ileum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Villi</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Microvilli on absorptive cells</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Goblet cells</td>
<td>some</td>
<td>more</td>
<td>most</td>
</tr>
<tr>
<td>Paneth cells</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Brunner’s glands</td>
<td>yes</td>
<td>no</td>
<td>no</td>
</tr>
<tr>
<td>Peyer’s patches</td>
<td>no</td>
<td>no</td>
<td>yes</td>
</tr>
</tbody>
</table>
Gastrointestinal System Lecture Outline

- Introduction
- Esophagus
- Stomach
- Small intestine
- Large intestine
Functions of the Large Intestine

- Absorption of water
- Secretion of mucus to lubricate dehydrated feces
Anatomical Regions of Large Intestine

- Transverse colon
- Ascending colon
- Cecum
- Vermiform appendix
- Rectum
- Descending colon
- Sigmoid colon
- Anal canal
Wall of large intestine
Large intestine: low-power view

- Submucosa
- Muscularis mucosa
- Epithelium and lamina propria
- Muscularis externa
- Serosa or adventitia
- Large intestine: low-power view
Large intestine: layers

- Epithelium and lamina propria
- Muscularis mucosa
- Submucosa
- Muscularis externa
Mucosa of Large Intestine

• Epithelium is simple columnar and contains:
  • Absorptive cells with microvilli
  • Mucous goblet cells (abundant!)
  • Enteroendocrine cells
  • Stem cells

• Epithelium invaginates into lamina propria forming Crypts of Lieberkuhn (intestinal glands).

• Differences from small intestine: Villi and plicae circulaires are not present, and Paneth cells are rare.
Colon: mucosa

Epithelium

Lamina propria

Muscularis mucosa

Colon: mucosa
Large Intestine: Remaining Layers

- Submucosa is similar to small intestine; may have lymphoid nodules extending from lamina propria
- Muscularis externa
  - Inner circular layer
  - Outer longitudinal layer (in 3 bundles: taenia coli)
- Serosa or adventitia
  - Transverse colon has serosa
  - Ascending and descending colon have adventitia
Colon: muscularis externa

- Inner circular layer
- Auerbach’s plexus
- Outer longitudinal layer (taenia coli)
Appendix

- Attached to cecum
- Histology similar to colon except:
  - No taenia coli
  - Lots of lymphatic tissue (both diffuse and in nodules) present in lamina propria and submucosa
Appendix: mucosa

Crypts

Lamina propria
Rectum

- Last 6-8 inches of large intestine
- Epithelium has tons of goblet cells
- Mucosa has longitudinal folds called the rectal columns of Morgagni
Anus

- Last 1-1 ½ inches of large intestine
- Stratified squamous epithelium; no muscularis mucosae or lamina propria
- Submucosa has large veins (susceptible to dilation)
- Internal anal sphincter is composed of circular layer of smooth muscle
- External anal sphincter is composed of skeletal muscle (under voluntary control)
Recto-anal junction: super low-power view

Simple columnar epithelium of colorectal zone

Pectinate line

Stratified squamous epithelium of the anal canal
Recto-anal junction

- **Internal anal sphincter (smooth muscle)**
- **External anal sphincter (skeletal muscle)**
- **Anal glands**
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