

Cells and Tissues of the GI System

Directly exposed to the outside world – has protective mechanisms

Components:

- Esophagus – transit of ingested food
- Stomach – site of physical fragmentation
- Small intestine – where digestion and absorption occurs
- Large intestine/rectum – elimination of waste
- Liver – makes bile
- Gallbladder – stores bile
 - Bile delivered to digestive tract to solubilize fats and assist in process
- Salivary glands – produce amylase
- Pancreas – produces enzymes

Digestive process involves 5 phases:

- Ingestion of food
- Physical fragmentation
- Enzymatic digestion
- Absorption
- Elimination of waste

Goal is to break down macromolecules into simple molecules

- Proteins – amino acids
- Complex sugars – monosaccharides
- Lipids – fatty acids and monoglycerides

Maximization of surface area

- Length
- Surface specializations
- Ex. Small intestine: plicae circulars, villi, microvilli

Overall common structure of GI tract

- **Mucosa** – three layers make up the mucous membrane
 - Epithelial lining – barrier between outside world and body, simple columnar, lines glands
 - Lamina propria – connective tissue layer containing fibroblasts, lymphocytes, and vessels
 - Muscularis mucosae – thin muscular layer involved in local movement for mixing process
 - Structures
 - Lymphoid nodules – protective mechanism
 - Mucosal glands – crypts of Lieberkuhn
 - Intestinal villi - folds
- **Submucosa** – next connective tissue layer, also contains blood vessels, collagen and submucosal glands
 - Meissner's plexus – important nerve plexus, helps innervate muscularis mucosa
- **Muscularis externa** – comprised of two muscle layers organized at right angles to one another, involved in peristalsis.
 - Inner circular muscle – runs circumferentially
 - Outer longitudinal muscle – runs the length of the tube
 - Auerbach's plexus – between two muscle layers, controls peristalsis
- **Serosa** – outermost layer where gut suspended by mesentery, covered by mesothelium, some places called **adventitia** (at esophagus)

Structures

- Glands – mucous helps passage of food and provides a protective coating over epithelial lining
 - Mucosal glands - dip down into mucosa, simple epithelium lining villi of intestine continuous with epithelium of glands

- Crypts of Lieberkuhn – in small and large intestine
 - Submucosal glands
- Blood vessels – enter through mesentery and ramify throughout wall of GI tract (submucosa and lamina propria)
 - Capillaries are continuous except for in villi
 - In villi, capillaries are fenestrated to absorb nutrients from absorptive cells
 - Blood flows from intestines to liver for processing
- Lymphatics
 - Lacteal – in core of villus, responsible for lipid absorption in the form of chylomicrons. Evade liver and go into general circulation
- Nerves – Meissner’s and Auerbach’s plexus
 - Meissner’s plexus – large nerve cell bodies seen
 - Auerbach’s plexus – in between inner circular and outer longitudinal
 - Hirschsprung’s disease (congenital megacolon) – caused by absence of these nerve plexuses in a segment of the colon, resulting in lack of peristalsis and obstruction. Often requires resection.
- Lymphoid cells – lymphocytes throughout lamina propria in the GI tract, protective role against microorganisms
 - In some cases, organized into lymph nodules
 - MALT – mucosal associated lymphoid tissue
 - Most common antibody is IgA, specific to GI tract, secreted in lamina propria by lymphocytes
 - IgA picked up by receptor on epithelial cell surface → endocytosed and transcytosed to lumen of epithelium → proteolytic cleavage of antibody from receptor but leaves portion of receptor called secretory component → secretory components protect IgA inside lumen

GI tract

- **Esophagus** – muscular tube that conveys food from the pharynx to stomach
 - Mucosa in relaxed state is deeply infolded – flattens out upon passage of bolus of food
 - Stratified squamous epithelium is protective
 - Layers
 - Mucosal layer
 - Epithelium - thick stratified squamous epithelium, protects, stretches
 - Lamina propria
 - Muscularis mucosa – discontinuous, patchy; because involved mostly in digestion
 - Submucosa
 - Submucosal mucous glands – lubrication via ducts into lumen
 - Muscularis externa – inner circular and outer longitudinal skeletal muscle in upper esophagus, smooth muscle in other parts of tract
 - In mid-esophagus, patches of smooth muscle mixed with striated muscle.
 - In bottom esophagus, all smooth muscle
 - Adventitia
- Esophageal-gastric junction – a sphincter is closed in the absence of food bolus to prevent acid reflux
 - Distinct junction in epithelial layer – stratified squamous epithelium of esophagus abruptly changes to a simple columnar epithelium of stomach that is glandular. Signifies change in function.
- **Stomach** – food held 2 hrs, mechanical breakdown, some chemical denaturation of protein by HCl and protein breakdown by pepsin. Ingested microbes killed by HCl, very little absorption
 - Pitted surface – pits go down into gastric glands which produce HCl, pepsin and mucous.
 - Mucous protects stomach lining from HCl
 - Four components
 - **Cardiac** – first part
 - Short pits, short glands
 - Almost all mucous cells
 - **Fundus** – characterized by fundic glands
 - Short pits and long glands
 - Produce pepsin and HCl
 - **Body (corpus)** – histologically categorized with fundic regions, most of the stomach
 - **Pyloric** – last part, chyme exits stomach through pyloric sphincter
 - Long pits, short glands

- Mucous cells and G-cells scattered throughout glands
 - Helicobacter pylori – replicates in mucous of pyloric region, produces molecules that attack epithelial lining, major cause of stomach ulcers
 - **Rugae** – folds that stretch and flatten out when stomach fills
 - Mucosa
 - Stomach glands – gastric pits lead into glands in mucosal tunic
 - Fundic glands
 - Pit
 - Neck – branches out to body
 - Body of gland – lumens very narrow
 - 5 cell types
 - **Surface mucus**
 - **Neck mucus** – produces different kind of mucus
 - **Parietal cell** – HCl and Intrinsic factor, “fried eggs”
 - Contain infoldings and, in resting cells, contain vesicles
 - Vesicles contain H⁺ pumping ATP-ase; when stimulated to produce HCl, tubulovesicles fuse with indentation to make a canaliculus (a channel for HCl to leave cell)
 - H⁺ pumped into lumen of canaliculus, Cl⁻ channel in luminal wall also
 - Also makes Intrinsic Factor – combines with vitamin B₁₂ and makes it absorbable by small intestine
 - **Peptic Chief** – bottom of cell glands, contain pepsinogen containing granules
 - HCl causes conversion to pepsin which digests protein
 - **Enteroendocrine** – **APUD** cell, secretes peptide hormones into lamina propria, not lumen, where it is taken up into circulation and coordinates gut processes
 - Scattered throughout gastric glands
 - APUD (amine precursor uptake and decarboxylase), chromaffin cells (stain brown with chromium), argentaffin cells (stain with silver stains), located on edges of glands
 - Two types – some in contact with and sampling the lumen, others at the lamina propria side of epithelium
 - Different types secrete specific types of protein hormones
 - G-cells produce gastrin, S-cells produce secretin, I-cells produce CCK, EC-cells produce serotonin, etc.
 - Regulate and coordinate GI tract function, multiple roles of hormones, long-term effects, effects on different organs
 - Differential distribution of APUD cell types across GI epithelium
 - Gastrin concentrated in pyloric antrum
- Submucosa
- Muscularis
 - **Inner oblique** – an additional layer, mechanical agitation
 - Middle circular
 - Outer longitudinal
- **Small Intestine**
 - **Villi** - a distinctive feature, villi covered with goblet and absorptive cells
 - Lined with simple columnar epithelium continuous with that of Crypts
 - **Enterocytes** – intestinal absorptive cells, columnar cells with basal nuclei, both digestion and absorption
 - Synthesizes digestive enzymes that are tethered to their surface
 - Secrete enterokinase, which activates trypsinogen from pancreas to form trypsin
 - Absorb sugars, amino acids, fatty acids, monoglycerides; passed on to lamina propria and fenestrated capillaries and delivered to portal circulation
 - Resynthesize triglycerides and package them into chylomicrons, which are secreted into lamina propria and picked up by lacteals
 - Glycocalyx – surface involved with digestion with transporters involved in absorption
 - **Crypts**
 - Enterocytes
 - Goblet cells
 - Dividing cells – give rise to enterocytes and goblet cells

- **Paneth cells** – at the base of the Crypts, filled with granules containing secretory products
 - Lysozyme and defensins for protection from bacteria
 - Enteroendocrine cells (APUD)
 - **Gastroduodenal junction** – abrupt change in epithelium from pitted glandular stomach epithelia to villi of small intestine
 - **Duodenum** – where pancreatic enzymes and bile from liver enter GI tract
 - **Brunner's glands** – submucosal, distinctive feature; makes alkaline mucous that counteracts stomach acid
 - Pancreatic enzymes and bile enter via common bile duct
 - Digestion and absorption
 - **Jejunum**
 - **Plicae circulares** – permanent folds that help increase surface area, covered in villi which are covered by absorptive cells (enterocytes), most prominent in jejunum, serves as platform for villi
 - Site of most absorption
 - **Ileum**
 - **Peyer's patches** – clusters of lymphatic nodules, distinctive of ileum; covered by M-cells which sample antigens in the lumen
 - **Ileo-caecal junction**
 - Ileo-caecal valve – outcropping of inner circular muscle
 - Shows differences between small and large intestine
 - **Colon** – flat, pitted surface, glandular
 - No villi, colonic glands (crypts) instead
 - Recovery of H₂O and salts from undigested material and propulsion of solid waste to rectum (mucous important)
 - Cell types
 - Absorptive cells
 - Goblet cells
 - APUD cells
 - Outer longitudinal muscle is divided into three separate bands called taenia coli
 - **Appendix** – small, blind-ended sac extending from the first part of the colon (caecum), just past ileo-caecal junction
 - Function unknown, similar to colon, narrower lumen
 - Massive amount of lymphoid tissue in the form of follicles or large aggregations of lymphocytes in the lamina propria
 - **Recto-anal junction** – distinct change in epithelium reflects function
 - Simple columnar rectum, stratified squamous anus
 - Rectum – short, dilated terminal portion of the large intestine that functions to store feces

Digestion

- Begins with amylase produced by salivary glands – begins to break down starches
- In the stomach, HCl denatures proteins and pepsin begins to break down proteins
- In duodenum, the major portion of macromolecular breakdown occurs
 - Chyme enters from the stomach
 - Acid neutralized by alkaline mucous
 - Amylases, peptides, lipases
 - Many are produced in pancreas
 - Many produced by enterocytes
 - Bile from liver help to solubilize fats
- Mucous secretion is super important throughout, protective function to underlying cells

Mucosa is a diagnostic feature of the GI tract sections

- Esophagus – stratified, squamous epithelium
- Stomach – flat, pitted, glandular epithelium
- Small intestine – villi
- Large intestine – flat, glandular (test tubes in a rack)