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Tubular GI tract

Pharynx
Esophagus
Stomach
Small Intestine
Cecum and appendix
Large intestine
Rectum/Anus

J. Matthew Velkey
M1 – GI Sequence
Winter, 2009

Original: Fig 14.1 from Young & Heath, Wheater’s Functional Histology, 4th ed. (2000), p250
Ingestion: 2L/day

Absorption: 8.8L/day

Secretion: 7L/day

Saliva: 1L
Stomach: 2L
Bile: 1L
Pancreas: 2L
Small intestine: 1L

Feces: 0.2L/day

Four distinct layers in the GI tube:
- Mucosa (*)
- Submucosa
- Muscularis externa
- Serosa

*Mucosa = Epithelium Lamina propria Muscularis mucosae

Frank Boumphrey, M.D, Wikipedia

Original: Fig 14.1 from Young & Heath, Wheater’s Functional Histology, 4th ed. (2000), p250
Functions of the GI mucosa*

(*Mucosa = Epithelium, lamina propria, muscularis mucosae)

Protection - Esophagus, stomach, colon
Absorption - Small intestine (colon)
Secretion - Stomach (Small intestine)

Secretion is accomplished by glands located:
 a. In the mucosa (stomach, small + large intestine)
 b. In the submucosa (only in esophagus, duodenum)
 c. Outside of the tubular gut (extramural glands)
   e.g., liver, pancreas.
Pharynx

Short region connecting oral cavity with the larynx and esophagus.

Passageway for air and food; Resonating chamber for speech
Pharynx

Epithelium: stratified squamous non-keratinized

Prominent elastic fibers in lamina propria

Muscle wall: striated muscle

No muscularis mucosae, no submucosa.

(accessory salivary gland)
Esophagus

Delivers food and liquid from pharynx to stomach

Attributes:
Straight tube, ~25 cm long

Expandable lumen: extensive muscularis mucosae, elastic fibers in submucosa

Protective epithelium (stratified squamous non-keratinized)

Muscularis externa:
upper 1/3 = striated (skeletal) muscle
middle 1/3 = mixed smooth and striated
lower 1/3 = smooth muscle
Muscularis externa (Muscularis propria):
Inner circular (CM)
Outer longitudinal (LM)

Epithelium (E):
Stratified squamous
Non-keratinized

Extensive muscularis mucosae (MM)

Glands (G)
- Mostly in submucosa
- Primarily mucous secretion
- Note: upper and lower esophagus also has MUCOSAL glands (called “cardiac” due to similarity to cardiac glands of the stomach)

As with any region of the GI tract, lymph nodules (Ly) may be present –usually in the lamina propria and occasionally extending into the submucosa
Lymphatic nodules in lamina propria and/or submucosa (part of GALT, gut-associated lymphoid tissue)

Esophageal glands (submucosal) secrete acidic mucous - lubricates the luminal wall; ducts carry secreted mucous to the lumen.
Esophagus: mucosa & submucosa

• Stratified squamous epithelium (stem cells in stratum basale)
• Thick muscularis mucosae (circular layer & longitudinal layer)
• Submucosal mucous glands

Muscularis externa & Myenteric plexus (Auerbach’s plexus)

Controls contraction of muscularis externa; wave-like contractions that move contents = peristalsis
Gastroesophageal junction

Abrupt epithelial transition:

Stratified squamous non-keratinized (esophagus)

simple columnar (stomach)

“Cardiac glands” of the esophagus (mucosal, i.e. IN LAMINA PROPRIA); secrete neutral mucous, protect esophagus from stomach acid

Cardiac glands of the stomach; also mucosal (in the lamina propria) and also mucus-secreting

Ross and Pawlina, Histology: A Text and Atlas, 5th ed. (2006). Fig. 17.6, p.525
Gastroesophageal junction
*Transition from stratified squamous to simple columnar epithelium*

Bloom and Fawcett, 12th ed. Fig. 25-6, p.599
Gastroesophageal junction

Inferior esophageal sphincter = a physiological sphincter
- Pressure difference between esophagus and stomach
- Diaphragmatic contraction
- Unidirectional peristalsis
Prevents reflux of stomach contents into esophagus

Ly = lymph nodule
Ep* = infolded epithelium
Gastroesophageal junction

A medically important region:

Pyrosis (heartburn) – acid reflux

Dysphagia (difficulty in swallowing)
  Generic term used to describe ANY difficulty in swallowing
  Could be something “extrinsic:” mediastinal mass, vascular anomaly
  Could be “intrinsic:” e.g. esophageal tumor, inflammation, motility disorder

Achalasia (“failure to relax”)
  Lack of peristalsis in the lower esophagus due to loss of myenteric neurons
  (chalasis = relaxation)

Barrett’s esophagus/Intestinal metaplasia
  Change in esophageal mucosa from squamous to “intestinal” (i.e. columnar)
  Result of prolonged injury: e.g. chronic reflux, noxious agents (smoking, etc.)
  “pre-cancerous:” 10% risk of progression to adenocarcinoma

Esophageal cancer
  Squamous cell carcinoma – carcinogenesis of basal cells
  Adenocarcinoma – progression of Barrett’s esophagus into cancer or (rarely)
  from submucosal glands
Stomach

*Mixes and partially digests food*  
Flowchart: Chyme

**Attributes:**
- Expanded region where food can reside while initial digestion occurs
- Mechanism to digest food: acid, enzymes
- Mechanisms to prevent self-digestion
- Mechanism to prevent undigested food from passing on to the small intestine
Stomach

Four anatomical regions:

a. Cardia - Cardiac glands
b. Fundus\(^*\) - Gastric glands
c. Corpus\(^*\) - Gastric glands
d. Pylorus - Pyloric glands

Because they are HISTOLOGICALLY similar, histologists lump fundus and corpus together (and you may sometimes hear gastric glands referred as “fundic glands” – the terms are synonymous)
Rugae: folds of mucosa w/ submucosal core — somewhat analogous to intestinal plicae* - allow stomach to distend

Pits (foveolae): invaginations of mucosal epithelium (similar to intestinal crypts*); continuous with the lumen of underlying glands

* More about plicae and intestinal crypts in a later lecture

University of Michigan Virtual Microscopy slide collection, slide #156
Cardiac glands - stomach

In cardiac region - located at gastro-esophageal junction

Epithelium consists of simple columnar, mostly mucous cells (pale, homogeneous staining – similar to cells lining the pits)

Tubular, somewhat tortuous, and sometimes branched

Empty into gastric pits

Ross and Pawlina, Histology: A Text and Atlas, 5th ed. (2006). Fig. 17.14, p.532
Fundic (Gastric) glands - stomach

Shallow pits open to long branched glands

Pits are lined by mucous cells (Pit cells)
Glands contain:
• Stem cells
• Mucous neck cells
• Parietal cells
• Chief cells

Each cell type takes up stain differently so these glands will have a heterogeneous appearance

Produce gastric juice
(~ 2L/day)

Anatomy of a gastric gland

Pit lined by surface mucous cells

Short isthmus region - contains stem cells (can’t identify without immunostaining, but know their approximate location and function)

Several glands (2-3) open into one pit

Neck lined by mucous neck cells, with some parietal cells

Parietal, chief and enteroendocrine cells occupy glandular portion

Original: Ross and Pawlina, *Histology: A Text and Atlas, 5th ed.* (2006). Fig. 17.8b, p.527
Gastric gland - PAS* stain

Mucus of the mucous surface cells -
Viscous, insoluble mucus with bicarbonate (deep purple)

Mucous of the mucous neck cells -
More soluble, watery mucous

Physiologic gastric mucosa barrier

*PAS = periodic acid Schiff (stains mucous)
Parietal cells

Major secretions:
• Intrinsic factor
  (binds Vitamin B12; required for absorption of B12 in ileum)
• HCl (ATPase exchange pumps and ion transport channels move H+ and Cl- into lumen)

REQUIRES:
• Lots of mitochondria
• Lots of surface area

Eosinophilic due to:
• Abundant membranes (microvilli, canaliculi, tubulovesicular system)
• Numerous mitochondria

Original Source: Ross and Pawlina, *Histology: A Text and Atlas, 5th ed.* (2006). Fig. 17.11, p.530
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EM-Parietal Cell (oxyntic cell)

Note:
- mitochondria (m)
- microvilli (mv) on surface & lining intracellular canaliculi
- tubulovesicular system

Junquiera and Carneiro. Basic Histology, 10th ed. (2003), p305 Fig 15-15
Cells of the gastric glands- Chief cell

Chief cells -

Basophilic base (RER)  
Granules in apex  
(variable appearance)

Secrete pepsinogen  
-converted to pepsin by  
acid hydrolysis

Original Source: Ross and Pawlina, Histology: A Text and Atlas, 5th ed. (2006). Fig. 17.9, p.529
Fundic (Gastric) glands - stomach

**Parietal cells** (blue arrows)
- Large, often triangular
- Eosinophilic
- “Fried egg” appearance
- More often in neck of gland

**Chief cells** (black arrows)
- Basophilic base
- Round nuclei
- Found in lower portions of glands
Enteroendocrine cells

- Found throughout GI tract
- Not very easy to see by LM in the stomach, but can identify them in EMs

“Open” type:
- Secretory granules in basolateral domain
- Microvilli project into lumen

Enteroendocrine cells

“Closed” type:
Cell rests on basal lamina; does not reach lumen

Original: Fig 17.12 from Ross and Pawlina, Histology: A Text and Atlas, 5th ed. (2006), p530
Enteroendocrine cells
“Diffuse neuroendocrine system” (DNES)

- Classified by staining for products
- ~20 different types
- ALL secrete primarily into connective tissue space NOT the lumen of the GI tract

**Important examples in stomach:**
Gastrin - stimulates parietal cells to secrete HCl
Somatostatin - Inhibits gastrin release, inhibits HCl secretion
Vasoactive intestinal peptide (VIP) - stimulates pancreatic and intestinal enzyme secretion; inhibits sphincter contraction

*a.k.a.*

APUD (Amine Precursor Uptake and Decarboxylation) cells*, Enterochromaffin cells*, argentaffin cells*, argyrophil cells*

* These terms actually refer to specific sub-types of cells, whereas the term “enteroendocrine” covers ALL types
Pylorus - stomach

Deep pits open to
Relatively straight glands

Mostly mucous cells
(occasional parietal cells)

Comparison of stomach glands

**Pit depth (% of mucosa)**
- Cardiac - 50%
- Gastric - 25%
- Pyloric – 66%

**Gland morphology**
- Cardiac – tortuous, homogeneous
- Gastric – straight, heterogeneous
- Pyloric – ~tortuous, homogeneous

**Location**
- Cardiac – near gastro-esophageal junct.
- Gastric – in fundus and corpus
- Pyloric – near gastro-duodenal junct.

Original: Fig 15-10 from Junqueira and Carneiro, *Basic Histology, 10th ed.* (2003), p300
**Gastroduodenal junction:**

- Transition from gastric epithelium (with pits) to intestinal epithelium (with crypts & villi)
- Duodenal region specifically identifiable by presence of SUBMUCOSAL glands
- Pyloric sphincter, a true anatomical sphincter, expansion of circular layer of smooth muscle

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**mm** = musc. mucosae; **sm** = submucosa

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Learning Objectives

• Be able to identify and describe the function of the layers AND COMPONENT CELLS in the wall of the digestive tract (mucosa, submucosa, muscularis (propria), and adventitia/serosa), and explain how they differ in the pharynx, esophagus, and stomach.

• Know the histological differences in the pharynx and the upper, middle and lower portions of the esophagus.

• Be able to recognize gastric glands, identify their constituent cells, and know their secretory products.

• Be able to recognize gastric glands, cardiac glands, and pyloric glands of the stomach.
Additional Source Information

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