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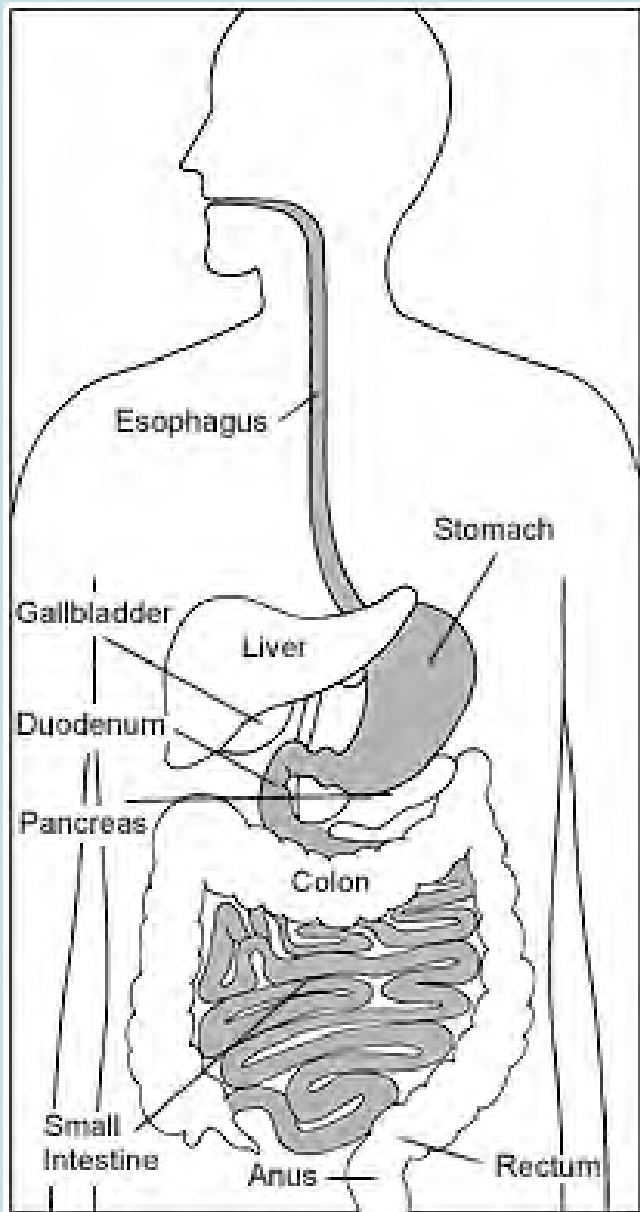


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# Tubular GI tract



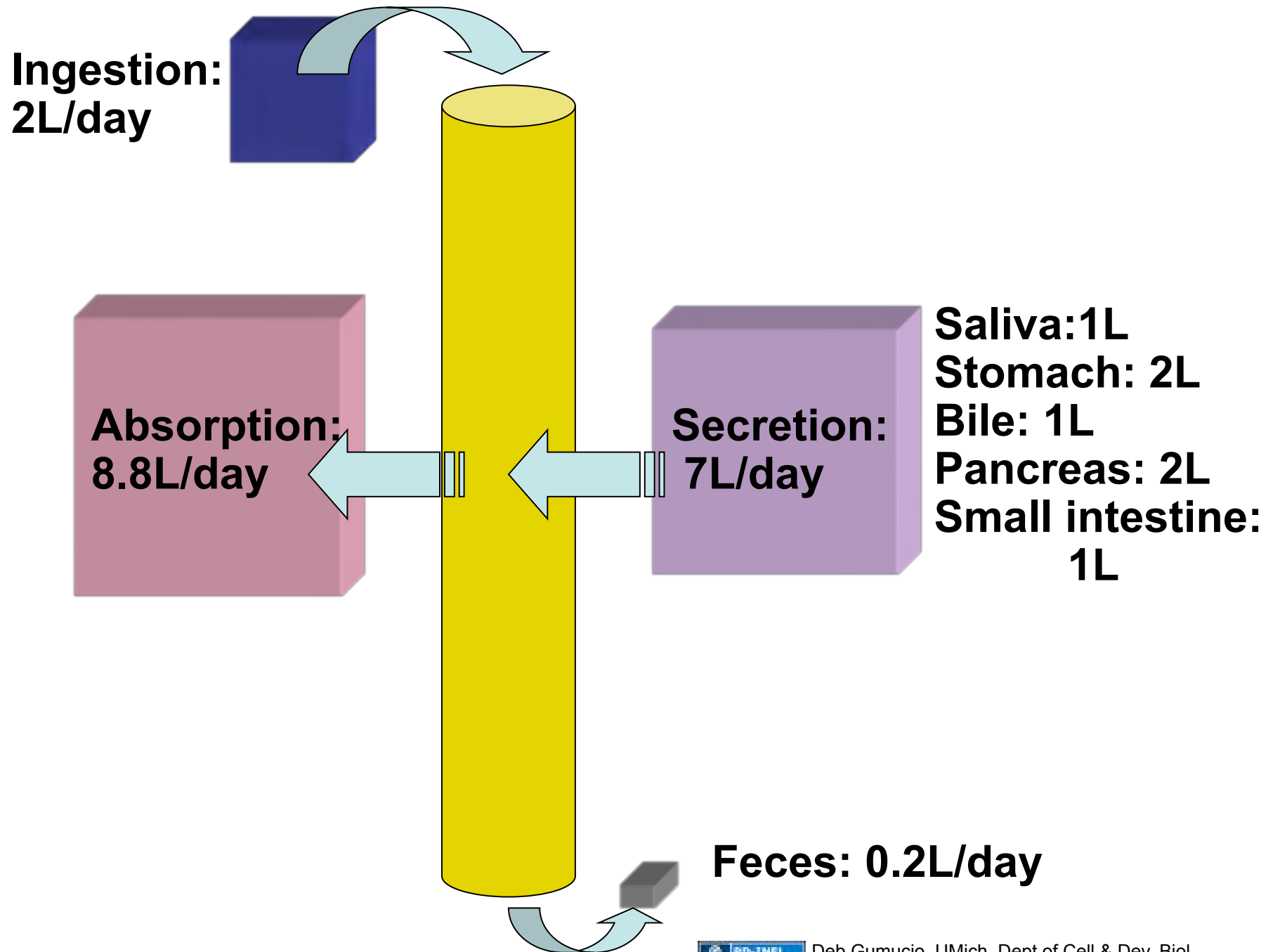
Pharynx  
Esophagus  
Stomach  
.....  
Small Intestine  
Cecum and appendix  
Large intestine  
Rectum/Anus

 National Digestive Diseases Information Clearinghouse [US Federal Government](http://www.fda.gov/oc/ohrt/)

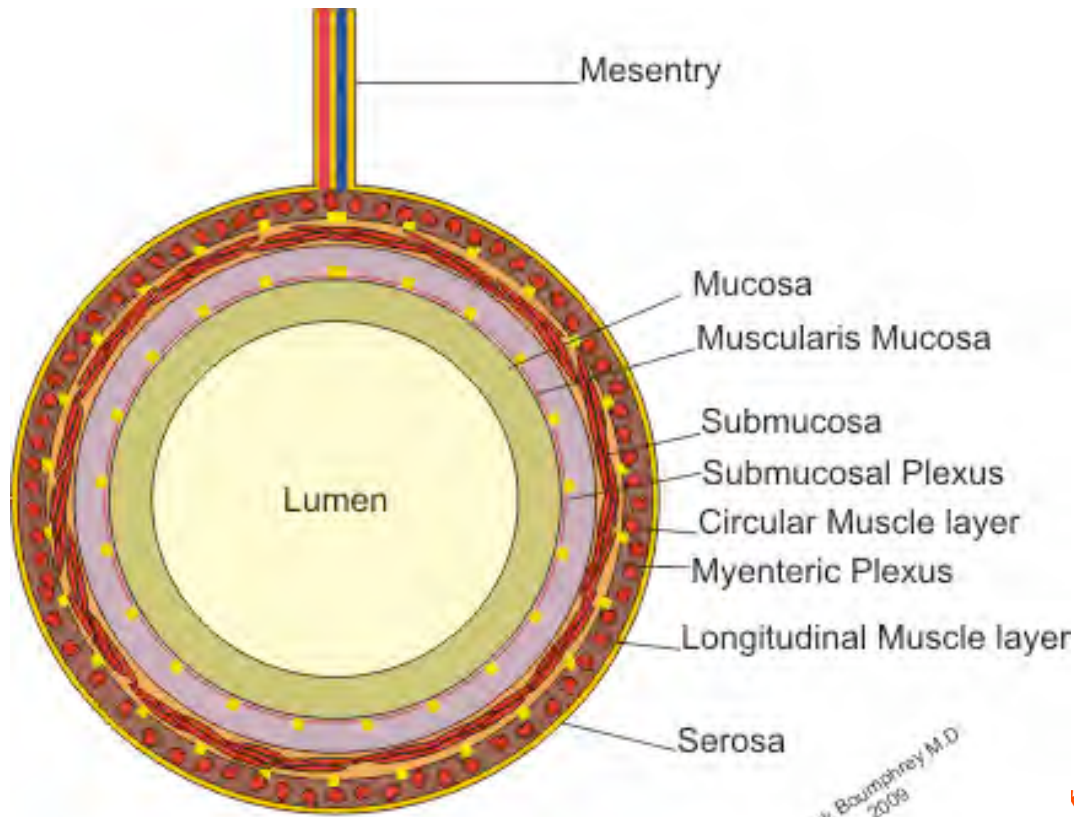
Original: Fig 14.1 from Young & Heath, *Wheater's Functional Histology*, 4<sup>th</sup> ed. (2000), p250

**J. Matthew Velkey**  
**M1 – GI Sequence**  
**Winter, 2009**





# Tubular GI tract



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

\*Mucosa = {  
Epithelium  
Lamina propria  
Muscularis mucosae

Frank Boumphey M.D.  
2009

 Frank Boumphey, M.D, Wikipedia

Original: Fig 14.1 from Young & Heath, *Wheater's Functional Histology*, 4<sup>th</sup> 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:**

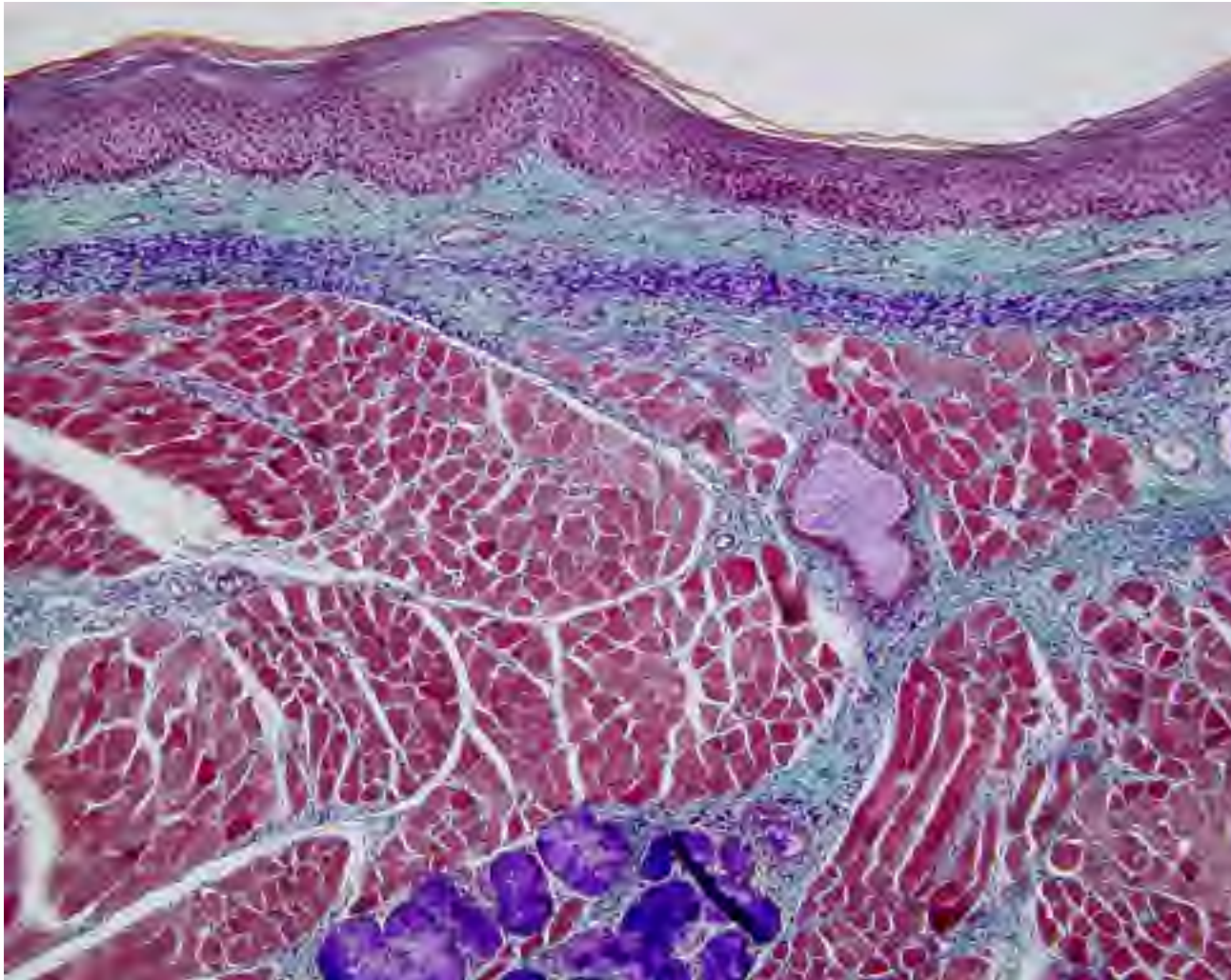
- a. In the mucosa (stomach, small + large intestine)**
- b. In the submucosa (only in esophagus, duodenum)**
- c. Outside of the tubular gut (extramural glands)  
e.g., liver, pancreas.**

# 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**

# Esophagus



 Young & Heath, *Wheater's Functional Histology*, 4<sup>th</sup> ed. (2000), p253 Fig 14.4a

**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)**

**Muscularis externa (Muscularis propria):**  
**Inner circular (CM)**  
**Outer longitudinal (LM)**

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

# Esophagus

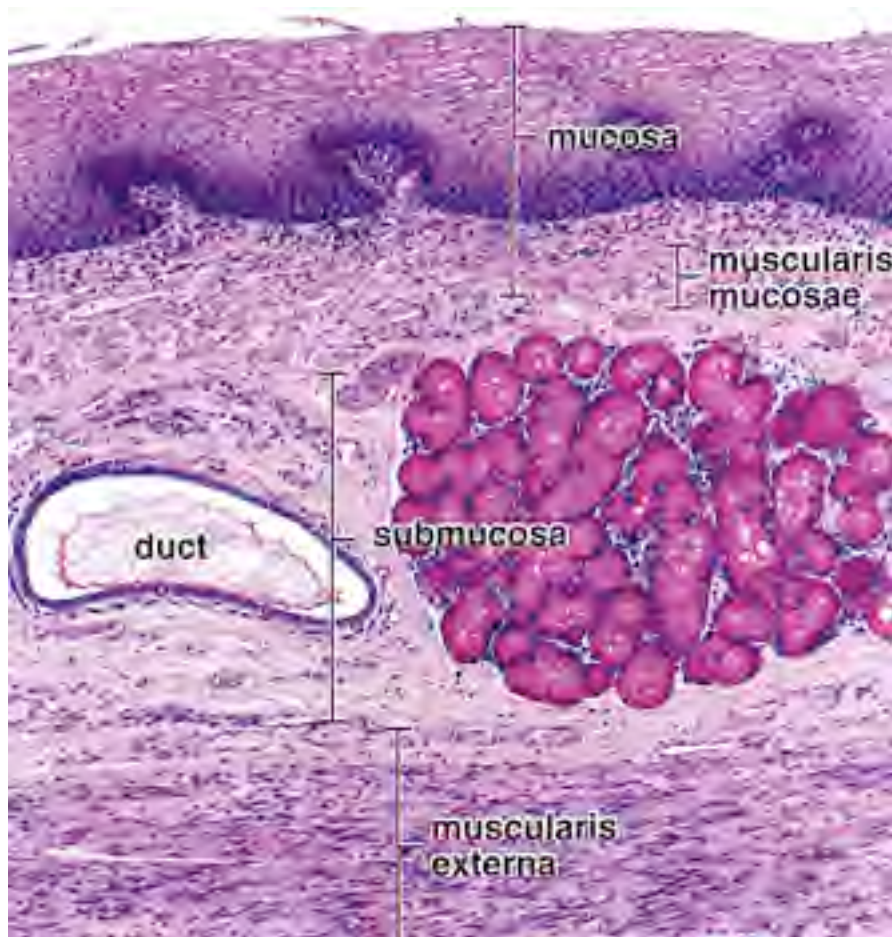


PD-INEL Ross and Pawlina, *Histology: A Text and Atlas, 5th ed.* (2006), p522 Fig 17.2

**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



PD-INEL Ross and Pawlina, *Histology: A Text and Atlas, 5<sup>th</sup> ed.* (2006)



PD-INEL Ross and Pawlina, *Histology: A Text and Atlas, 5<sup>th</sup> ed.* (2006)

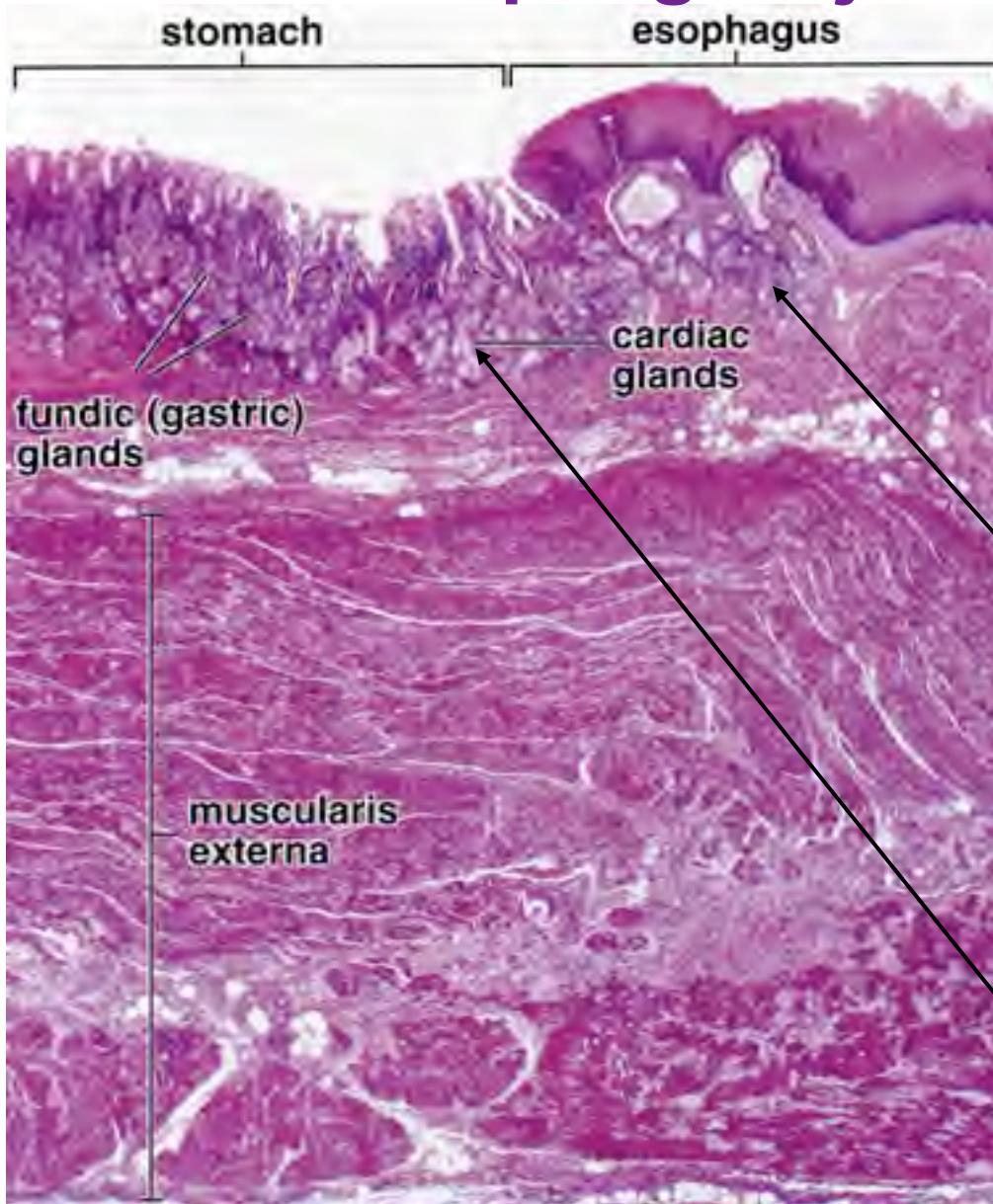
- Stratified squamous epithelium (stem cells in stratum basale)
- Thick muscularis mucosae (circular layer & longitudinal layer)
- Submucosal mucous glands

## Muscularis externa & Myenteric plexus (Auerbach's plexus)

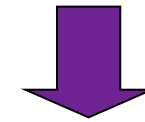


**Controls contraction of muscularis externa; wave-like contractions that move contents = peristalsis**

# Gastroesophageal junction



**Abrupt epithelial transition:  
Stratified squamous  
non-keratinized (esophagus)**



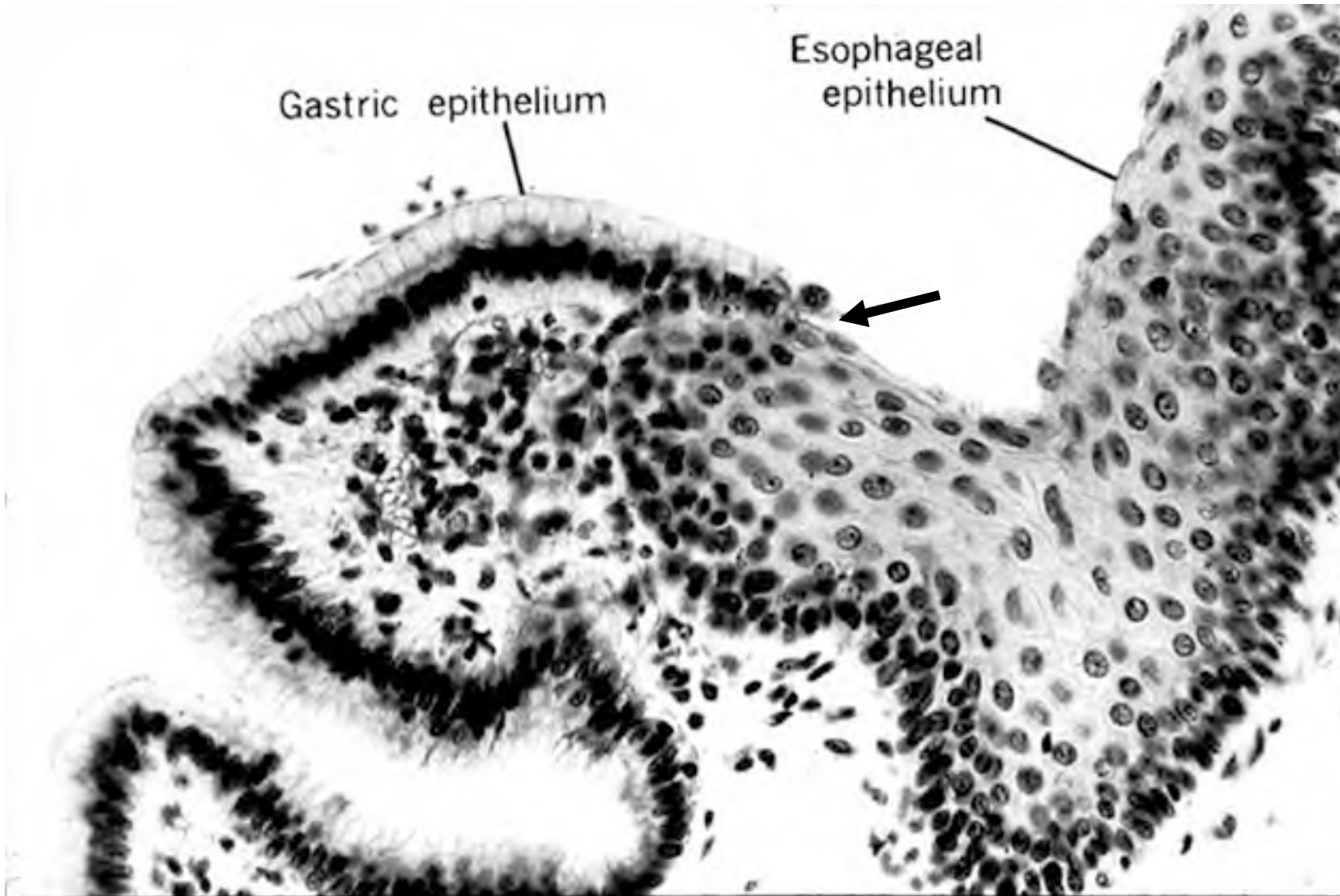
**simple columnar (stomach)**

**“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**

# Gastroesophageal junction

*Transition from stratified squamous to simple columnar epithelium*




# Gastroesophageal junction

Ly = lymph nodule  
Ep\*=infolded epithelium

**Esophagus**

**Stomach**



 University of Michigan Virtual Microscopy slide collection, slide #155

Inferior esophageal sphincter = a physiological sphincter

- Pressure difference between esophagus and stomach
- Diaphragmatic contraction
- Unidirectional peristalsis

Prevents reflux of stomach contents into esophagus



# 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  
(*chalsis* = 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

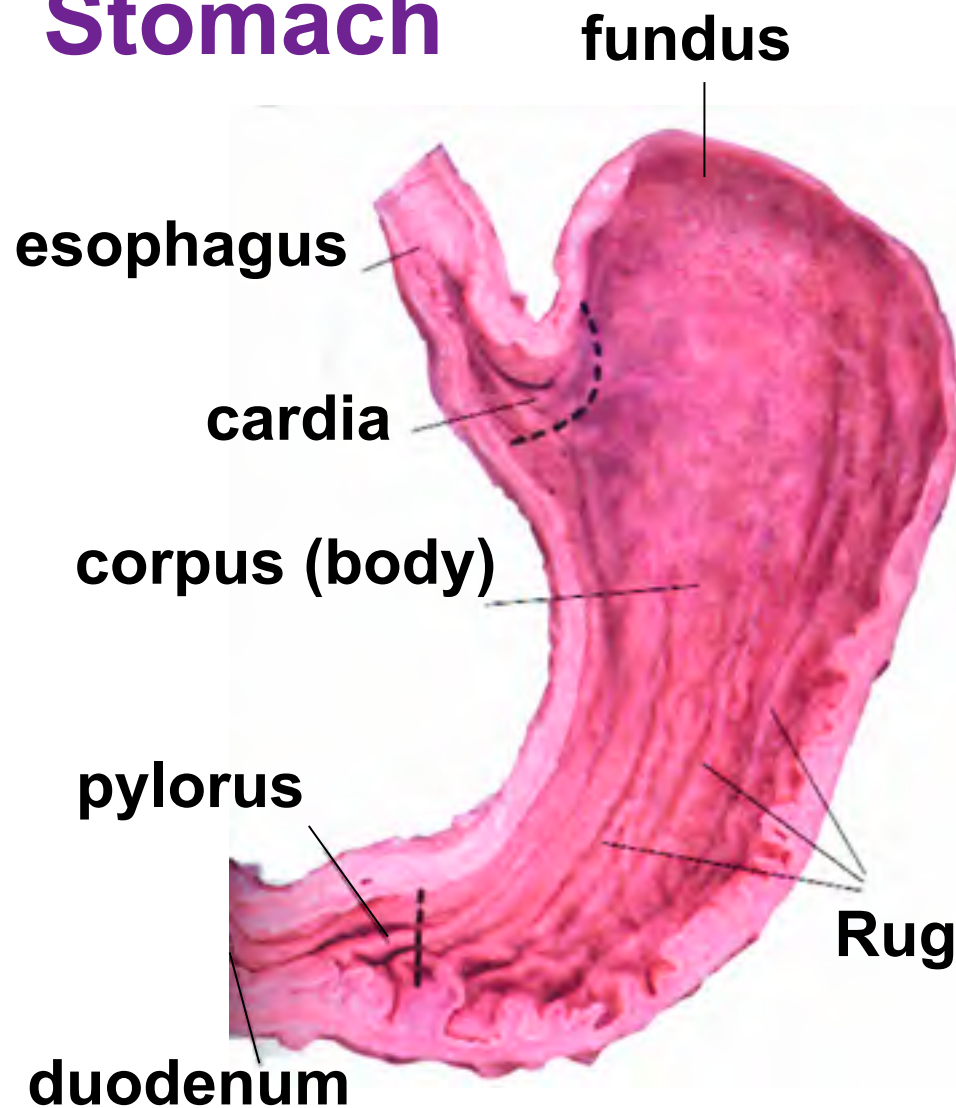
# Stomach

*Mixes and partially digests food* → *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

**Rugae - longitudinal folds  
(allow distention)**

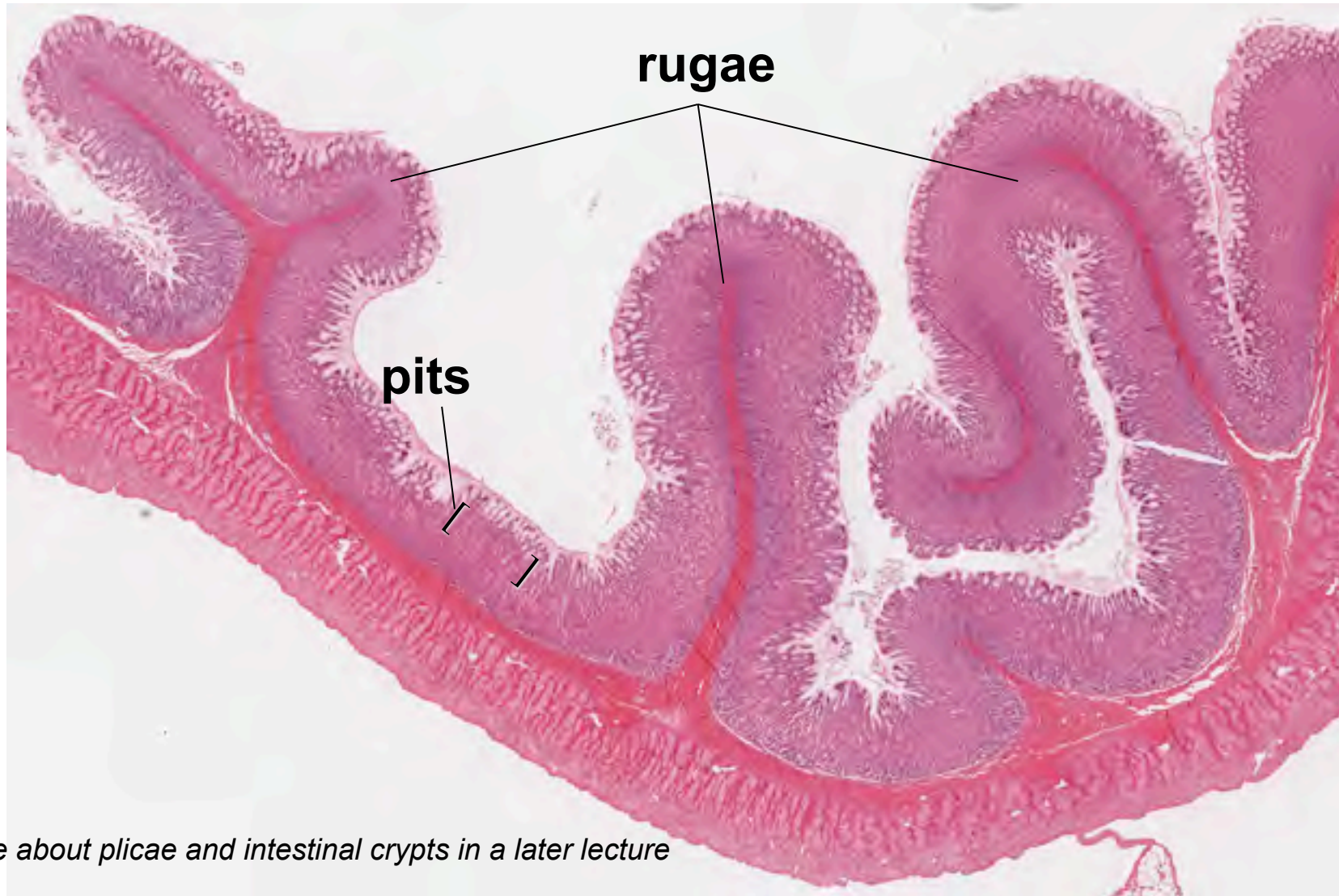
 Ross and Pawlina, *Histology: A Text and Atlas*, 5<sup>th</sup> ed. (2006). Fig. 17.5, p.524

*Because they are HISTOLOGICALLY similar, histologists lump fundus and corpus together (and you may sometimes hear gastric glands referred to as “fundic glands” –the terms are synonymous)*

# Stomach

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

# Cardiac glands - stomach



esophageal epithelium

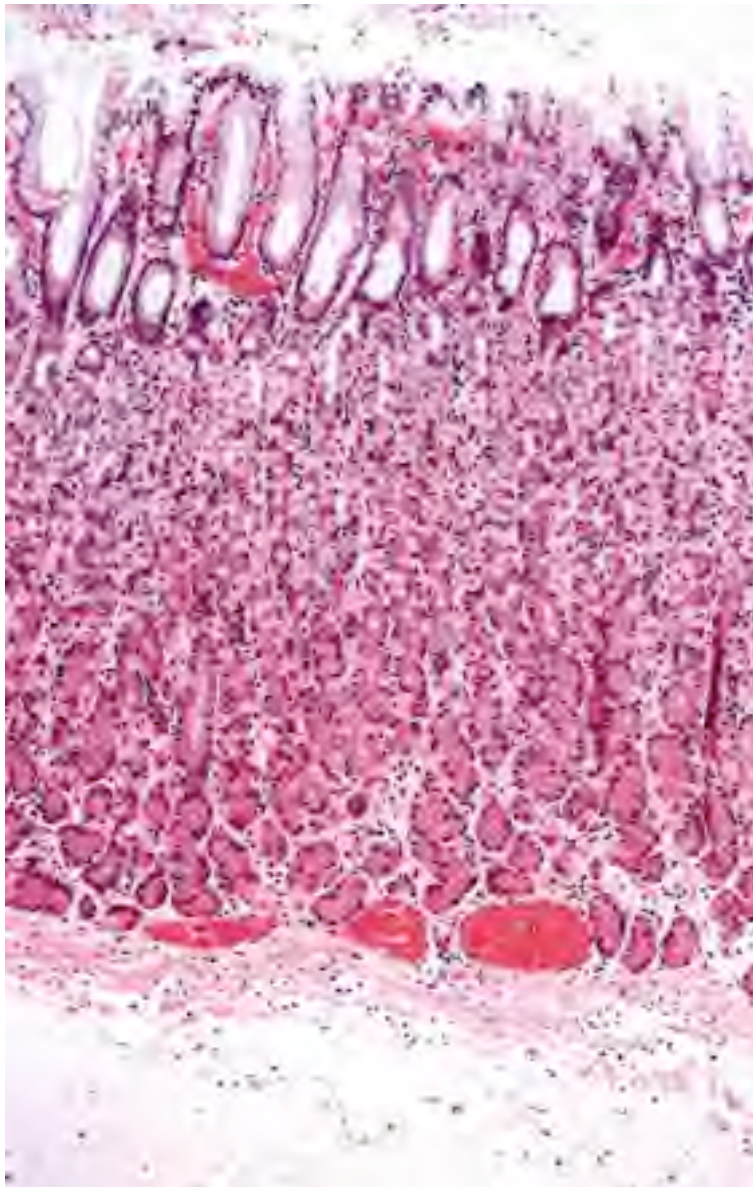
**In cardiac region - located at gastro-esophageal junction**

**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**

# Fundic (Gastric) glands - stomach



**Shallow pits open to long branched glands**

**Pits are lined by mucous cells (Pit cells)**

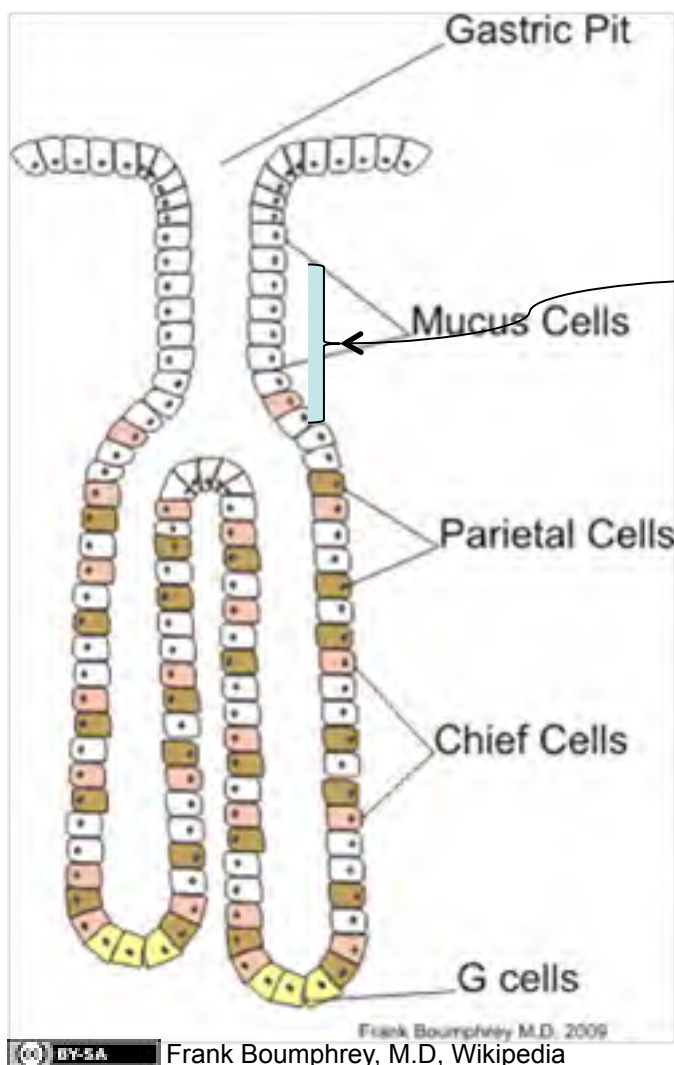
**Glands contain:**

- **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**

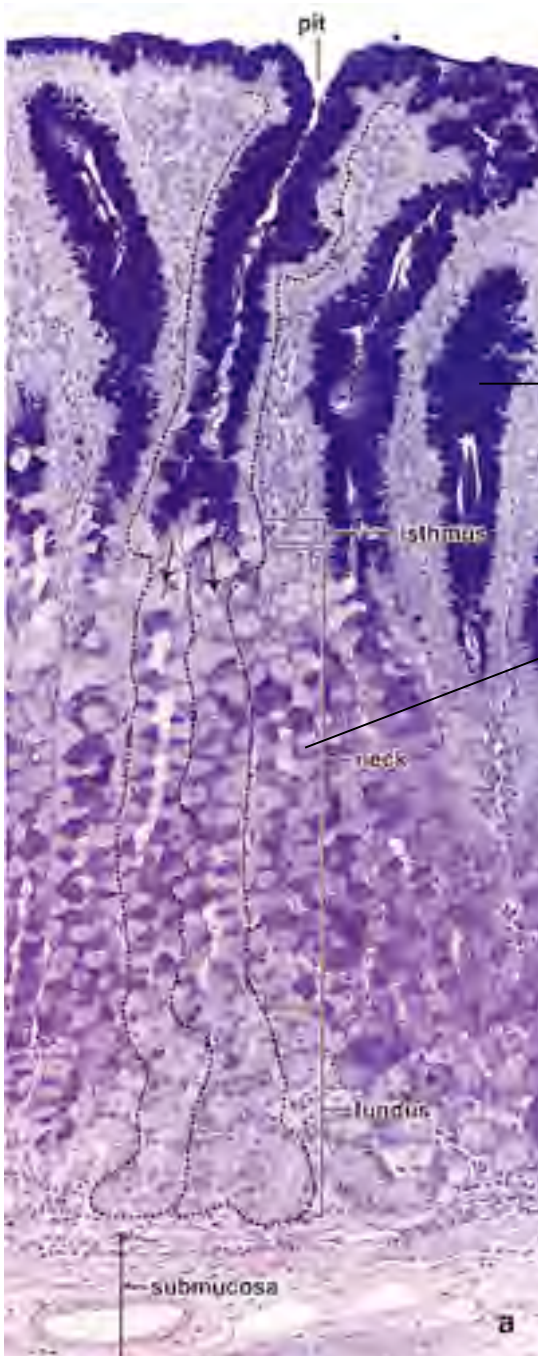
# Gastric gland - PAS\* stain

**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:

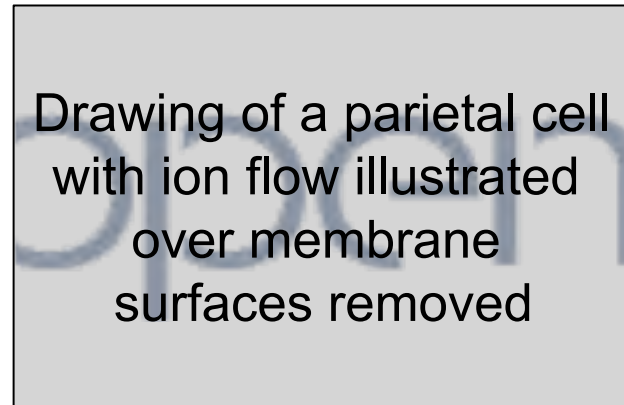
- **Intrinsic factor**  
(binds Vitamin B12; required for absorption of B12 in ileum)
- **HCl** (ATPase exchange pumps and ion transport channels move H<sup>+</sup> and Cl<sup>-</sup> into lumen)

## REQUIRES:

- Lots of mitochondria
- Lots of surface area

## Eosinophilic due to:

- **Abundant membranes**  
(microvilli, canaliculi, tubulovesicular system)
- **Numerous mitochondria**



# Parietal cells

## Major secretions:

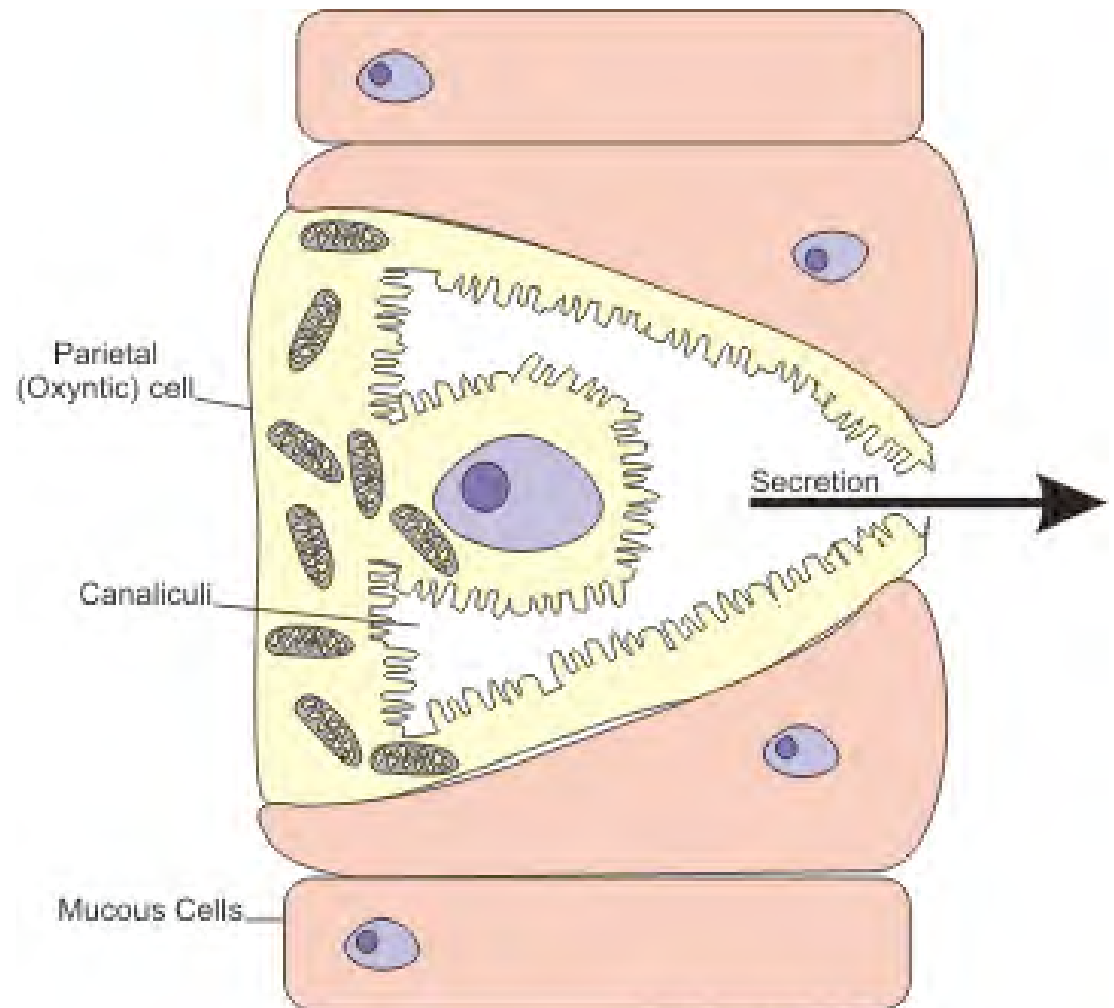
- **Intrinsic factor**  
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## REQUIRES:


- Lots of mitochondria
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## Eosinophilic due to:

- Abundant membranes  
(microvilli, canaliculi,  
tubulovesicular system)
- Numerous mitochondria



Frank Boumphrey M.D. 2009

 Frank Boumphrey, M.D., Wikipedia

Original: Fig 15-15 from Junquiera and Carneiro. *Basic Histology*, 10th ed. (2003), p305.

# EM- Parietal Cell (oxyntic cell)

## Note:

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



# 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**

A rectangular box with a thin black border and a light gray background. Inside the box, the text "Drawing of a chief cell as would appear on electron micrograph removed." is centered in a black, sans-serif font. A faint, large watermark of the word "open" is visible in the background of the box.

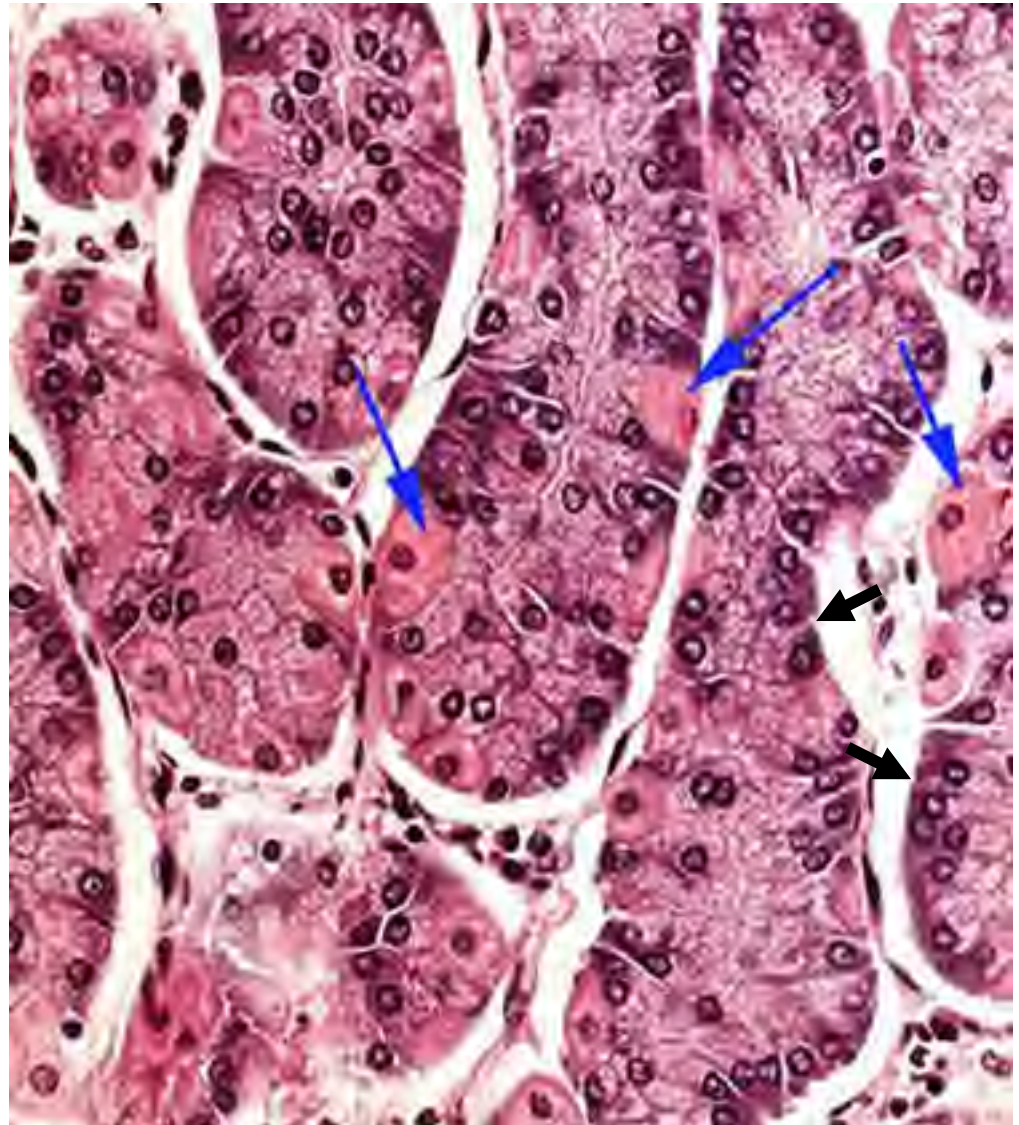
# Fundic (Gastric) glands - stomach

## 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



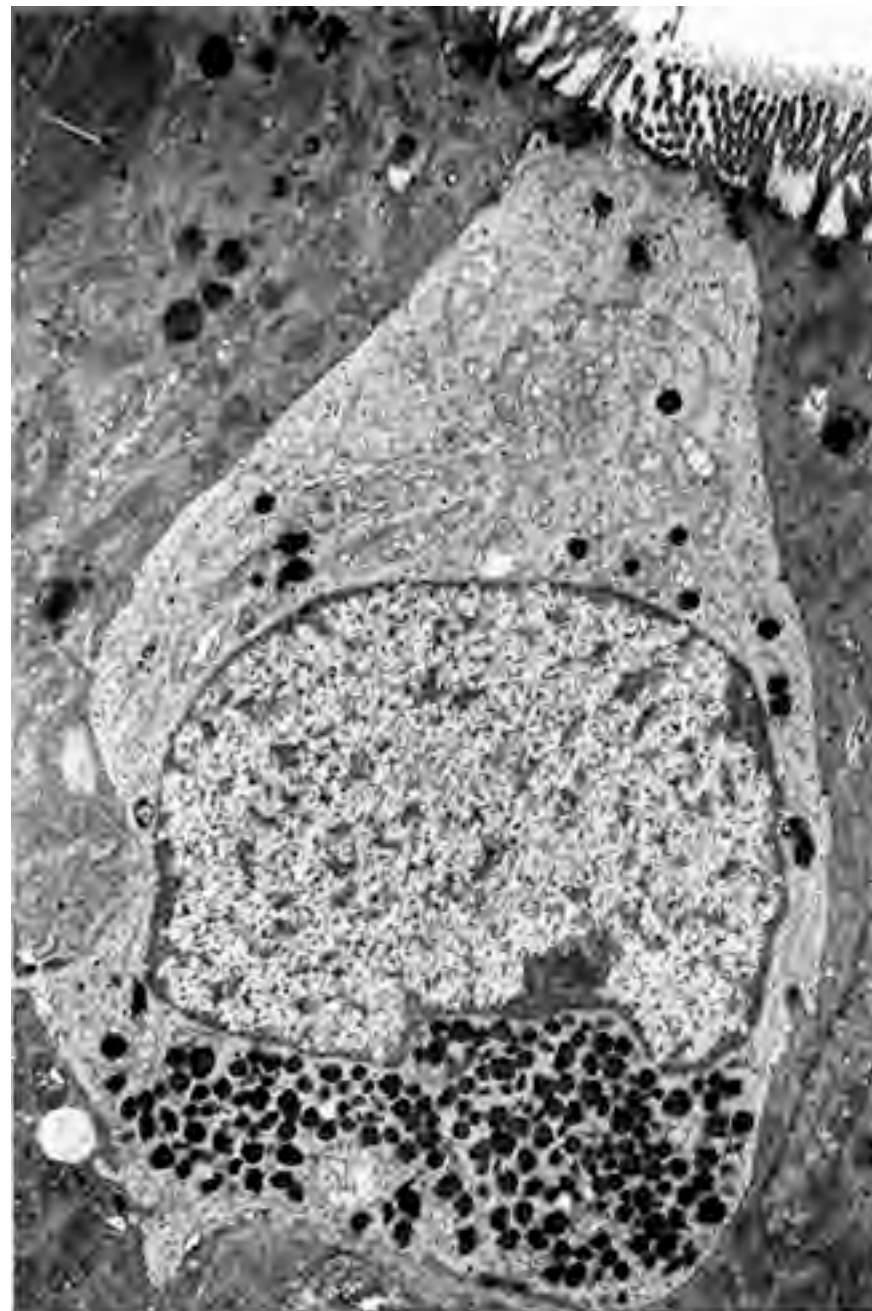
Slide 843 (35mm Kodachrome slide collection)  
from Mizoguti, *Color Slide Atlas of Histology* (1985).


# 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



 Junquiera and Carneiro, *Basic Histology*, 10<sup>th</sup> ed. (2003), p307. Fig 15-18

# Enteroendocrine cells

Drawing of a  
“closed type”  
entero-  
endocrine cell.



Original: Fig 17.12 from Ross and Pawlina, *Histology: A Text and Atlas*, 5<sup>th</sup> ed. (2006), p530

PD-INEL Source Undetermined

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

# 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

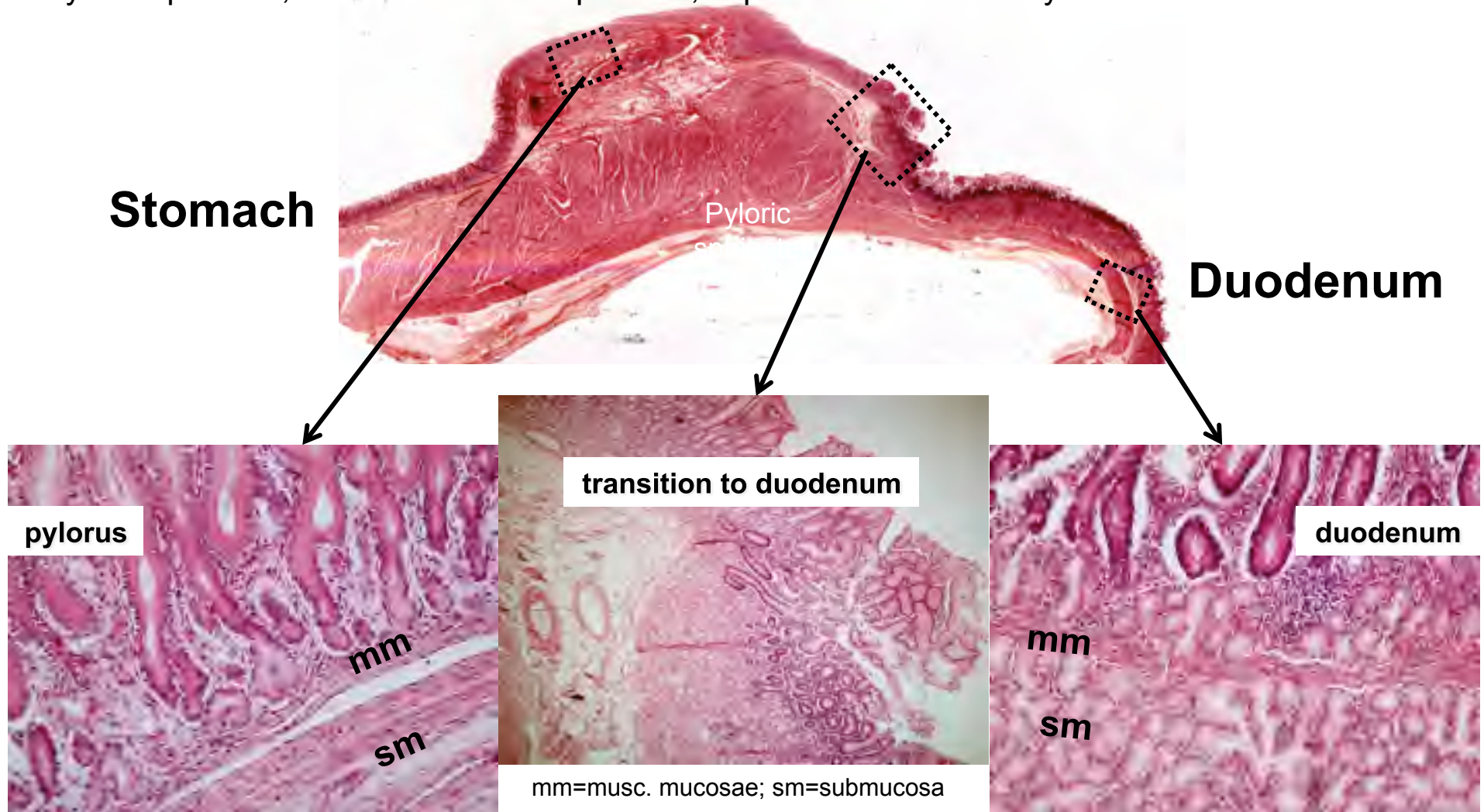
Pyloric – near gastro-duodenal junct.

Drawing of the stomach with sections from the body, cardiac, and pyloric regions of the stomach illustrated in histological cross-section to show the glands of each region.

Original: Fig 15-10 from Junqueira and Carneiro, *Basic Histology, 10<sup>th</sup> 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



# 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

for more information see: <http://open.umich.edu/wiki/CitationPolicy>

Slide 3: National Digestive Diseases Information Clearinghouse, US Federal Government,  
<http://digestive.niddk.nih.gov/ddiseases/pubs/upperqi/index.htm>

Slide 4: Deb Gumucio, UMich, Dept of Cell & Dev. Biol.

Slide 5: Boumphreyfr, Frank Boumphrey, M.D., Wikipedia, [http://commons.wikimedia.org/wiki/File:Smallintestine\\_layers2.png](http://commons.wikimedia.org/wiki/File:Smallintestine_layers2.png)

Slide 8: University of Michigan Virtual Microscopy collection Slide 152

Slide 10: Young & Heath, *Wheater's Functional Histology, 4th ed.* (2000), p253 Fig 14.4a

Slide 11: Ross and Pawlina, *Histology: A Text and Atlas, 5th ed.* (2006), p522 Fig 17.2

Slide 12: Ross and Pawlina, *Histology: A Text and Atlas, 5th ed.* (2006); Ross and Pawlina, *Histology: A Text and Atlas, 5th ed.* (2006)

Slide 13: University of Michigan Virtual Microscopy Slide Collection, slide #155.

Slide 14: Ross and Pawlina, *Histology: A Text and Atlas, 5th ed.* (2006). Fig. 17.6, p.525

Slide 15: Bloom and Fawcett, *12th ed.* Fig. 25-6, p.599

Slide 16: University of Michigan Virtual Microscopy slide collection, slide #155

Slide 19: Ross and Pawlina, *Histology: A Text and Atlas, 5th ed.* (2006). Fig. 17.5, p.524

Slide 20: University of Michigan Virtual Microscopy slide collection, slide #156

Slide 21: Ross and Pawlina, *Histology: A Text and Atlas, 5th ed.* (2006). Fig. 17.14, p.532

Slide 22: Young & Heath, *Wheater's Functional Histology, 4th ed.* (2000), p272 Fig 14.31b

Slide 23: Frank Boumphrey, M.D; Original: Ross and Pawlina, *Histology: A Text and Atlas, 5th ed.* (2006). Fig. 17.8b, p.527

Slide 24: Ross and Pawlina, *Histology: A Text and Atlas, 5th ed.* (2006). Fig. 17.8a, p.527

Slide 25: Original: Ross and Pawlina, *Histology: A Text and Atlas, 5th ed.* (2006). Fig. 17.11, p.530

Slide 26: Frank Boumphrey, M.D; *Replaced: Fig 15-15 from Junquiera and Carneiro. Basic Histology, 10th ed. (2003), p305.*

Slide 27: Junquiera and Carneiro. *Basic Histology, 10th ed.* (2003), p305 Fig 15-15

Slide 28: Original Source: Ross and Pawlina, *Histology: A Text and Atlas, 5th ed.* (2006). Fig. 17.9, p.529

Slide 29: Slide 843 (35mm Kodachrome slide collection) from Mizoguti, *Color Slide Atlas of Histology* (1985).

Slide 30: Junquiera and Carneiro, *Basic Histology, 10th ed.* (2003), p307. Fig 15-18

Slide 31: Source Undetermined; Removed Image - Fig 17.12 from Ross and Pawlina, *Histology: A Text and Atlas, 5th ed.* (2006), p530

Slide 33: Ross and Pawlina, *Histology: A Text and Atlas, 5th ed.* (2006), p533 Fig 17.15

Slide 34: Removed Image - Fig 15-10 from Junqueira and Carneiro, *Basic Histology, 10th ed.* (2003), p300

Slide 35: Matt Velkey Slide 162 of the University of Michigan Histology Collection (All Images)