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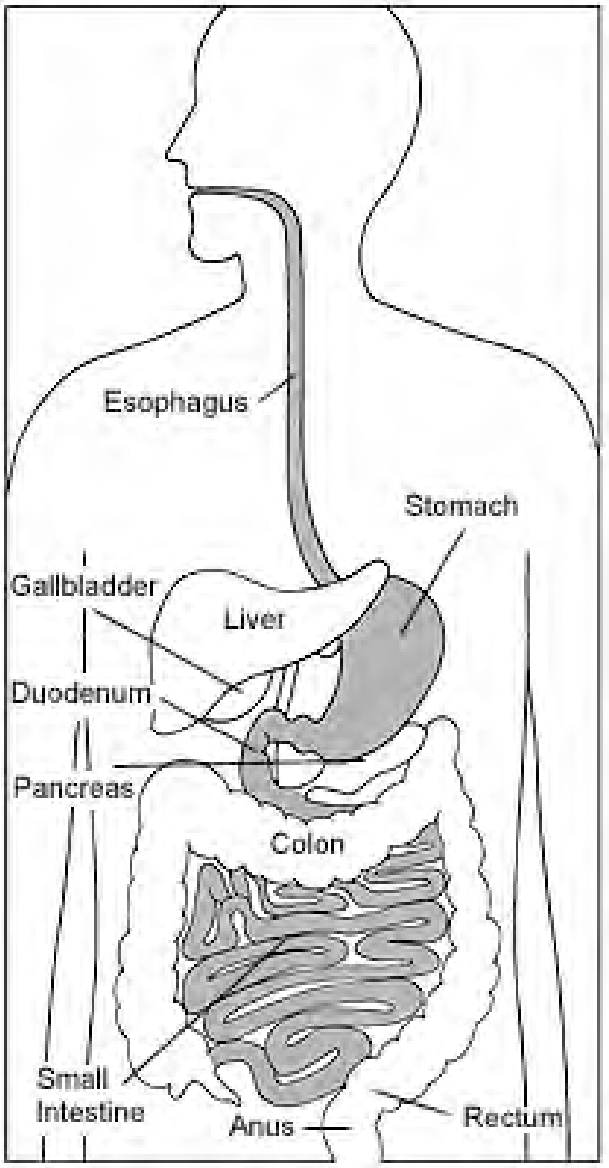
Tubular GI tract



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

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

J. Matthew Velkey
M1 – GI Sequence
Winter, 2009

University of Michigan Medical School

Intestine - Functions

Small Intestine

- **Digestion**
- **Absorption**
- **Endocrine secretion**

Duodenum
Jejunum
Ileum

Large Intestine

- **Absorption of water [passive, follows sodium]**
- **Formation and propulsion of feces**

How to get the most out of your intestine

Start with a long tube

PD-INEL Source Undetermined

Convolute the absorptive surface of the tube

Add enzymes that break down luminal contents

Keep the tube moving, mix contents

Multiple strategies for convolution of small intestinal absorptive surface

PD-INEL University of Delaware Library Institutional Repository

Original: Fig 14.16 from Young & Heath, Wheater's *Functional Histology* , *4th ed. (2000), p262*

Microvilli

PD-INEL Louisa Howard and Katherine Connolly

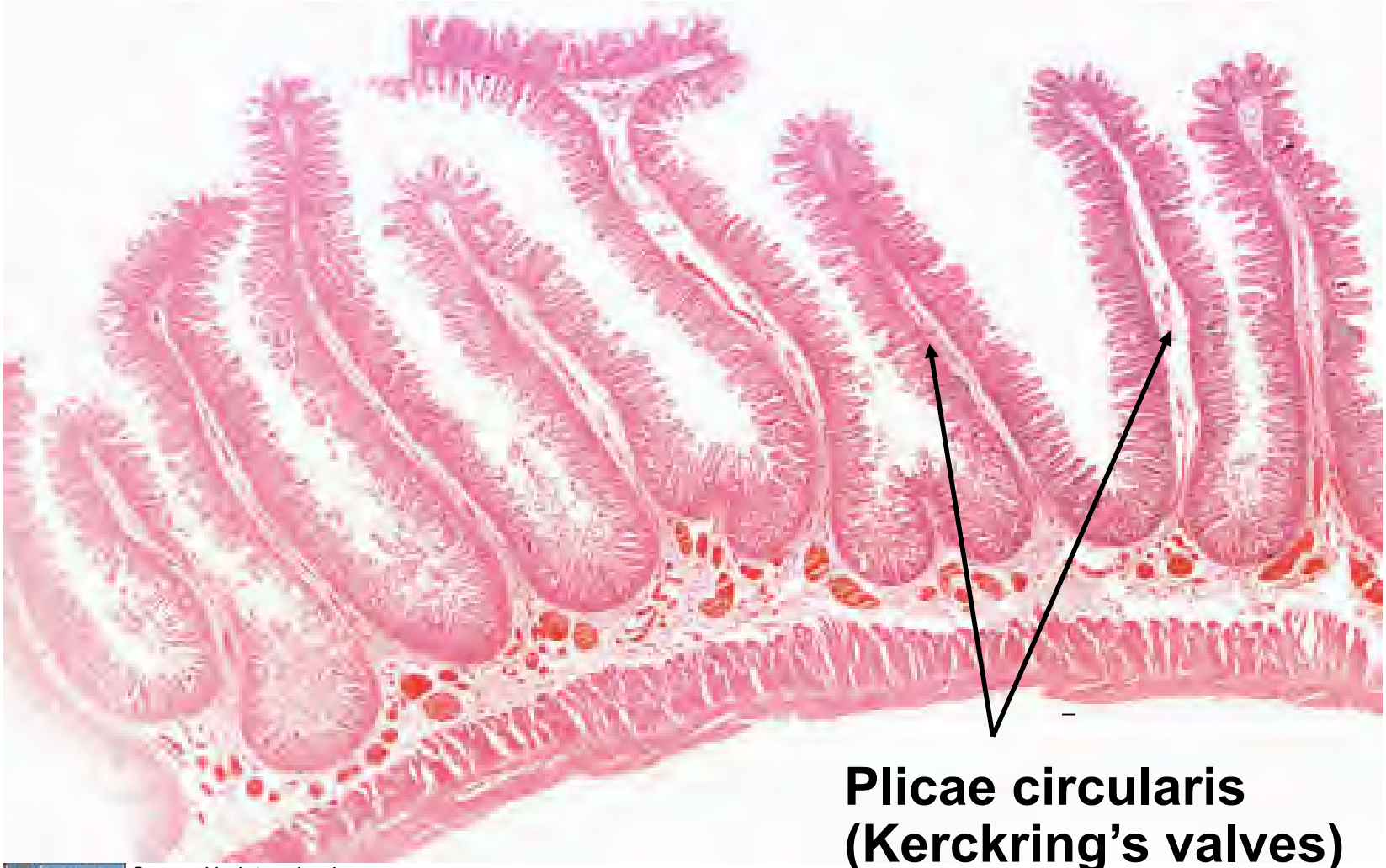
Original: Fig 14.16 from Young & Heath, Wheater's *Functional Histology, 4th ed. (2000), p262*

Convolute the surface of the tube

PD-INEL Ross and Pawlina, *Histology: A Text and Atlas, 5th ed.* (2006), p535 Fig 17.17

Plicae circulares (circular folds) – aka valves of Kerckring: <u>permanent</u> transverse folds of mucosa with submucosal connective tissue core; extend halfway to two-thirds around circumference of lumen; function to slow movement of chyme & increase surface area.

Convolute the surface of the tube



PD-3NEL Source Undetermined

Primarily found in jejunum

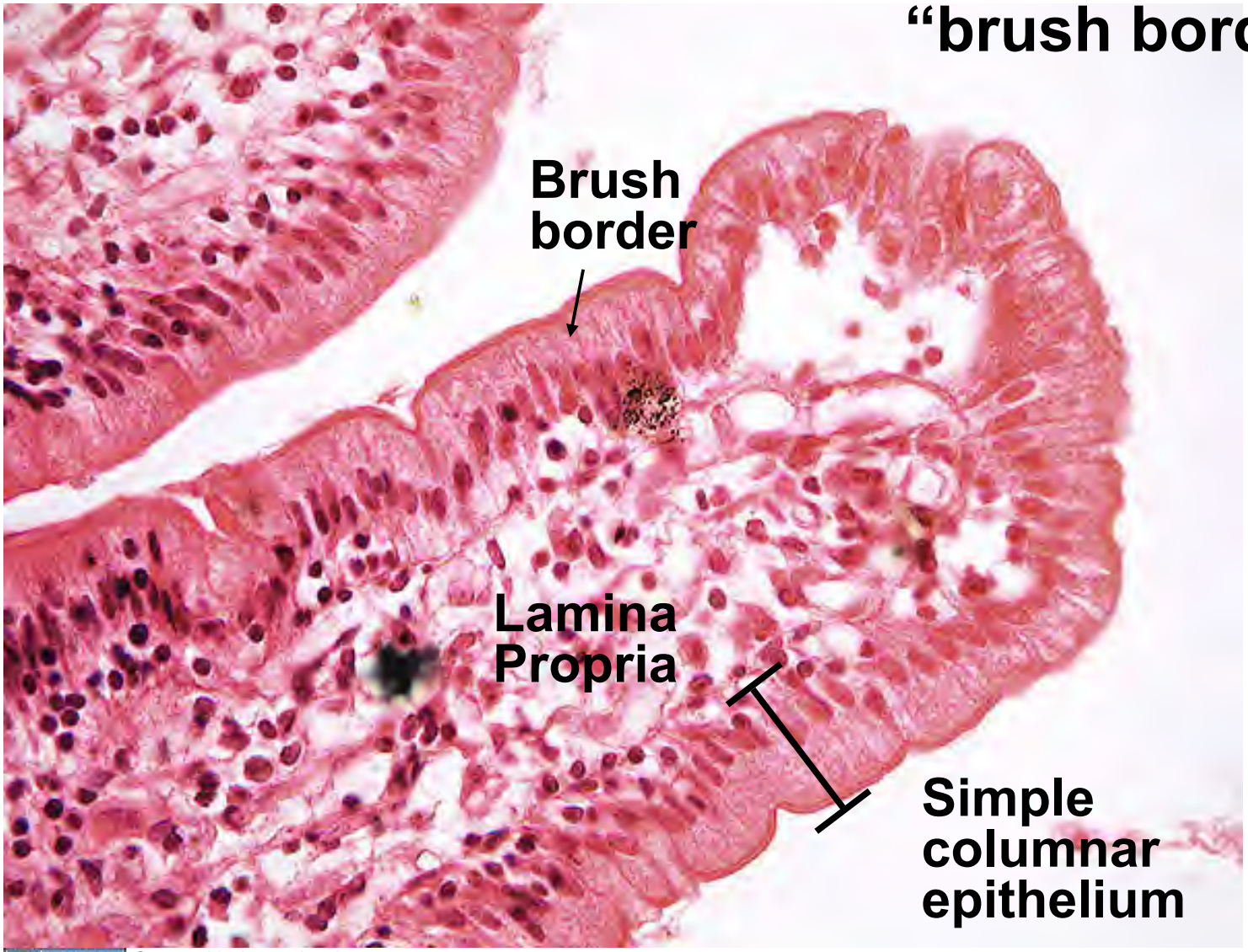
Plicae are covered with villi, fingerlike projections of mucosa…..

Drawing of intestinal plicae removed. Original: is Fig 16-32 from Kelly et al. *Bailey's Textbook of Histology, 18th ed.* (1984), p543.

Plicae are covered with villi, fingerlike projections of mucosa…..

PD-INEL Slide 246 of the Univ. of San Francisco School of Medicine Histology Collection

Villus cells have a "brush border"



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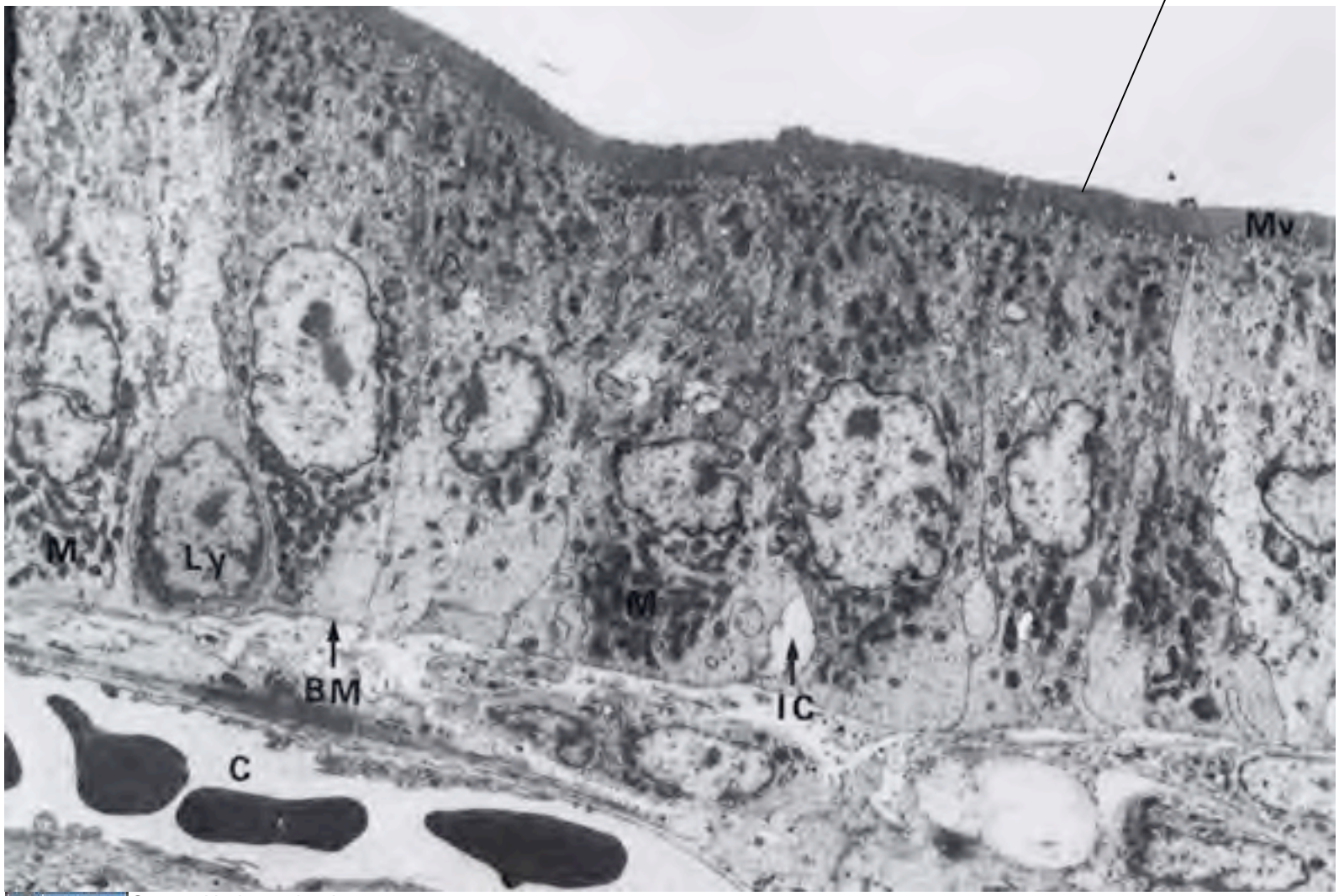
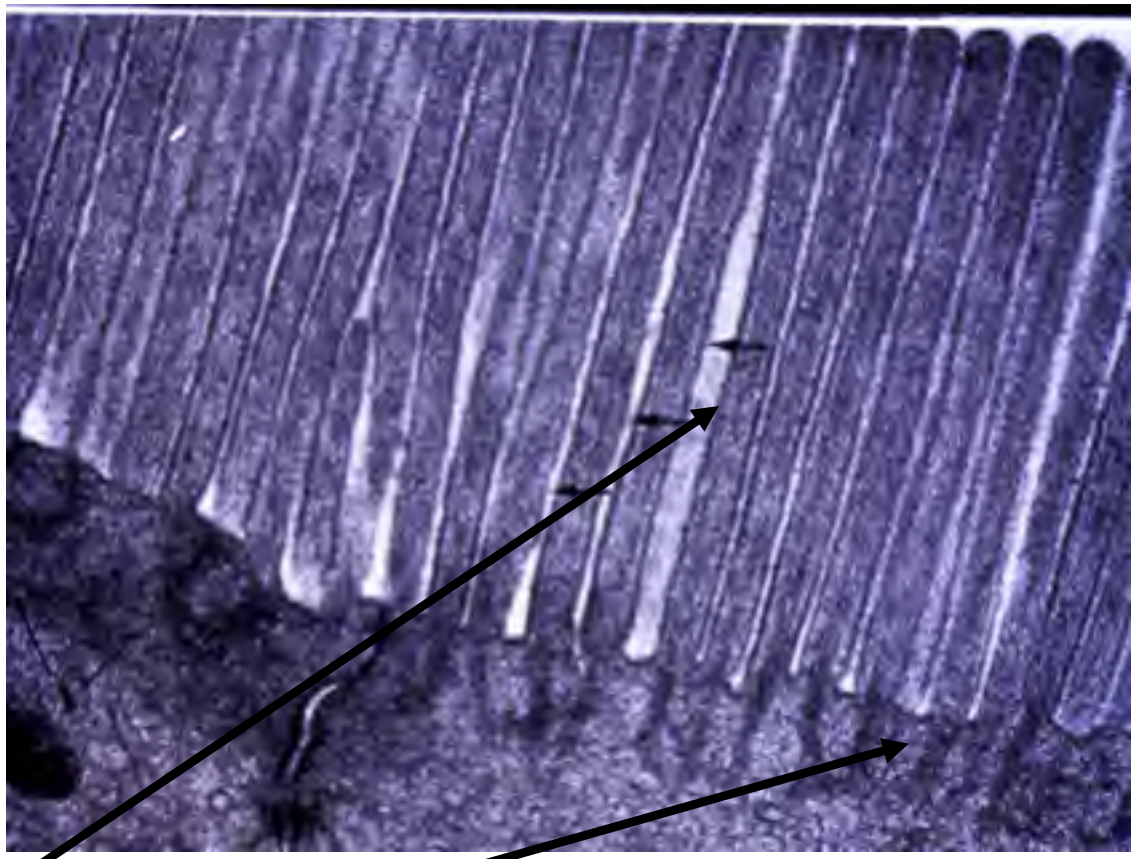
Core of each villus contains lamina propria

The Brush border is composed of microvilli



Electron microscopic view of the brush border

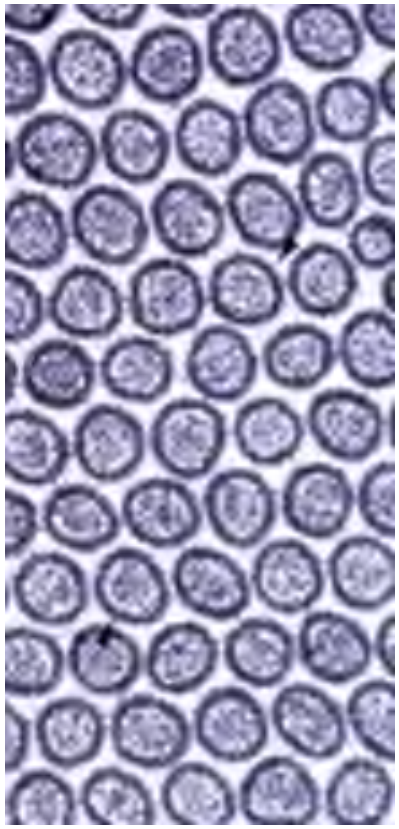
Apical surface (luminal surface) of absorptive cells



Microvilli

Terminal web

Microvilli, cross section



~3000 microvilli/cell !!!

The microvilli have a well-developed surface glycocalyx

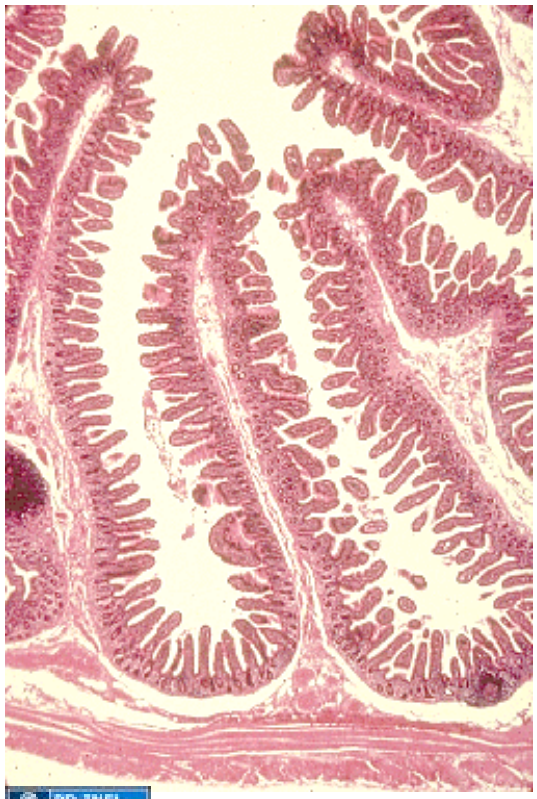
 Source: Fig 26-6 from Fawcett and Raviola, *Bloom and Fawcett, a Textbook of Histology, 12th ed.* (1994), p622

Intestinal tube = 20 ft long

Plicae → **Villi** → **Microvilli**

(3 fold) **(10 fold)** **(20-30 fold)**

Total: 600-900 fold (area 200 m^2) !



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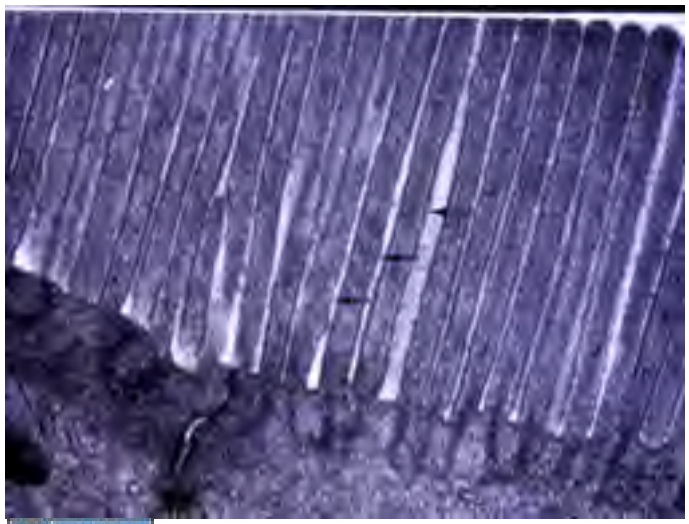


Source Undetermined

Original: Fig 14.16 from Young & Heath, Wheater's *Functional Histology, 4th ed. (2000), p262*

How to get the most out of your intestine

Start with a long tube

Convolute the absorptive surface of the tube

Add enzymes that break down luminal contents

Keep the tube moving, mix contents

Enzymes/bile digest luminal contents:

"Chyme" enters from stomach, stimulates intestinal enteroendocrine cells in intestine to secrete:

Secretin → pancreatic secretion

CCK (cholecystokinin) → pancreatic secretion

CCK (cholecystokinin) → gall bladder contraction

Ampulla of Vater: **intestinal segment of the common duct that delivers secretions to duodenum**

from pancreas (trypsin*, chymotrypsin*, amylase, lipase)

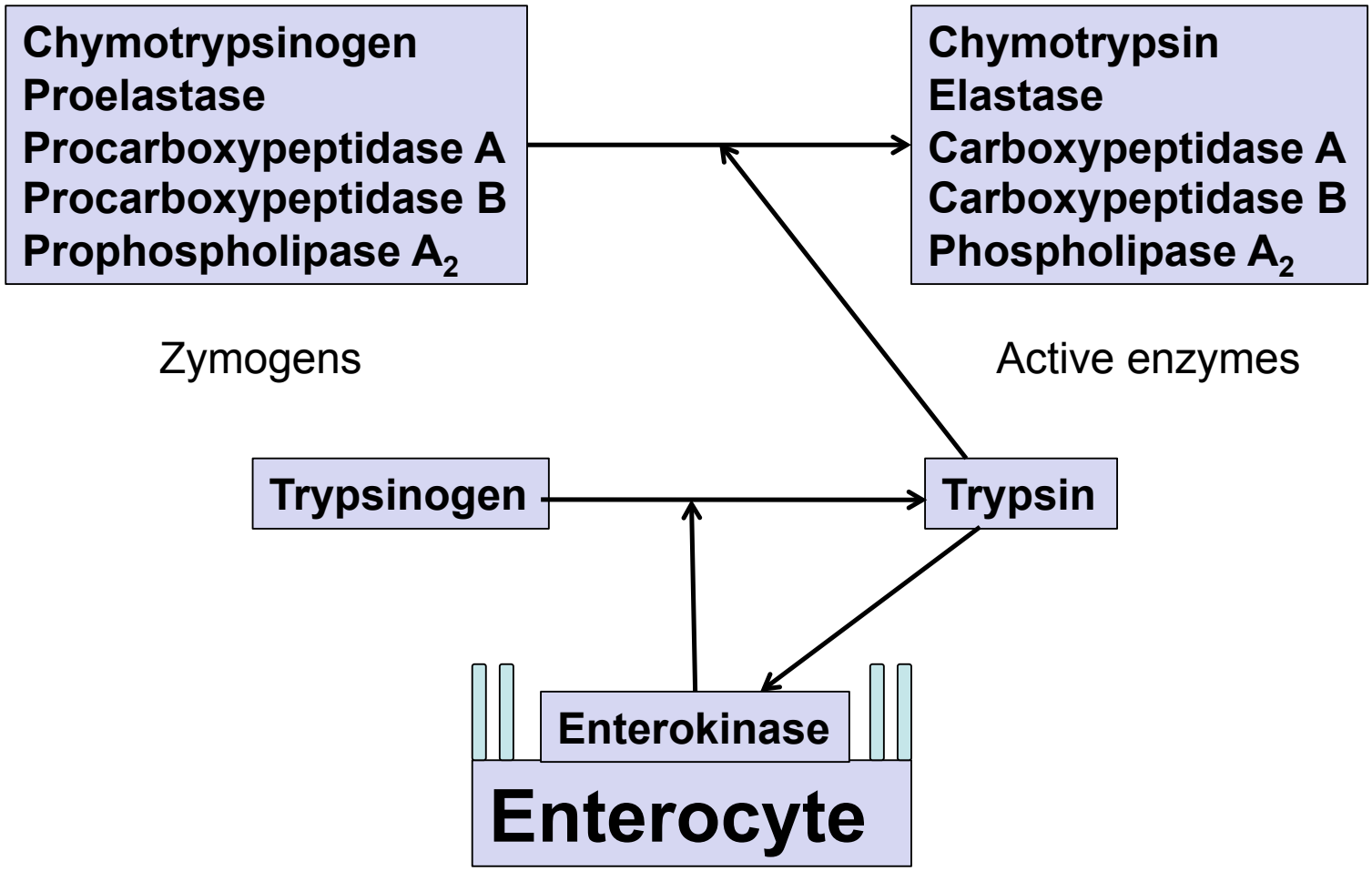
from liver *via* gall bladder (bile-emulsifies fat)

Enzymes in small intestinal absorptive cell (enterocyte) membrane complete the process of digestion and absorb the breakdown products

***Secreted as inactive forms, activated by enterokinase cleavage (enterokinase produced in duodenum)**

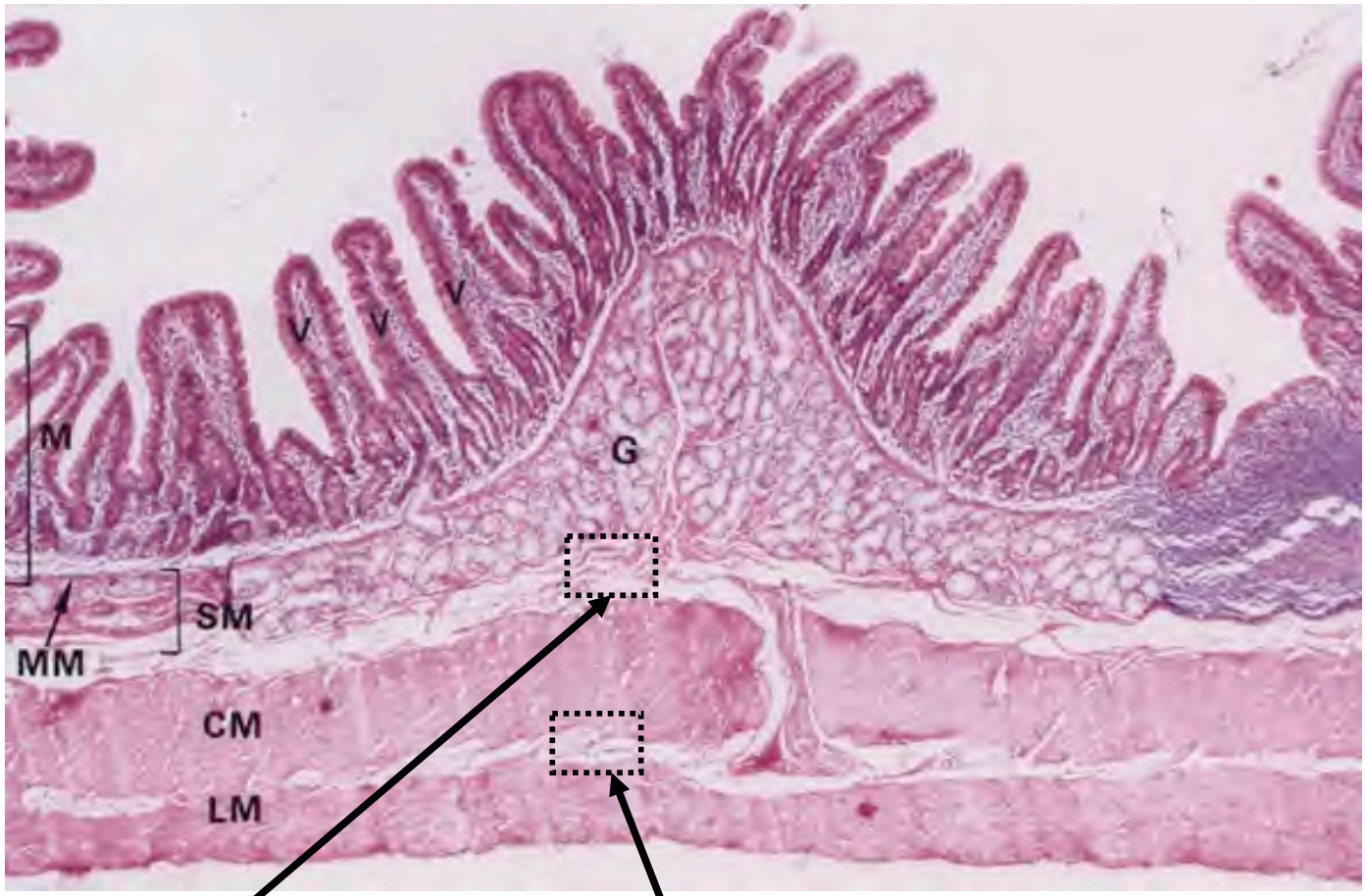
Enzymes/bile digest luminal contents:

activation of zymogens via enterokinase/trypsin



Replaced: Image is Fig 17.29 from Ross and Paulina, Histology: A Text and Atlas, 5th ed. (2006), p546.

Keep the tube moving, mix contents

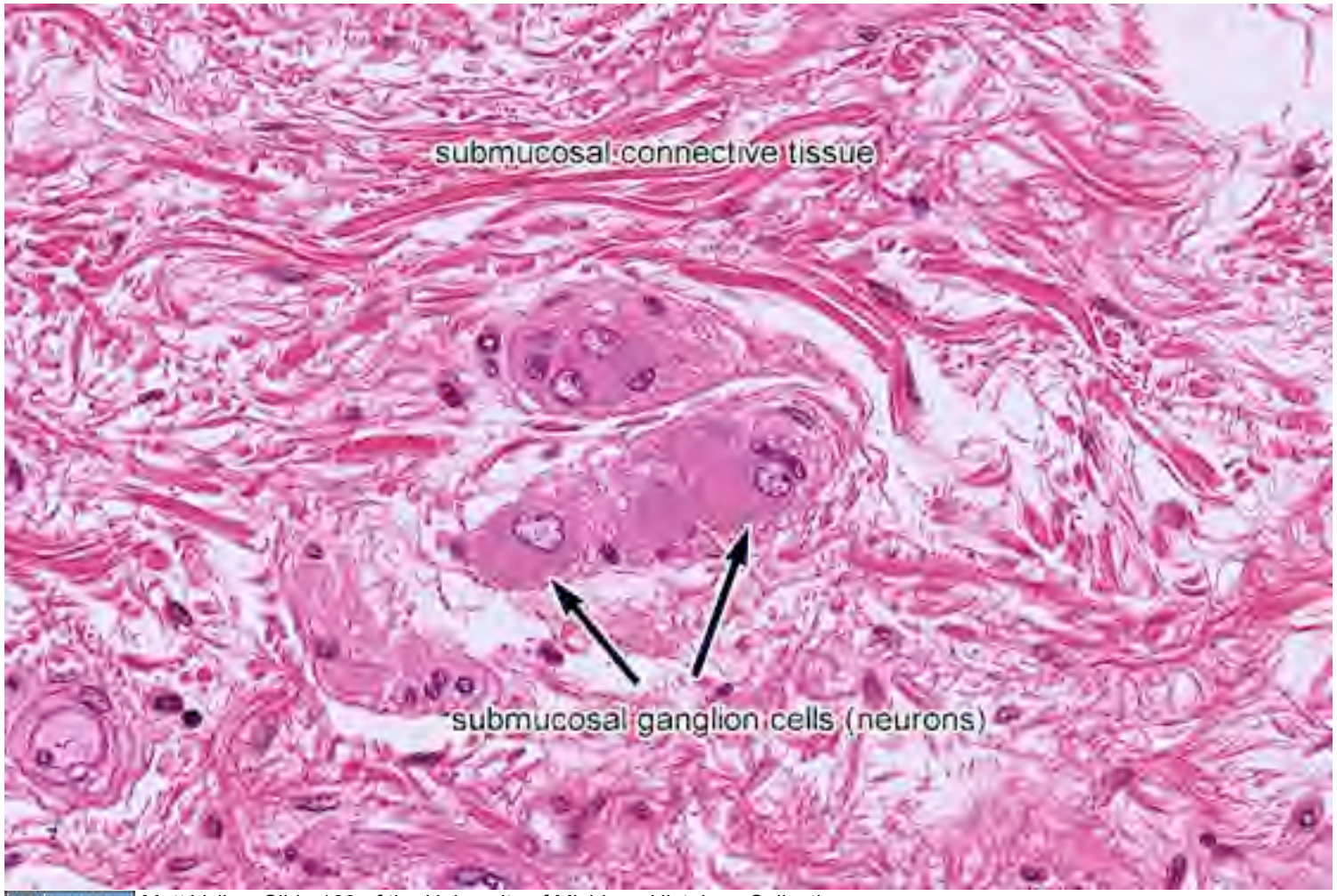


Location of Meissner's plexus (Submucosal plexus)

Location of Auerbach's plexus (myenteric plexus)

PD-INEL Young & Heath, *Wheater's Functional Histology, 4th ed.* (2000), p261 Fig 14.15a

Submucosal plexus (Meissner's plexus)



PD-INEL Matt Velkey Slide 169 of the University of Michigan Histology Collection

Controls contraction of muscularis mucosae, submucosal vascular tone, and secretory activity of mucosal epithelium

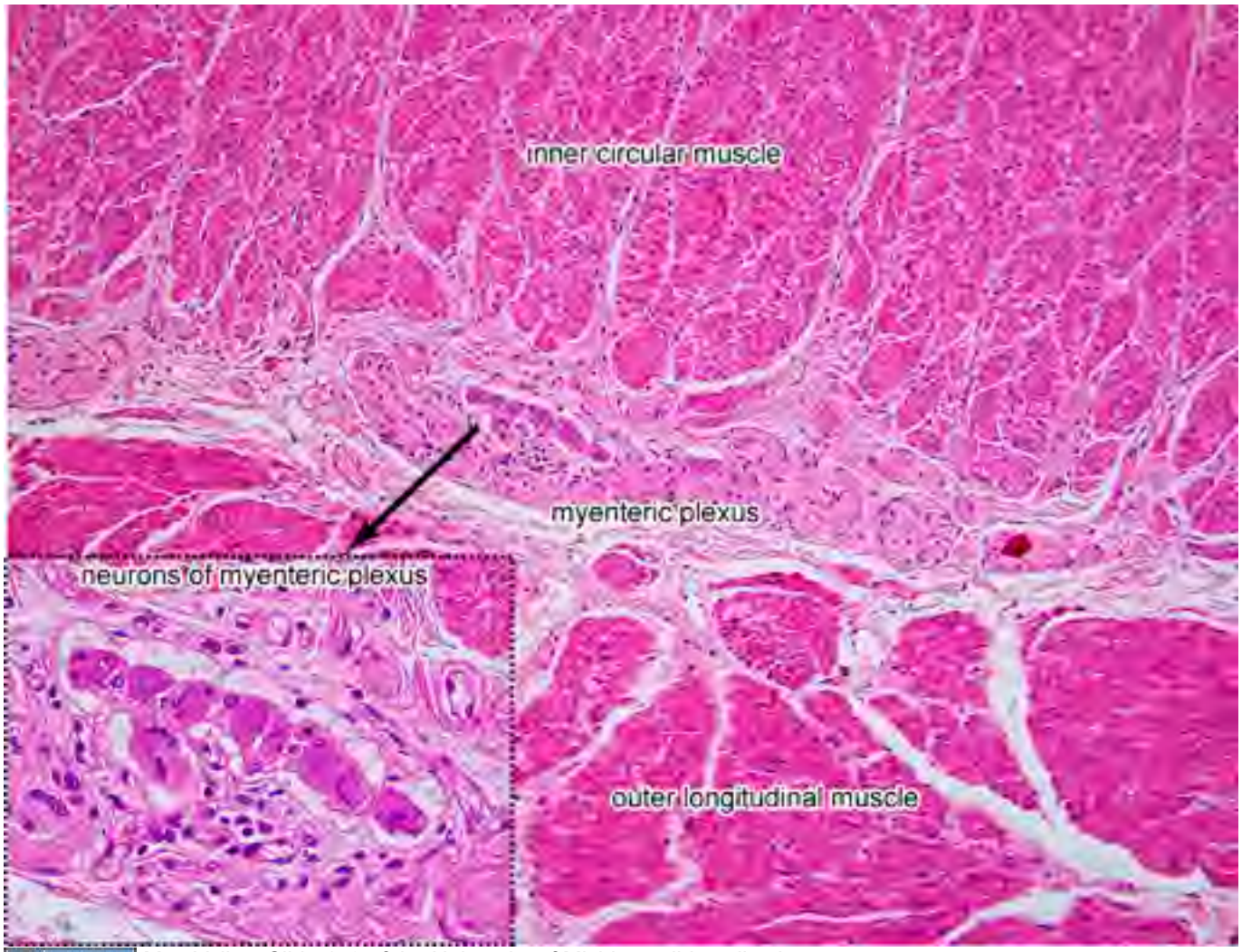
Keep the tube moving, mix contents

PD-INEL Young & Heath, *Wheater's Functional Histology, 4th ed.* (2000), p261. Fig 14.15a

Location of **Meissner's plexus (Submucosal plexus)**

Location of **Auerbach's plexus (myenteric plexus)**

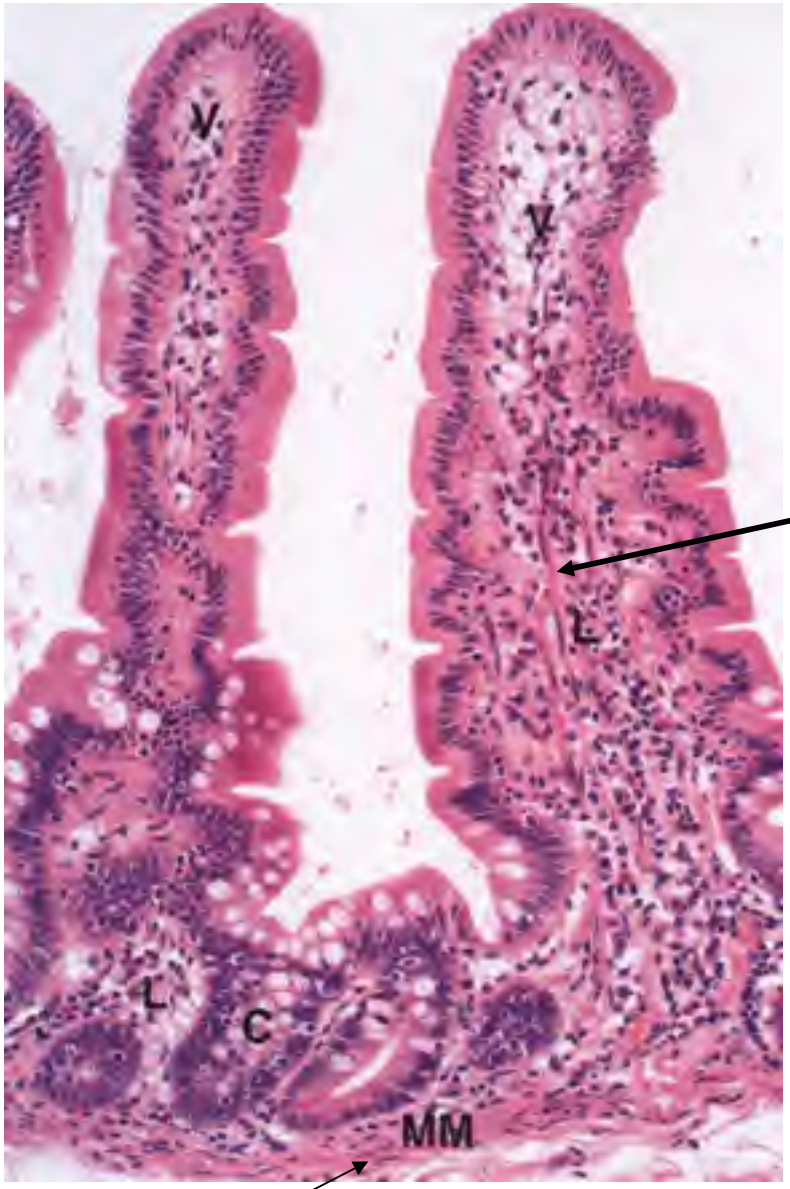
Muscularis externa & Myenteric plexus (Auerbach's plexus)



PD-INEL Matt Velkey Slide 153 of the University of Michigan slide collection

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

Keep the tube moving, mix contents



Smooth muscle cells run vertically from muscularis mucosae (MM) up the villi

Contraction pumps villi; propels lymph, blood from core of villi

L = lamina propria
V = villi
C = crypt

PD-INEL Young & Heath, *Wheater's Functional Histology, 4th ed.* (2000), p264 Fig 14.18b

Epithelial cell types: Small intestine

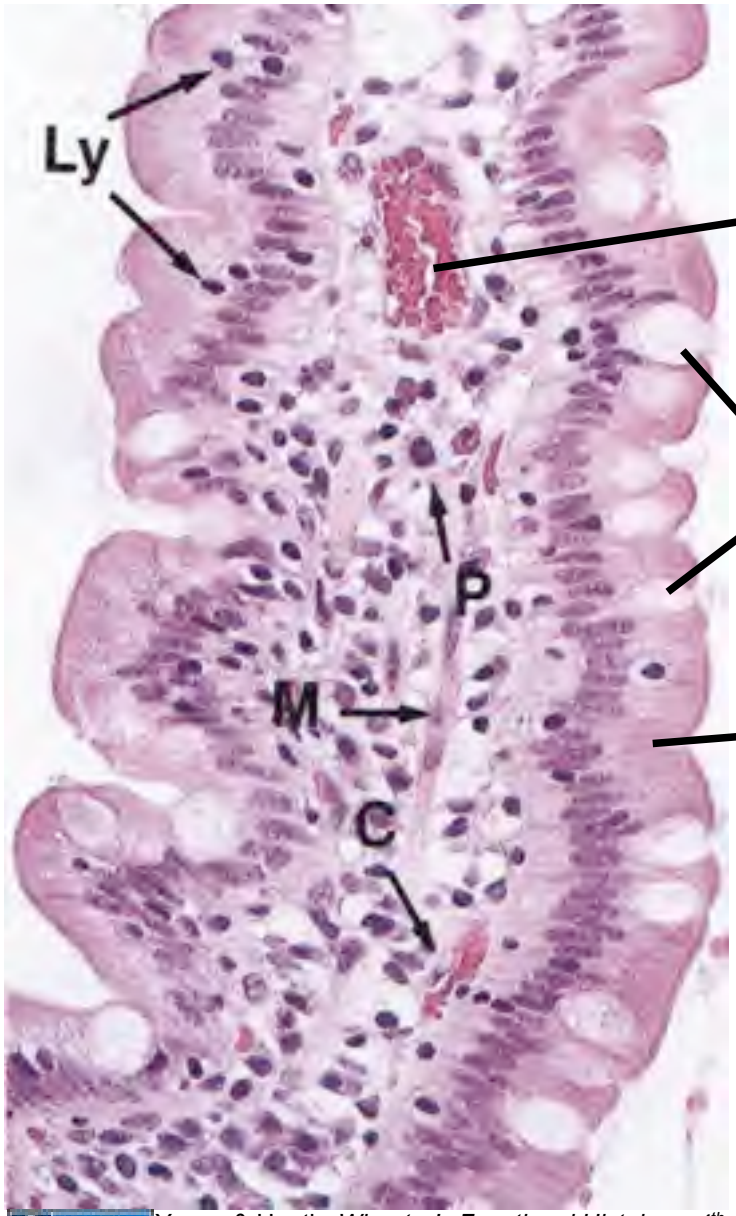
Enterocytes (majority of cells): Absorption (and secretion, e.g. enterokinase)

Goblet Cells: Increase in number as you descend the GI tract. Produce acid glycoproteins (mucins). Lubrication. Stain with Alcian Blue or PAS.

Enteroendocrine cells: Part of the "diffuse neuroendocrine system". Produce CCK, glucagon, secretin, motilin, etc. Hormone secretion.

Paneth cells: Located at base of crypts. Exocrine cells. Secrete lysozyme and α-defensins; Antibacterial activity.

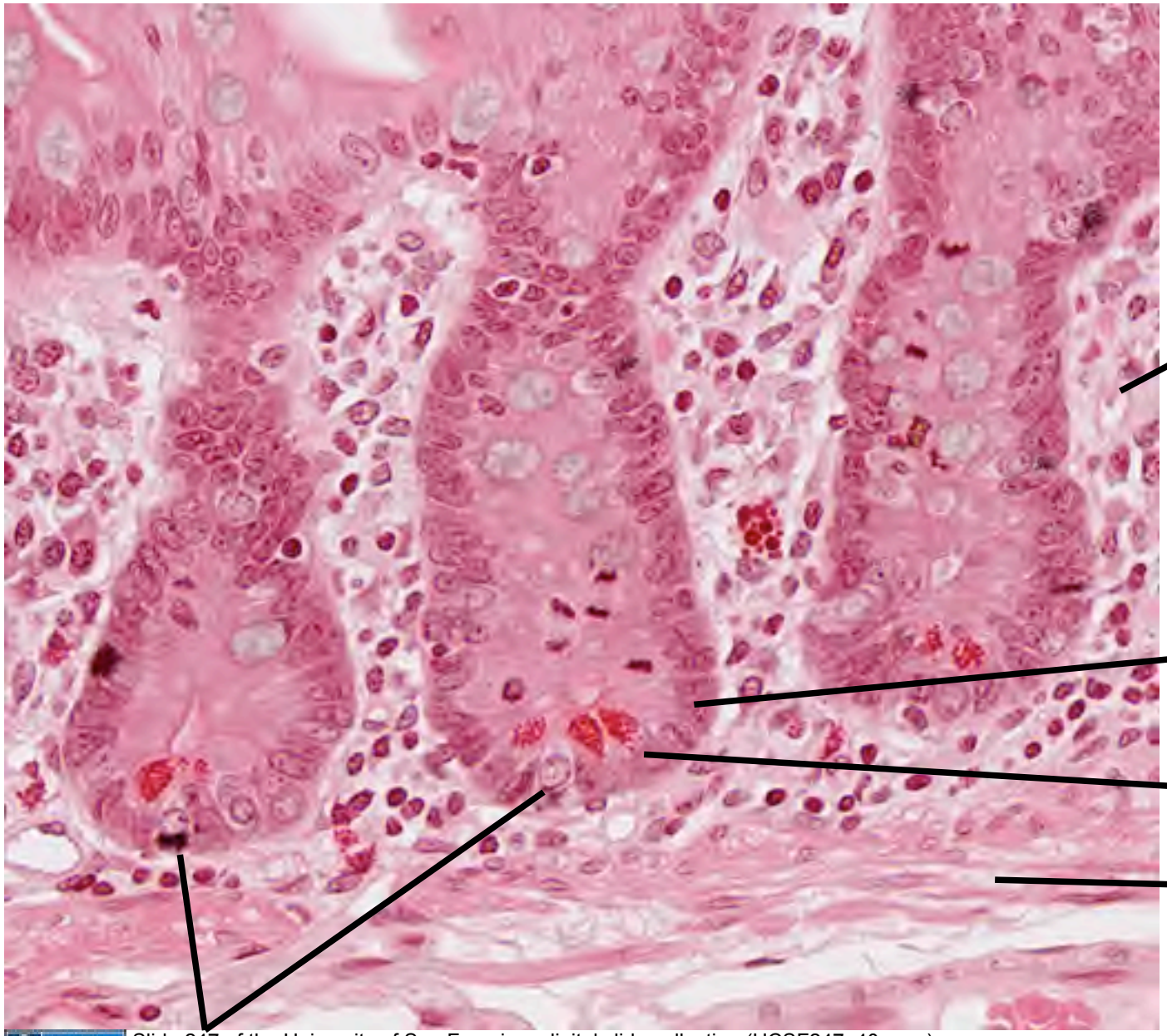
Villus tip



Young & Heath, *Wheater's Functional Histology, 4th ed.* (2000), p265 Fig 14.20a

Ly = Lymphocyte
P = Plasma cell
M = Muscle
C = Capillary

Crypt region (H&E+Argentaffin stain)



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Villi & Crypts - Scanning electron microscopy

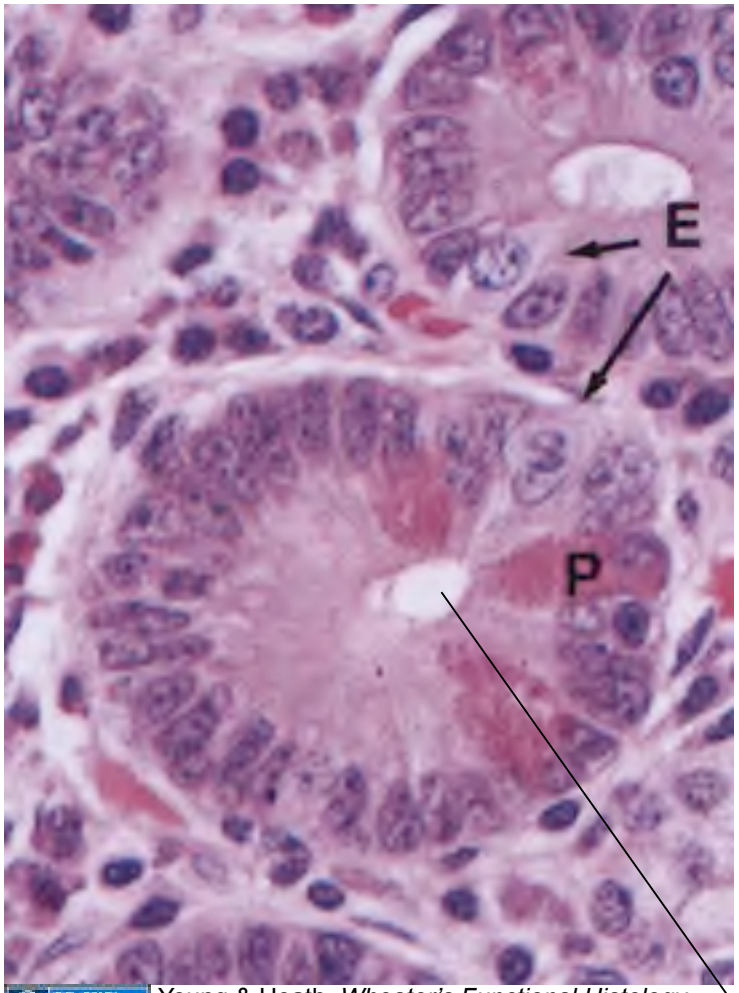
PD-INEL Young & Heath, *Wheater's Functional Histology, 4th ed.* (2000), p264 Fig 14.18a

Villi project into the lumen

Crypts (glands) invaginate into underlying lamina propria.

PD-INEL Cormack, *Ham's Histology 9th ed.* (1987) p505 Fig 18-29

Interpretation of cross-sections



Young & Heath, *Wheater's Functional Histology, 4th ed.* (2000), p265 Fig 14.19a

Young & Heath, *Wheater's Functional Histology, 4th ed.* (2000), p265 Fig 14.20b

Crypts

Intestinal lumen

Villi

The entire villus epithelium turns over every 3-4 days!!

PD-INEL Cormack, *Ham's Histology 9th ed.* (1987) p505 Fig 18-29

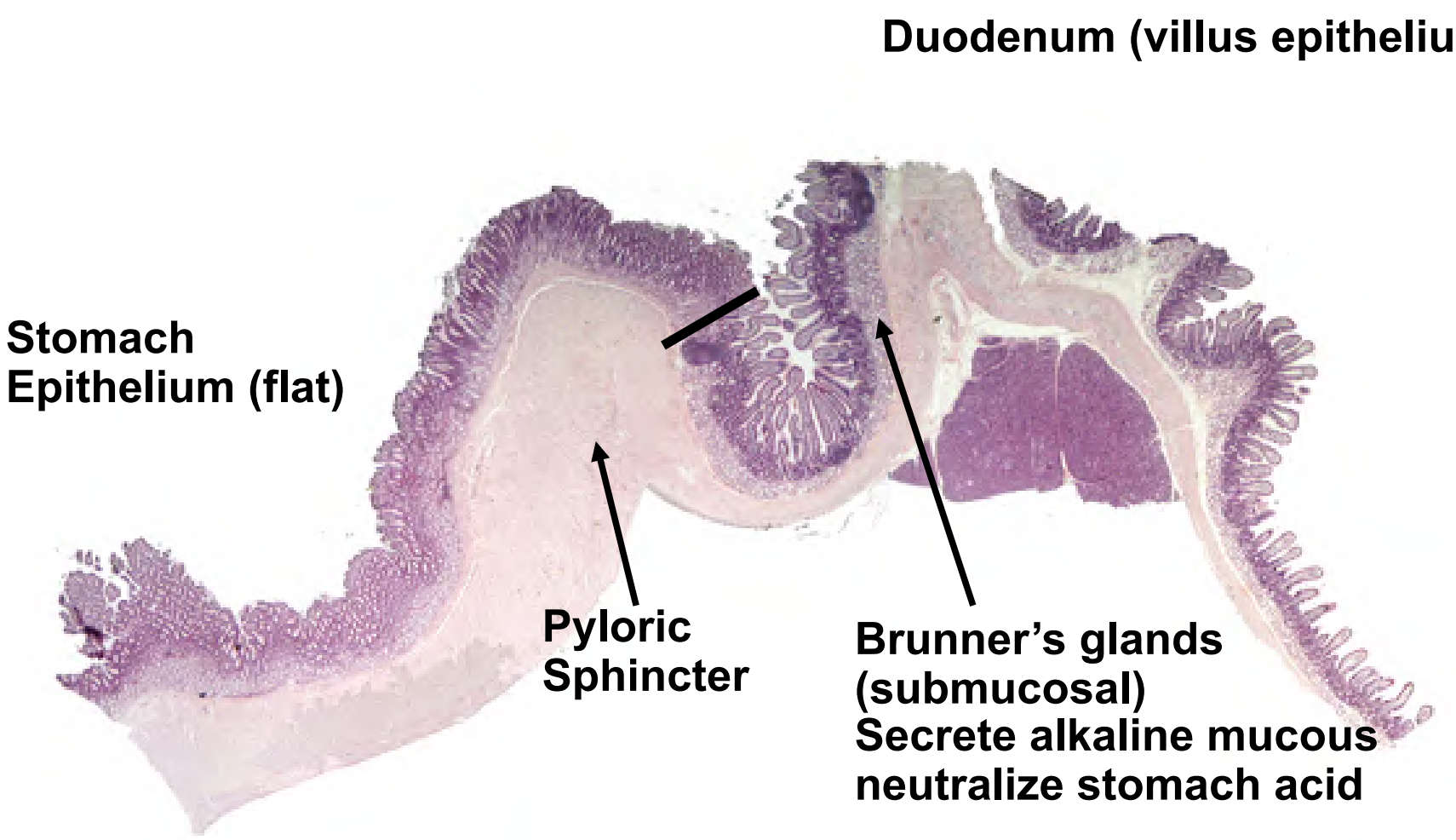
Cells at the apex slough off into the lumen

Cells differentiate as they migrate out of the crypts and up the sides of the villi.

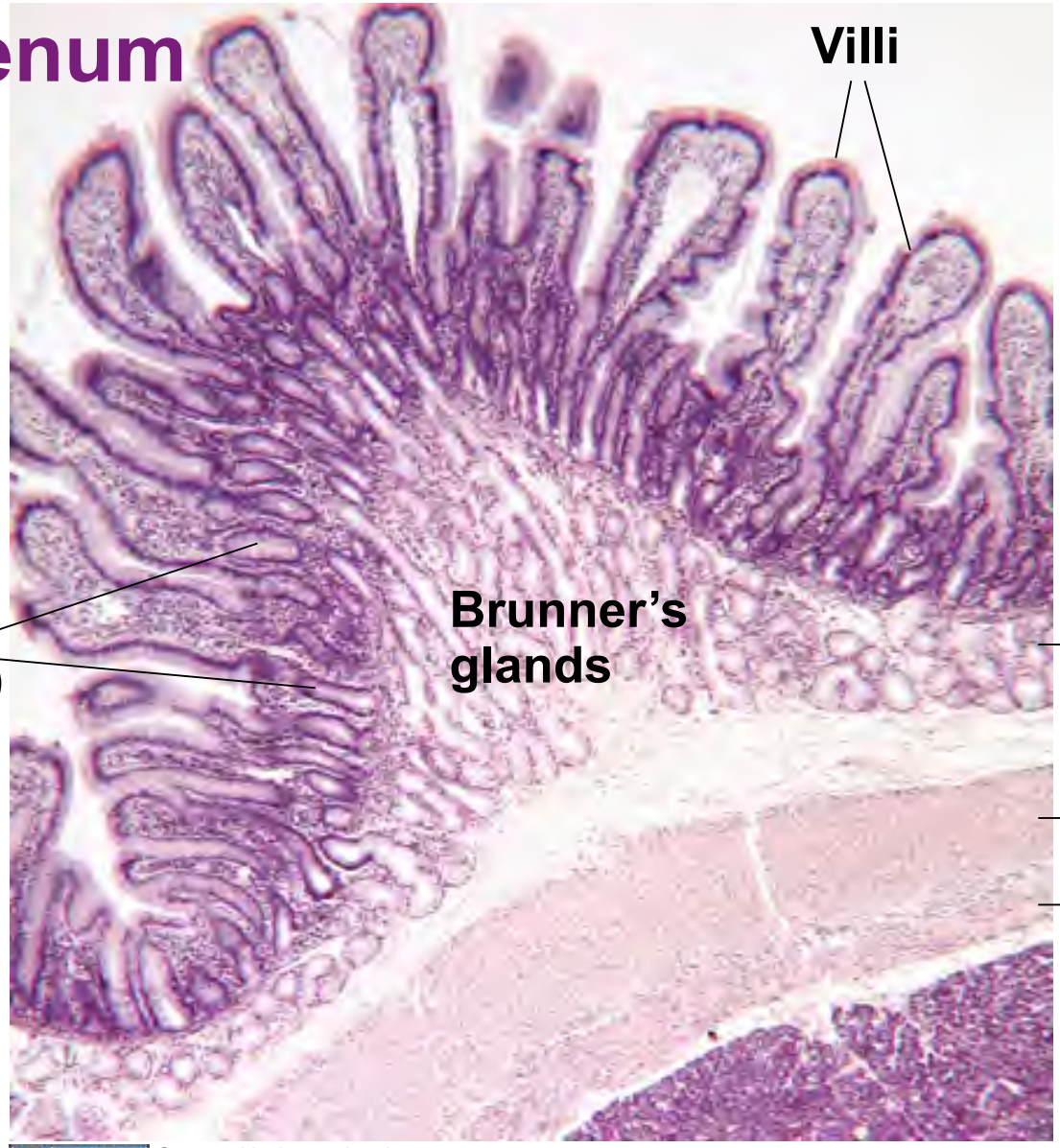
Stem cells (1-4/crypt) in crypt base give rise to four cell lineages

Note: villi and crypts are arranged such that each crypt contributes cells to a small stripe on multiple villi

Regional Morphology: Pyloric junction



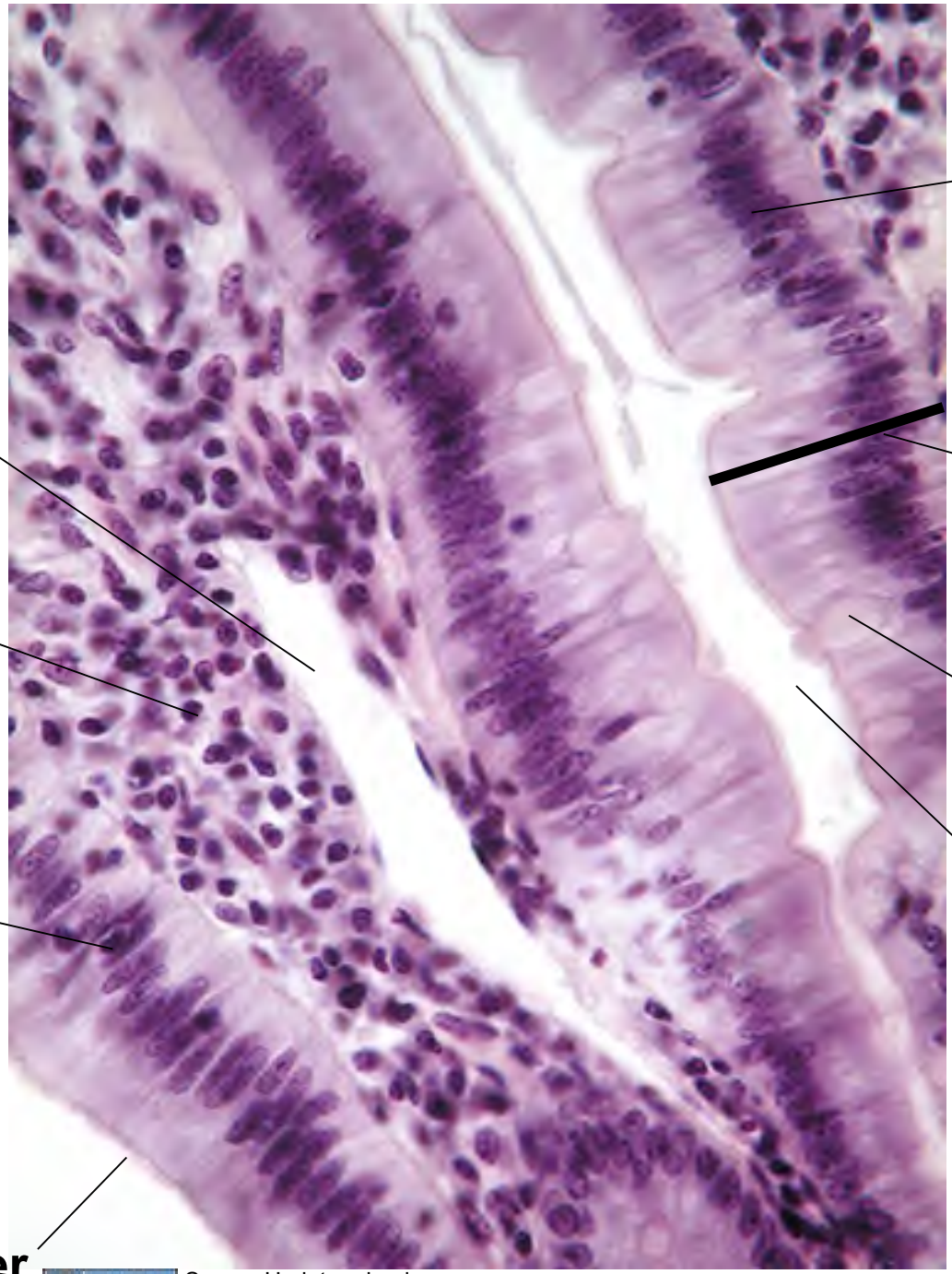
Duodenum



PD-INEL Source Undetermined

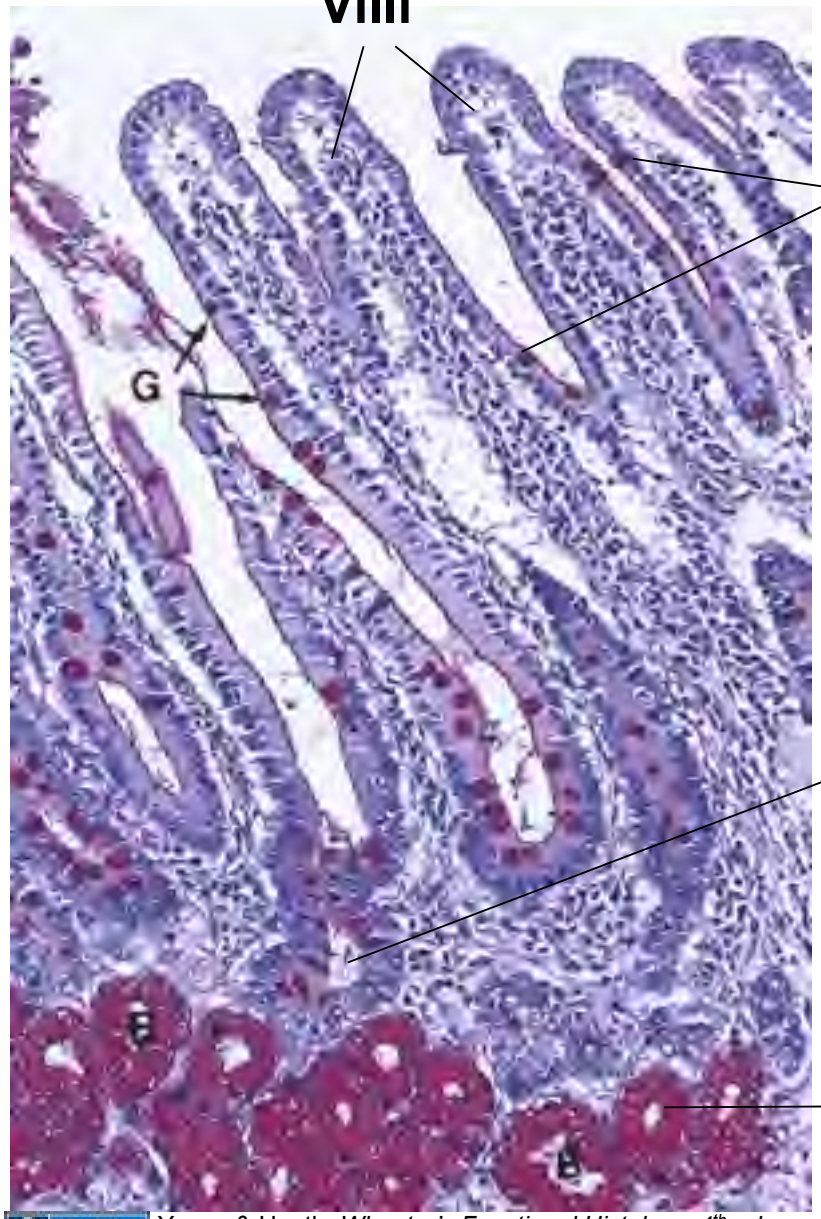
(Brunner's glands are diagnostic for duodenum….)

Surface of villi



Duodenum: Periodic Acid Schiff Stain (PAS)

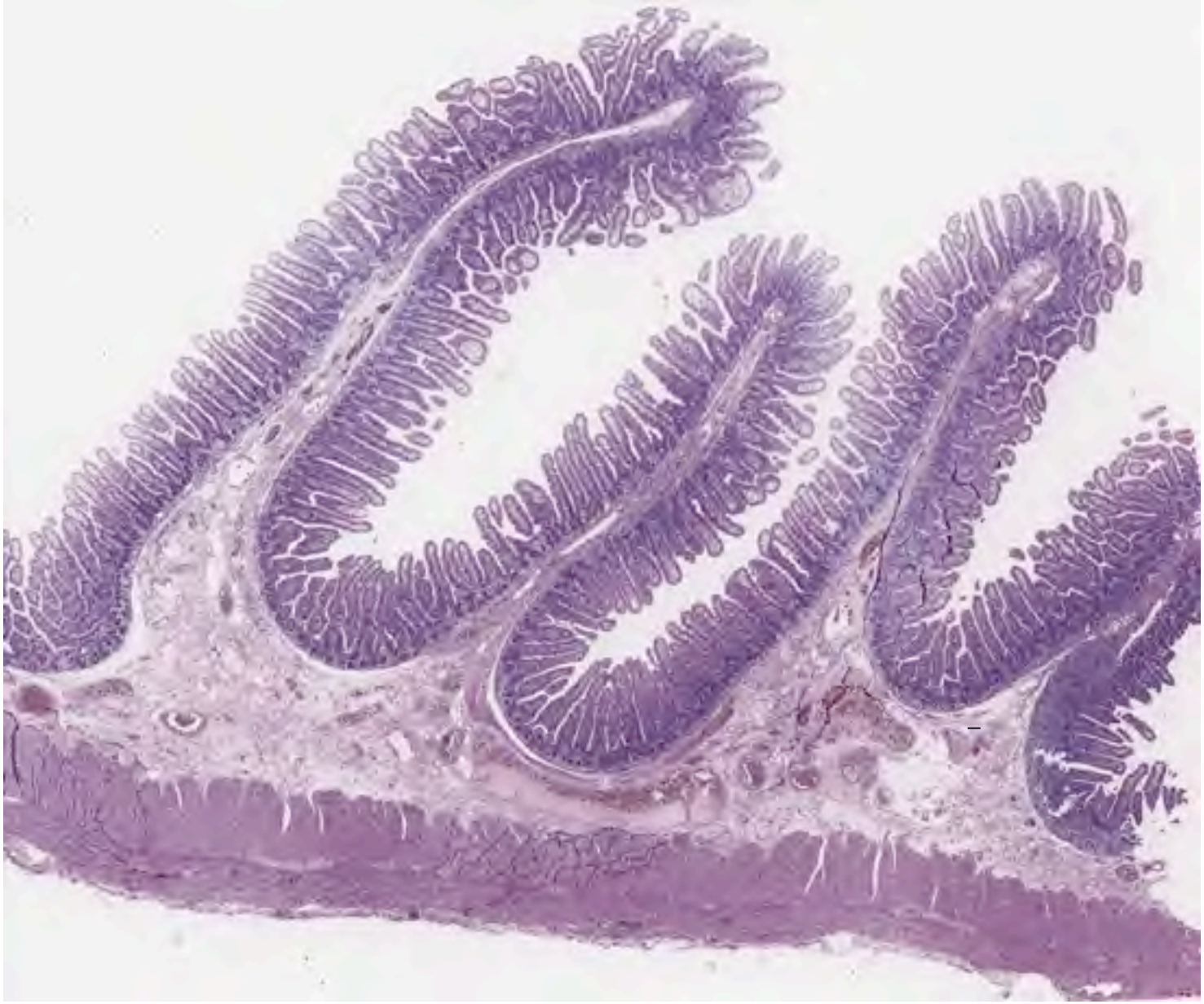
Stains complex carbohydrates (mucins) and negative charges strong magenta



PD-INEL Young & Heath, *Wheater's Functional Histology, 4th ed.* (2000), p263 Fig 14.17b

Jejunum/ileum

Jejunum, Ileum: no Brunner's glands
Jejunum has pronounced plicae circularis



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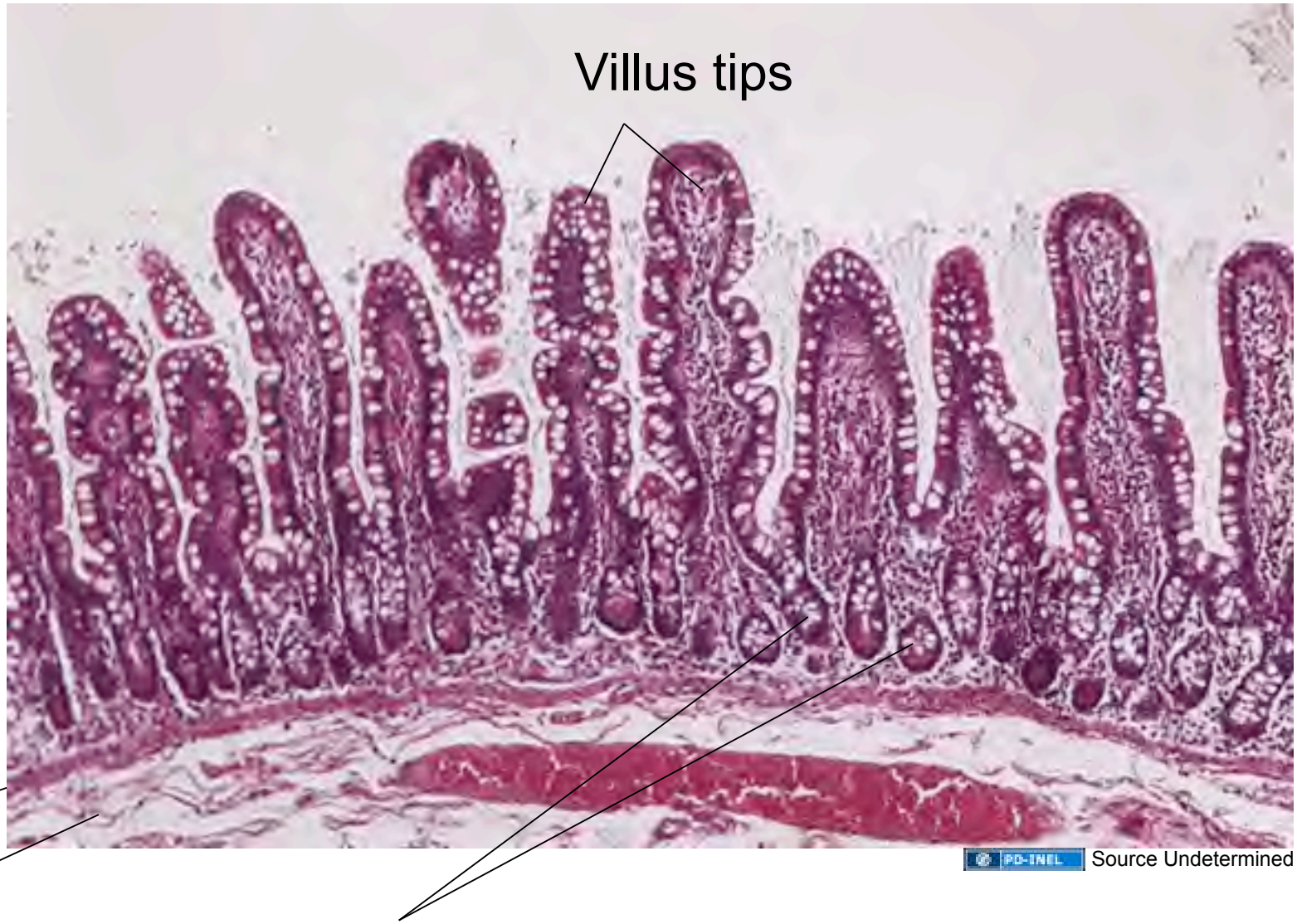
Jejunum/ileum



Crypts of Lieberkuhn (glands)
Contain stem cells

Jejunum/ileum

lymphoid follicles

PD-INEL Young & Heath, Wheater Functional Histology, 4th ed. (2000), p261 Fig 14.15b

Sr = Serosa

GALT: Gut Associated Lymphoid Tissue

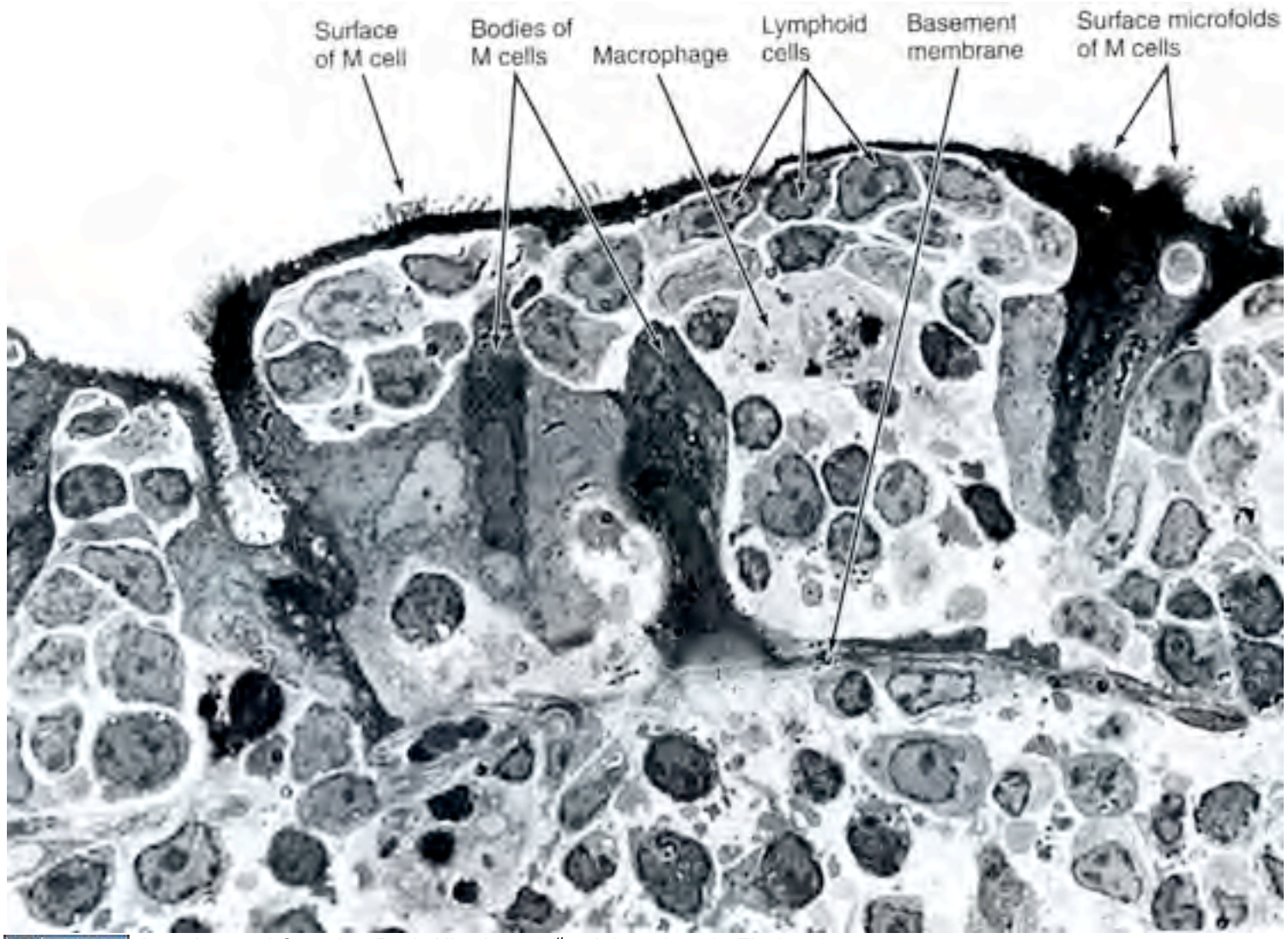
(approximately 1/4 of mucosa)

- Plasma cells, macrophages, lymphocytes located in lamina propria and submucosa
- Also “intraepithelial” lymphocytes – specialized T cells found between columnar epithelial cells
- Lymph nodules (or follicles): aggregations of lymphocytes usually in lamina propria, sometimes extending into submucosa
  -activated leukocytes go to nearby lymph nodes, activate T+B cells, which “home” to GI mucosa.
  -plasma cells develop from activated B cells in follicles and migrate into lamina propria to secrete antibodies (secretory IgA, which can be selectively transported across enterocytes into the gut lumen)

- “Peyer’s patches:” large aggregates of nodules (technically this term applies to aggregates found in ileum)
  -covered by M cells (specialized for uptake & presentation of antigen to underlying macrophages and lymphoid cells)

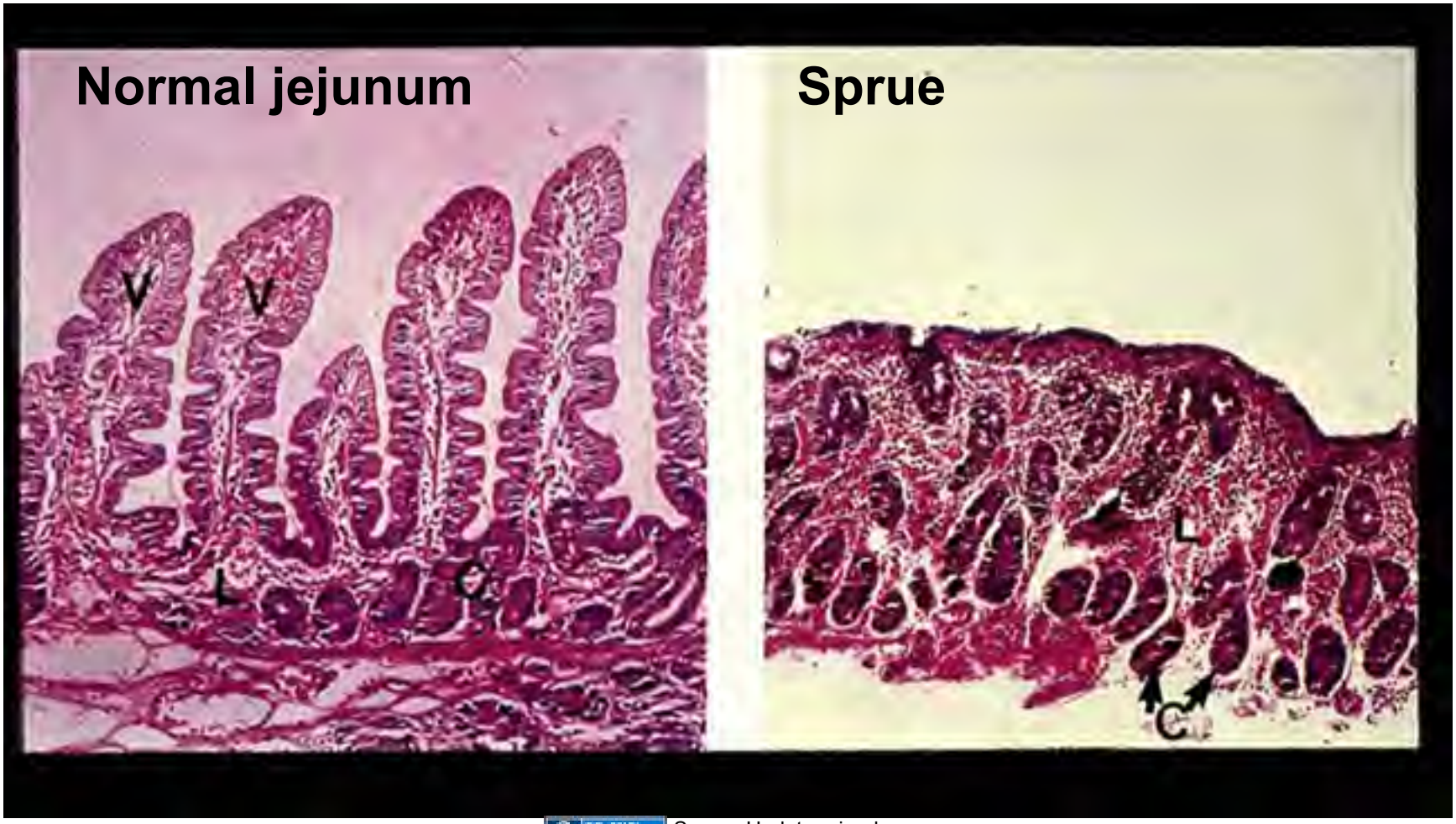
  Similar large aggregates also found in the APPENDIX

Peyer's patch histology - TEM



PD-INEL Junquiera and Carneiro. *Basic Histology, 10th ed.* (2003), p317 Fig 15-31

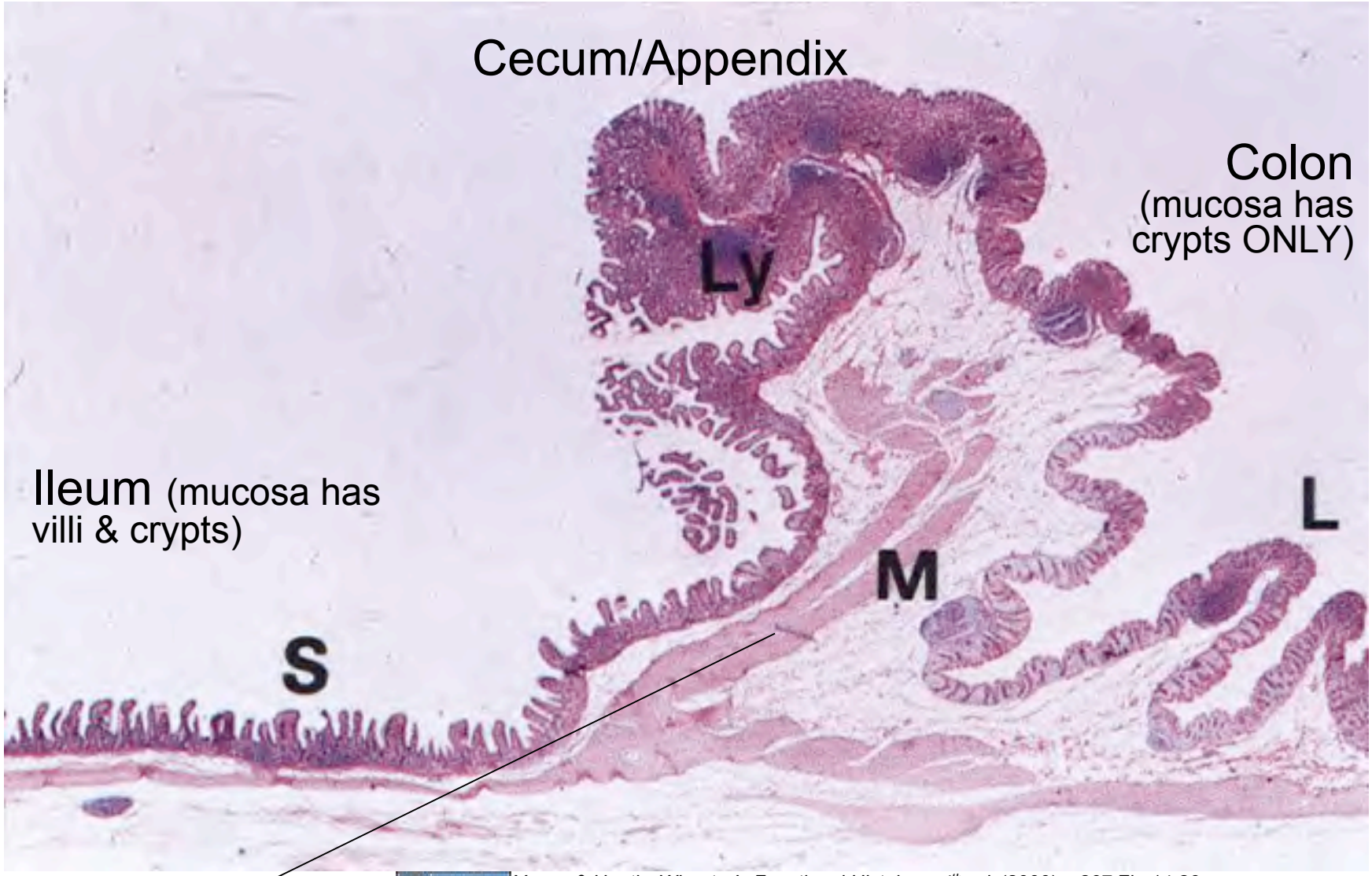
Sprue: **Immune reactivity to gliadin (a protein in most wheat cereals). Pathology primarily in jejunum. Diagnostic biopsy.**



PD-INEL Source Undetermined

Therapy: Gluten-free diet

Ileo-cecal junction (SI/LI)



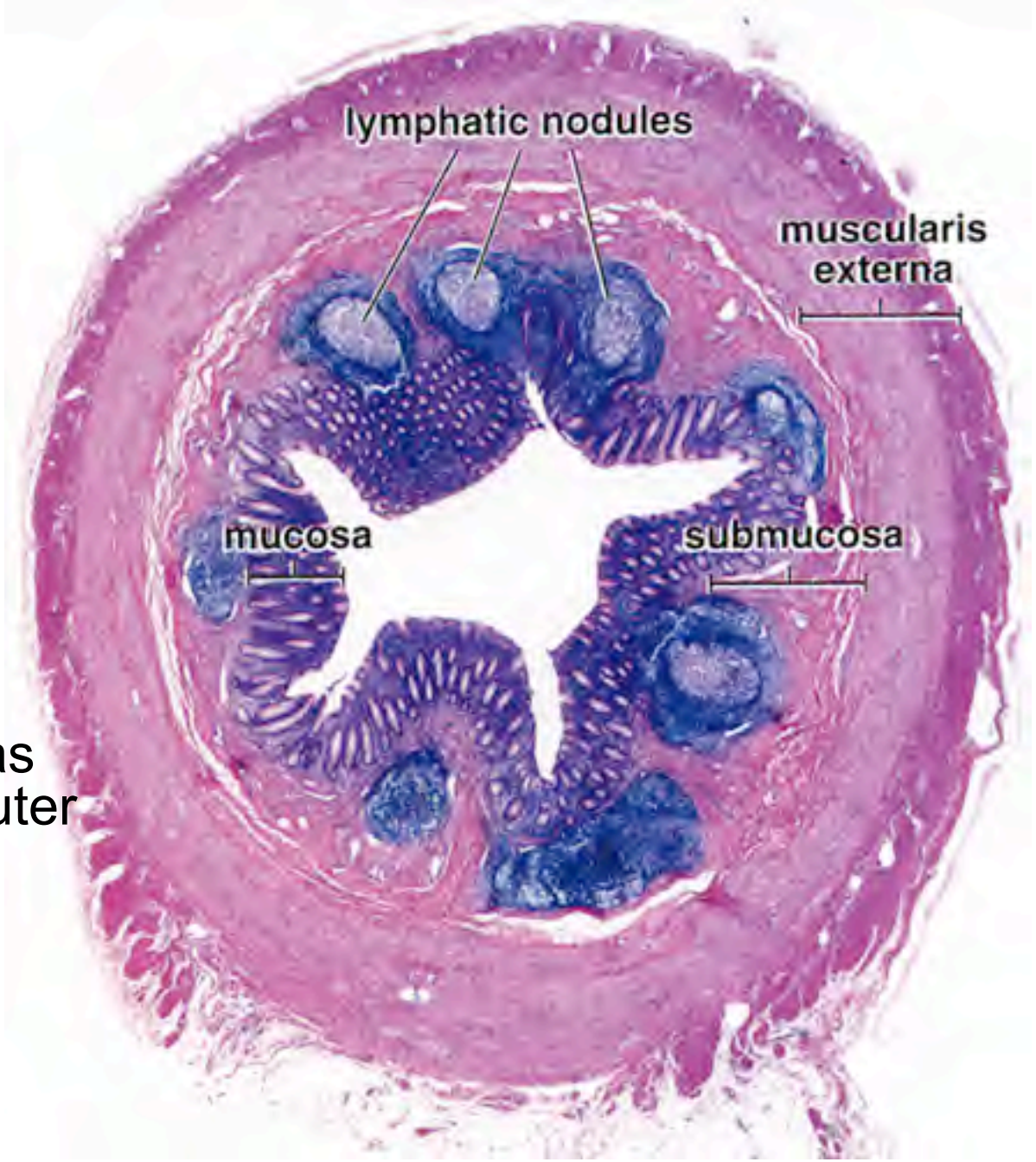
 Young & Heath, *Wheater's Functional Histology, 4th ed.* (2000), p267 Fig 14.26

Ileo-Cecal Valve
(extension of muscularis mucosae)

Appendix

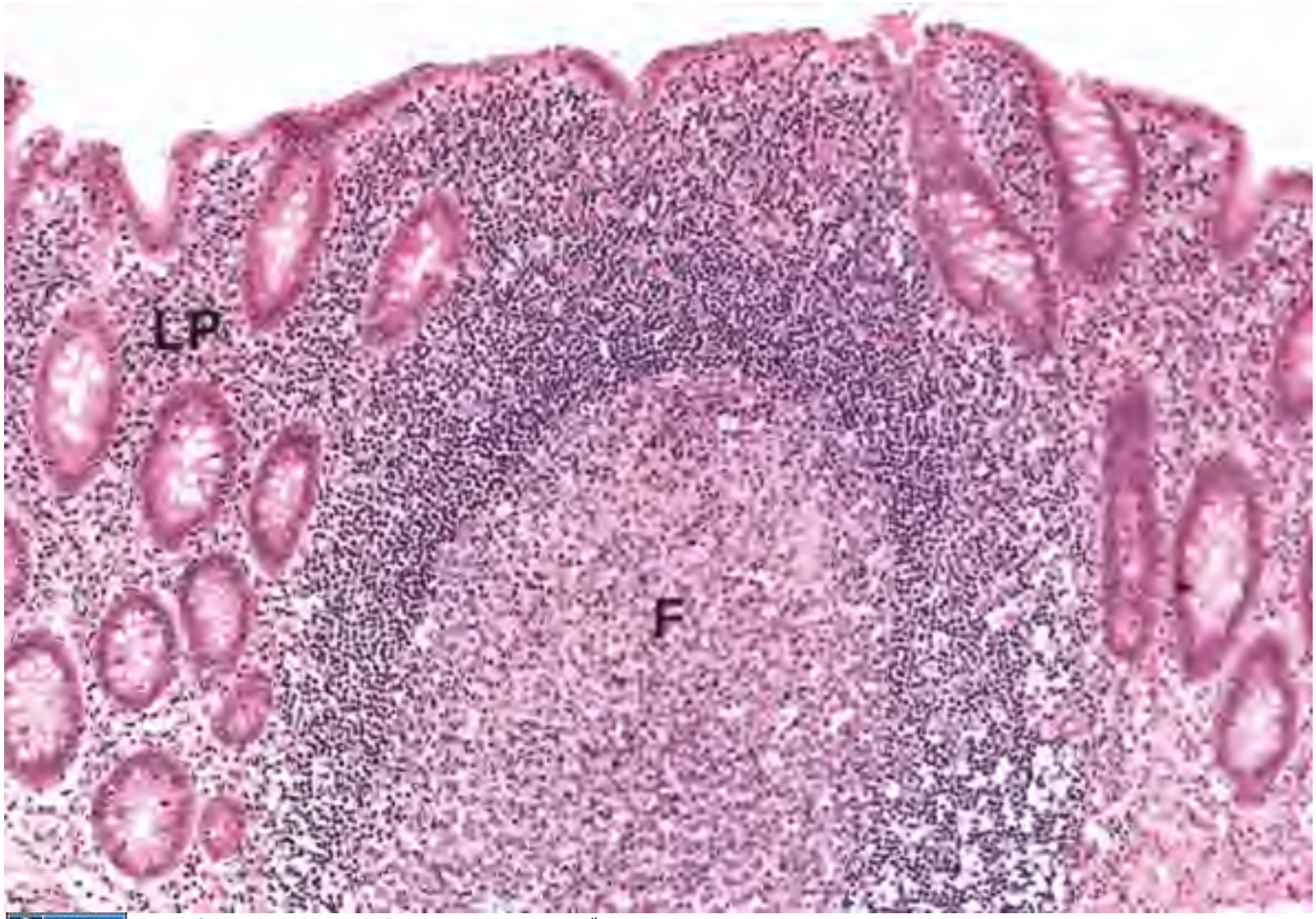
Blind sac extending from the caecum

- "Colonic" mucosa (crypts only)
- Note **prominent** lymphoid infiltrate in lamina propria (LP) and submucosa (SM)
- Muscularis externa has complete inner and outer smooth muscle layers (outer layer interrupted in colon)



PD-INEL Ross and Pawlina, *Histology: A Text and Atlas, 5th ed.* (2006), p550. Fig 17.35

Appendix - Lymphoid nodule/follicle



PD-INEL Young & Heath, *Wheater's Functional Histology, 4th ed.* (2000), p271.14.29b

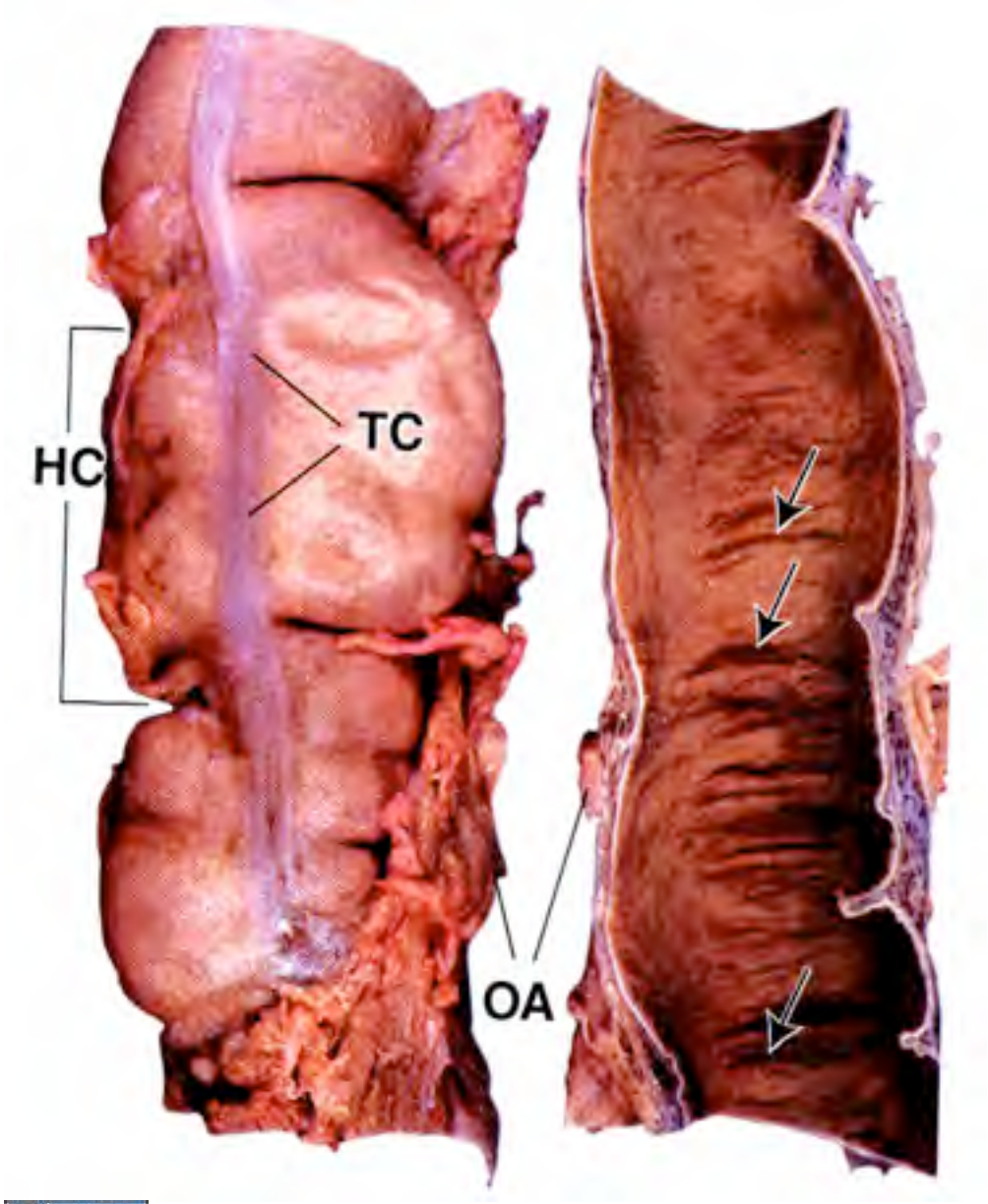
Colon - whole mount

Outer longitudinal muscle: three discontinuous bands (Teniae coli, TC)

Semilunal folds (arrows) caused by contraction of TC

Sacculations of external surface = Haustra coli (HC)

Small fatty projections of the serosa = omental appendices (OA)



PD-INEL Ross and Pawlina, *Histology: A Text and Atlas, 5th ed.* (2006), p548.

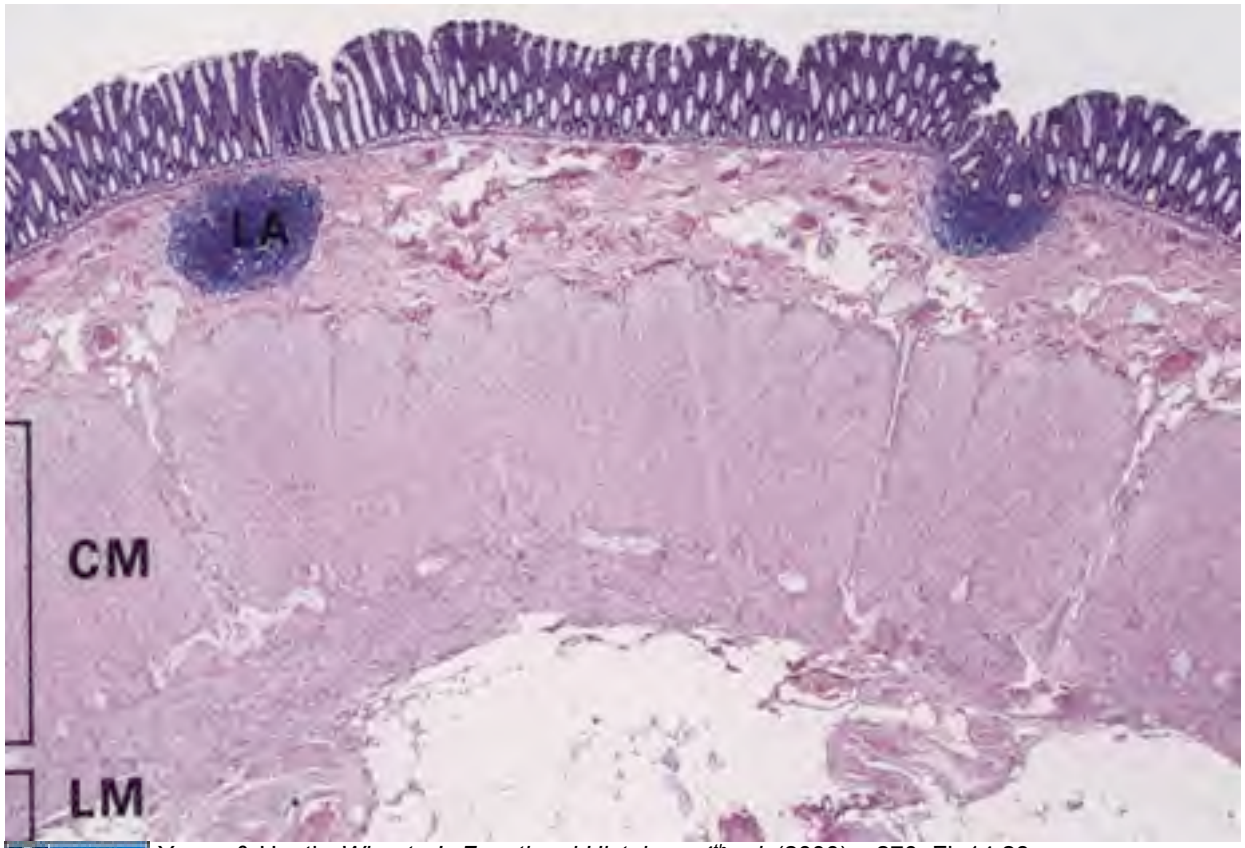
Colon

Flat epithelium (no villi)

Thick muscularis mucosae

Thick inner circular muscle

Three bands of longitudinal muscle (discontinuous) = *teniae coli*



PD-INEL Young & Heath, *Wheater's Functional Histology, 4th ed.* (2000), p270. Fig14.28a

Two types of muscle contraction by muscularis externa:

Segmentation: local contraction, mixes contents

Peristalsis: moves feces down the tube

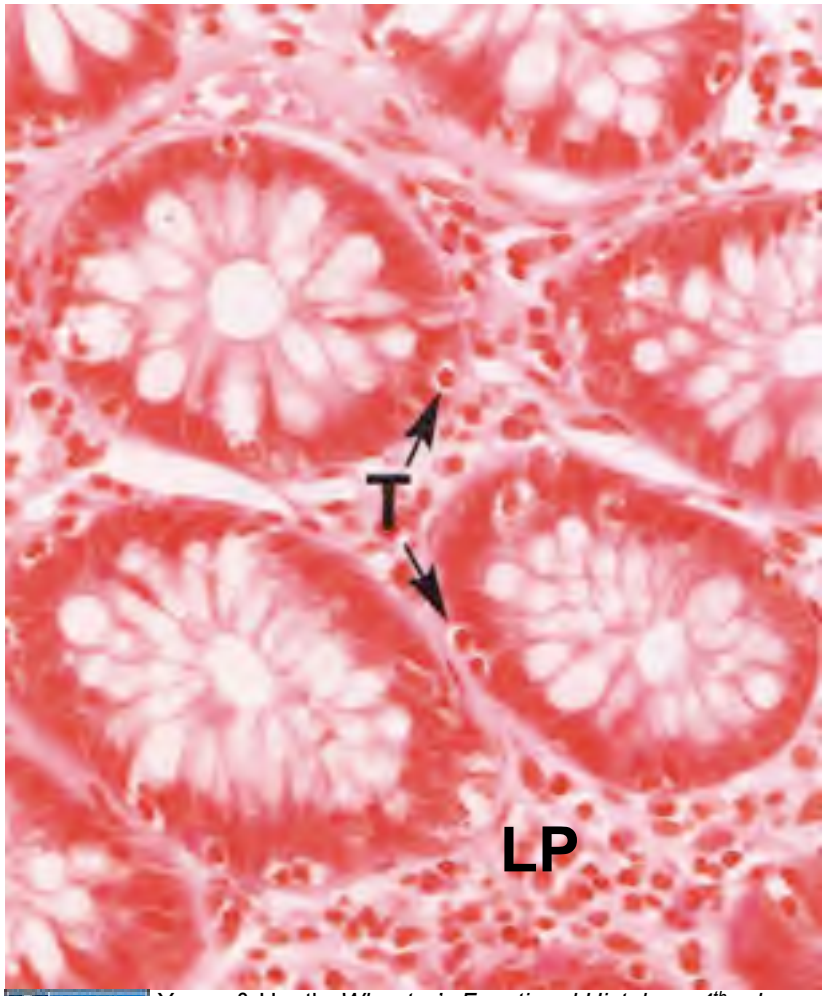
Colonic epithelium

PD-INEL Ross and Pawlina, *Histology: A Text and Atlas, 5th ed.* (2006), p548. Fig 17.33 (Both Images)

Rich in goblet cells; no villi (flat surface); tightly packed glands; stem cells at base of glands (arrows).

Colonic epithelium

PD-INEL Young & Heath, *Wheater's Functional Histology, 4th ed.* (2000), p261. Fig 14.28b



PD-INEL Young & Heath, *Wheater's Functional Histology, 4th ed.* (2000), p261. Fig 14.28e

T = intraepithelial T lymphocytes

LP = Lamina Propria

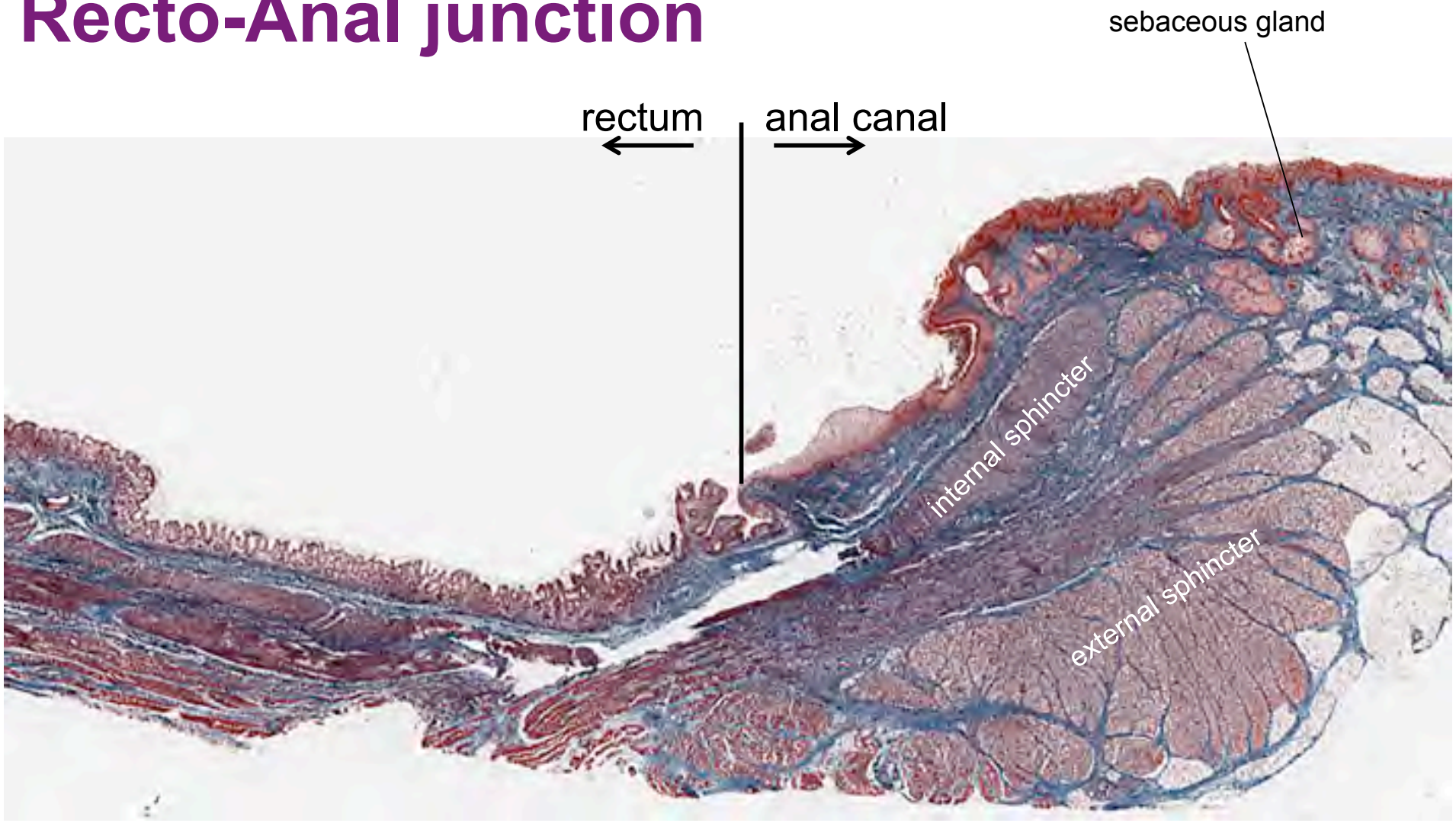
Susceptibility to disease is regional in the small and large intestine

Predominant **location of pathology:**

Sprue - jejunum
Crohn's disease - ileum
Ulcerative colitis - colon/rectum
Hirschprung's disease -colon
Bacterial colitis - SI and/or LI

Cancer is a disease of the large bowel and is rarely seen in the small intestine

Recto-Anal junction

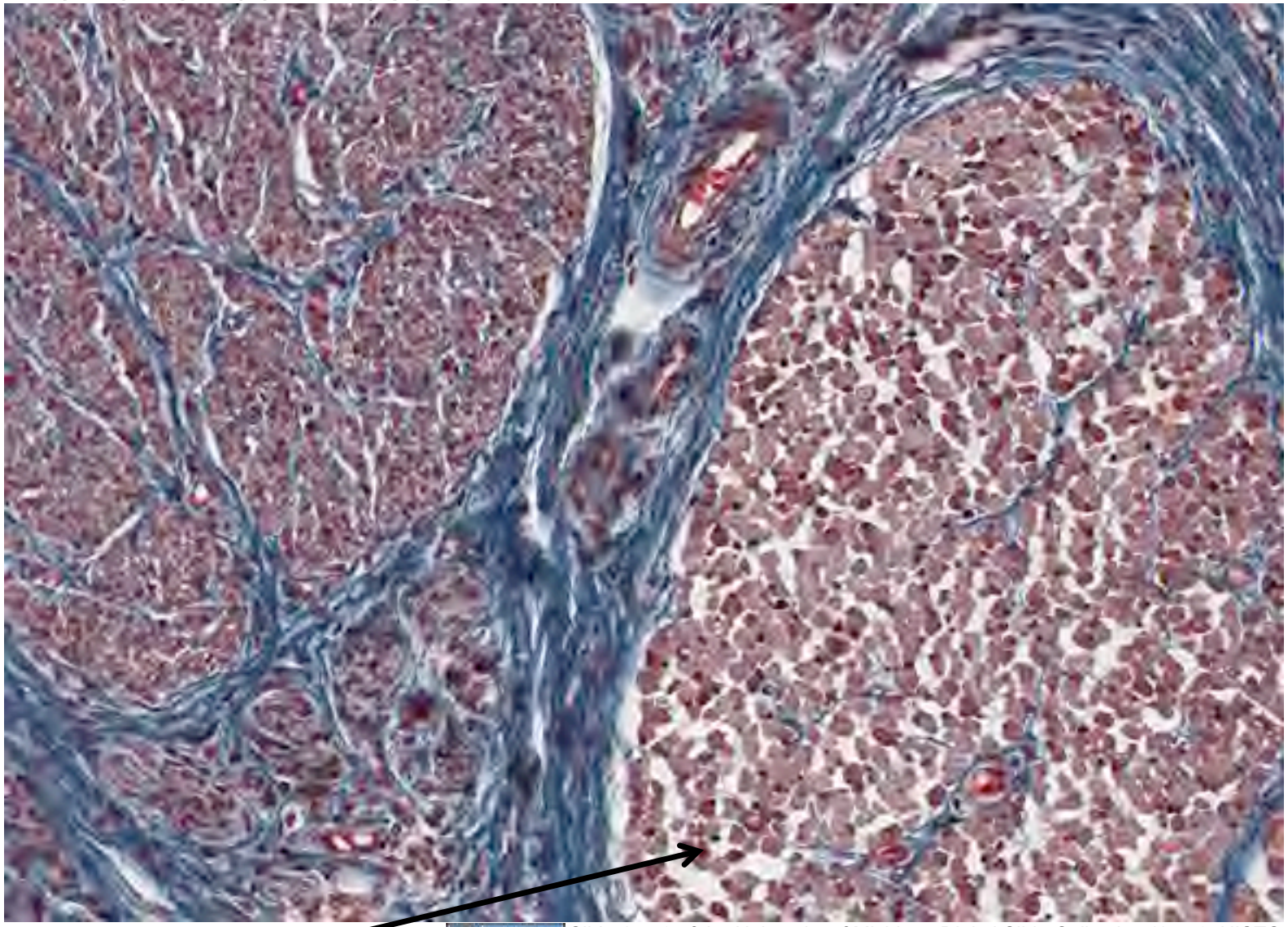


Slide 177-2 of the University of Michigan Digital Slide Collection (177-2_HISTO_20X.svs).

- Transition from columnar epithelium to stratified squamous epithelium (stratified epithelium is non-keratinized proximal, keratinized distal)
- Internal and external anal sphincters: smooth and skeletal m., respectively
- Note also dermal sebaceous glands and adipose tissue in wall of anal canal

Recto-Anal Junction: anal sphincters

internal: smooth muscle



PD-INEL Slide 177-2 of the University of Michigan Digital Slide Collection (177-2_HISTO_20X.svs).

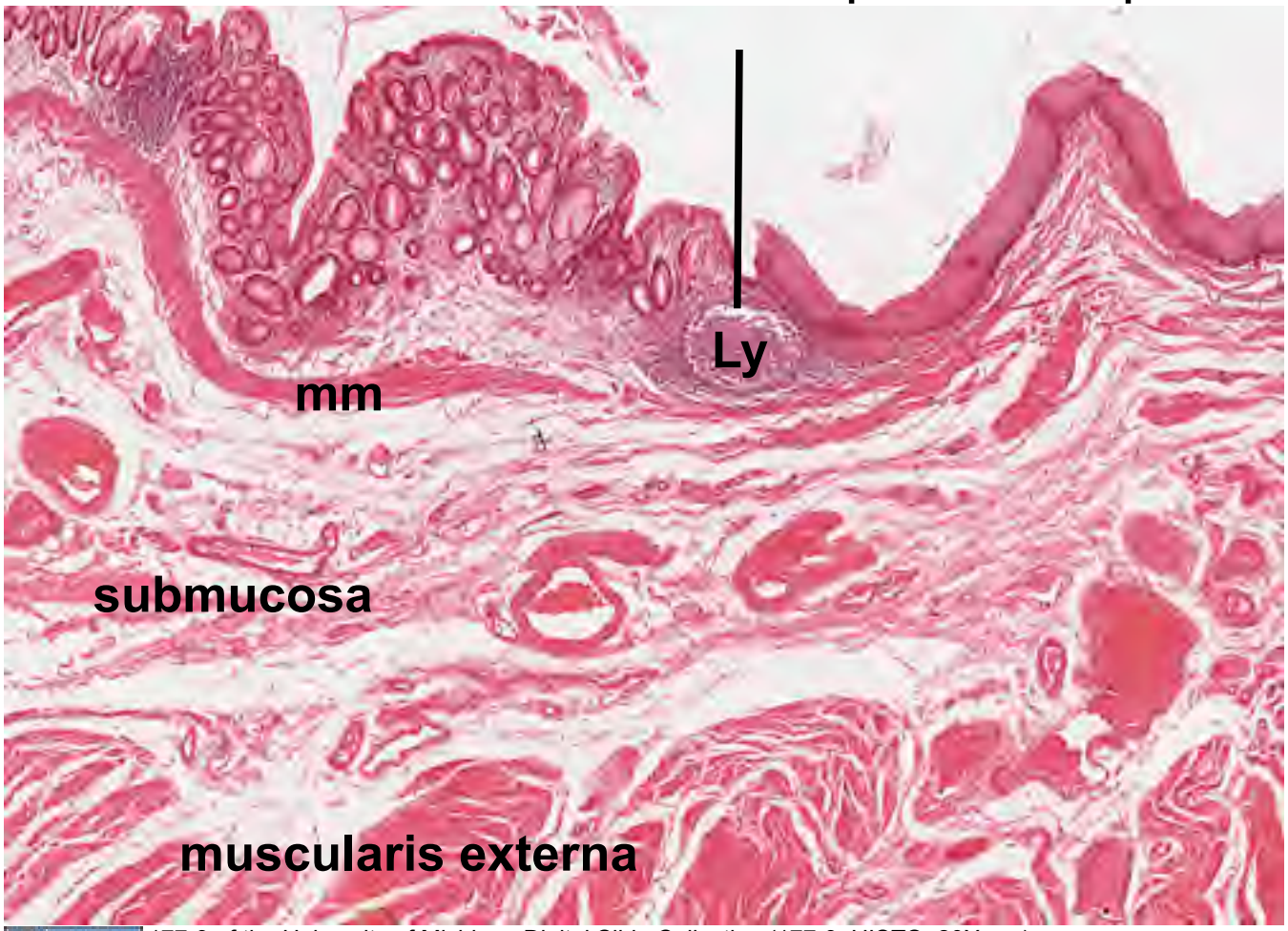
external: skeletal muscle

Recto-Anal junction

Rectal mucosa -
Columnar epithelium

Anal canal - stratified
squamous epithelium

mm=muscularis mucosae;
Ly=lymph nodule



PD-INEL 177-3 of the University of Michigan Digital Slide Collection (177-3_HISTO_20X.svs).

dilated submucosal vessels = “internal” rectal hemorrhoids

Recto-Anal junction

Young & Heath, *Wheater's Functional Histology, 4th ed.* (2000), p271. Fig14.31h

Learning Objectives

- Be able to identify and describe the function of the layers AND COMPONENT CELLS/TISSUES in the wall of the digestive tract (mucosa, submucosa, muscularis externa and adventitia/serosa), and be aware of how the layers may differ in the small and large intestine.

- Be able to identify and know the general functions of the following regions of the GI tract:
  - Duodenum
  - Jejunum/ileum
  - Colon
  - Appendix
  - Rectum
  - Anal canal

Additional Source Information

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

Slide 3: US Federal Government; Replaced: Fig 14.1 from Young & Heath, Wheater's Functional Histology, 4th ed. (2000), p250

Slide 6: University of Delaware Library Institutional Repository, http://dspace.udel.edu:8080/dspace/handle/19716/2169; Replaced: Fig 14.16 from Young & Heath, Wheater's Functional Histology ,4th ed. (2000), p262

Slide 7: Ross and Pawlina, Histology: A Text and Atlas, 5th ed. (2006), p535 Fig 17.17

Slide 8: Source Undetermined

Slide 9: Original: is Fig 16-32 from Kelly et al. Bailey's Textbook of Histology, 18th ed. (1984), p543.

Slide 10: Slide 246 of the Univ. of San Francisco School of Medicine Histology Collection

Slide 11: Source Undetermined

Slide 12: Source Undetermined

Slide 13: Sources Undetermined (All Images)

Slide 14: Source: Fig 26-6 from Fawcett and Raviola, Bloom and Fawcett, a Textbook of Histology, 12th ed. (1994), p622

Slide 15: University of Delaware Library Institutional Repository,http://dspace.udel.edu:8080/dspace/handle/19716/2169; Replaced: Fig 14.16 from Young & Heath, Wheater's Functional Histology, 4th ed. (2000), p262

Slide 18: Regents of the University of Michigan Replaced: Image is Fig 17.29 from Ross and Paulina, Histology: A Text and Atlas, 5th ed. (2006), p546.

Slide 19: Young & Heath, Wheater's Functional Histology, 4th ed. (2000), p261 Fig 14.15a

Slide 20: Matt Velkey Slide 169 of the University of Michigan Histology Collection

Slide 21: Young & Heath, *Wheater's Functional Histology,4th ed.* (2000), p261. Fig 14.15a

Slide 22: Matt Velkey Slide 153 of the University of Michigan slide collection

Slide 23: Young & Heath, *Wheater's Functional Histology, 4th ed.* (2000), p264 Fig 14.18b

Slide 25: Young & Heath, *Wheater's Functional Histology, 4th ed.* (2000), p265 Fig 14.20a

Slide 26: Slide 247 of the University of San Francisco digital slide collection (UCSF247_40x.svs)

Slide 27: Young & Heath, *Wheater's Functional Histology, 4th ed.* (2000), p264 Fig 14.18a; Cormack, *Ham's Histology 9th ed.* (1987) p505 Fig 18-29

Slide 28: Young & Heath, *Wheater's Functional Histology, 4th ed.* (2000), p265 Fig 14.19a; Young & Heath, *Wheater's Functional Histology, 4th ed.* (2000), p265 Fig 14.20b

Slide 29: Cormack, *Ham's Histology 9th ed.* (1987) p505 Fig 18-29

Slide 26: Slide 247 of the University of San Francisco digital slide collection (UCSF247_40x.svs)

Slide 27: Young & Heath, *Wheater's Functional Histology, 4th ed.* (2000), p264 Fig 14.18a; Cormack, *Ham's Histology 9th ed.* (1987) p505 Fig 18-29

Slide 28: Young & Heath, *Wheater's Functional Histology, 4th ed.* (2000), p265 Fig 14.19a; Young & Heath, *Wheater's Functional Histology, 4th ed.* (2000), p265 Fig 14.20b

Slide 29: Cormack, *Ham's Histology 9th ed.* (1987) p505 Fig 18-29

Slide 30: Source Undetermined

Slide 31: Source Undetermined

Slide 32: Source Undetermined

Slide 33: Young & Heath, *Wheater's Functional Histology, 4th ed.* (2000), p263 Fig 14.17b

Slide 34: Image is from Slide 246 of the Univ of San Francisco School of Medicine Histology Collection

Slide 35: Source Undetermined

Slide 36: Young & Heath, Wheater Functional Histology, 4th ed. (2000), p261 Fig 14.15b

Slide 38: Junquiera and Carneiro. *Basic Histology, 10th ed.* (2003), p317 Fig 15-31

Slide 39: Source Undetermined

Slide 40: Young & Heath, *Wheater's Functional Histology, 4th ed.* (2000), p267 Fig 14.26

Slide 41: Ross and Pawlina, *Histology: A Text and Atlas, 5th ed.* (2006), p550. Fig 17.35

Slide 42: Young & Heath, *Wheater's Functional Histology, 4th ed.* (2000), p271.14.29b

Slide 43: Ross and Pawlina, *Histology: A Text and Atlas, 5th ed.* (2006), p548.

Slide 44: Young & Heath, *Wheater's Functional Histology, 4th ed.* (2000), p270. Fig14.28a

Slide 45: Ross and Pawlina, *Histology: A Text and Atlas, 5th ed.* (2006), p548. Fig 17.33 (Both Images)

Slide 46: Young & Heath, *Wheater's Functional Histology, 4th ed.* (2000), p261. Fig 14.28b and Fig 14.28e

Slide 48: Slide 177-2 of the University of Michigan Digital Slide Collection (177-2_HISTO_20X.svs).

Slide 49: Slide 177-2 of the University of Michigan Digital Slide Collection (177-2_HISTO_20X.svs).

Slide 50: 177-3 of the University of Michigan Digital Slide Collection (177-3_HISTO_20X.svs).

Slide 51: Young & Heath, *Wheater's Functional Histology, 4th ed.* (2000), p271. Fig14.31h