



# **Atlas of Human Histology**

**A Guide to Microscopic Structure of  
Cells, Tissues and Organs**

***Robert L. Sorenson***



This atlas is a series of photographs ranging from low to high magnifications of the individual tissue specimens. The low magnification images should be used for orientation, while the higher magnification images show details of cells, tissues, and organs. Although every effort has been made to faithfully reproduce the colors of the tissues, a full appreciation of histological structure is best achieved by examining the original specimens with a microscope. This atlas is a preview of what should be observed.

The photomicrographs found in this atlas come from the collection of microscope slide used by medical, dental and undergraduate students of histology at the University of Minnesota. Most of these slides were prepared by Anna-Mary Carpenter M.D., Ph.D. during her tenure as Professor in the Department of Anatomy (University of Minnesota Medical School).

Each tissue specimen, in its entirety, has been digitized with a high resolution 40X or 60X lens to generate virtual microscope slides. The Virtual Microscope Collection includes additional slides which complement and extend the core slide collection. Producing the virtual slide collection and developing the web site for their presentation was done with the very capable assistance of Todd C. Brelje Ph.D.

The drawings that appear in the atlas are the product of Jean E. Magney, who is accomplished both as an histologist and an artist. Her talented interpretation of biological structure and its artistic rendering greatly facilitate the learning and comprehension of histology. These drawings first appeared in "Color Atlas of Histology" Stanley L. Erlandson and Jean E. Magney, Mosby 1992.

Robert L. Sorenson, Ph.D.



## TABLE OF CONTENTS

<b>CHAPTER 1 INTRODUCTION AND CELL</b>	<b>1</b>
<b>CHAPTER 2 EPITHELIUM</b>	<b>15</b>
<b>CHAPTER 3 CONNECTIVE TISSUE</b>	<b>29</b>
<b>CHAPTER 4 MUSCLE TISSUE</b>	<b>43</b>
<b>CHAPTER 5 CARTILAGE AND BONE</b>	<b>61</b>
<b>CHAPTER 6 NERVE TISSUE</b>	<b>85</b>
<b>CHAPTER 7 PERIPHERAL BLOOD</b>	<b>107</b>
<b>CHAPTER 8 HEMATOPOESIS</b>	<b>113</b>
<b>CHAPTER 9 CARDIOVASCULAR SYSTEM</b>	<b>127</b>
<b>CHAPTER 10 LYMPHOID SYSTEM</b>	<b>157</b>
<b>CHAPTER 11 SKIN</b>	<b>181</b>
<b>CHAPTER 12 EXOCRINE GLANDS</b>	<b>193</b>
<b>CHAPTER 13 ENDOCRINE GLANDS</b>	<b>205</b>
<b>CHAPTER 14 GASTROINTESTINAL TRACT</b>	<b>223</b>
<b>CHAPTER 15 LIVER AND GALL BLADDER</b>	<b>247</b>
<b>CHAPTER 16 URINARY SYSTEM</b>	<b>261</b>
<b>CHAPTER 17 RESPIRATORY SYSTEM</b>	<b>289</b>
<b>CHAPTER 18 FEMALE REPRODUCTIVE SYSTEM</b>	<b>305</b>
<b>CHAPTER 19 MALE REPRODUCTIVE SYSTEM</b>	<b>329</b>
<b>CHAPTER 20 ORGANS OF SPECIAL SENSE</b>	<b>343</b>
<b>INDEX</b>	<b>363</b>

## CHAPTER 14 GASTROINTESTINAL TRACT

The gastrointestinal tract is a hollow muscular tube that starts at the esophagus and ends with the anus. It is divided into four regions, the esophagus, stomach, small intestine and large intestine. The esophagus is a passage for transporting food to the stomach. The stomach adds gastric juices to begin digestion. It is divided into three histologic regions: cardiac, fundus/body and pyloric. The small intestine is the principle site for digestion and absorption. It transfers chyme from the stomach to the large intestine and is divided into three regions: duodenum, jejunum and ileum. The large intestine has the main function of re-absorbing water from the chyme and adding mucus to facilitate transport of the feces. The parts of the large intestine are the cecum, appendix, colon, rectum and anal canal.

### GENERAL PLAN FOR HOLLOW TUBULAR ORGANS

The walls of hollow organs have four layers or tunics: mucosa, submucosa, muscularis externa and adventitia or serosa.

**Mucosa** (mucous membrane): Mucous membranes line internal passages and provide a barrier between the tissues of the body and the external environment. The membranes are constantly wet and lubricated by mucus. The mucosa has three parts: an epithelium, lamina propria and muscularis mucosa. The **epithelium** varies in different regions depending on its function (i.e. protective, secretory or absorptive). The **lamina propria** is a connective tissue layer that supports the epithelium and contains small arteries, veins, lymphatics and nerves. Lymphocytes and plasma cells are also frequently seen in this layer. When glands are found in this layer they are referred to as mucosal glands. The **muscularis mucosa**, when present, consists of two or three layers of smooth muscle. It facilitates localized movement of the mucous membrane, aiding expression of secretions and movement of fluid across the surface of the epithelium.

**Submucosa:** The **submucosa** is a layer of fibroelastic connective tissue that supports the mucosa. Found in this layer are blood and lymphatic vessels and nerves. Parasympathetic ganglia found in this layer are called **Meissner's submucosal plexus**. When glands are found in this region (esophagus and duodenum) they are referred to as sub-mucosal glands.

**Muscularis externa:** This is a separate layer not to be confused with muscularis mucosa. The **muscularis externa** consist of two thick layers of smooth muscle – and inner circular layer and an outer longitudinal layer. Between the layers is a

vascular plexus and an autonomic nerve plexus associated with small parasympathetic ganglia of (**Auerbach's**) **myenteric plexus**. The muscularis externa maintains tonus in the tube and propels luminal contents by peristalsis.

**Adventitia or serosa:** This outermost layer is dense irregular connective tissue. When it blends with connective tissue of the surrounding area it is an **adventitia**. If it has a free surface projecting into the peritoneal cavity it is covered with a single layer of mesothelial cells (epithelial cells derived from mesoderm) and is called a **serosa**.

### ESOPHAGUS

The epithelium is stratified squamous and non-keratinized. This is a thick layer of 40-60 cells measuring 300-500  $\mu\text{m}$ . This is supported by a **lamina propria**. A well developed muscularis mucosa is present (200-300  $\mu\text{m}$ ) and surrounded by the submucosal region. **Submucosal mucous glands** are scattered in this region. The **muscularis externa** consists of an inner circular layer and an outer longitudinal layer. In the upper third of the esophagus the muscularis is skeletal muscle. In the middle third both smooth and skeletal muscle is present and in the lower third only smooth muscle is present. The myenteric plexus of nerves and ganglia (**Auerbach's plexus**) are found between the inner and outer layers of the muscularis externa. A tunica adventia is present.

### STOMACH

An abrupt transition occurs at the **cardio-esophageal junction**, where stratified squamous epithelium gives way to simple columnar epithelium. The simple columnar epithelium (**surface mucous cells**) dips into the lamina propria to form **gastric pits** (150-300  $\mu\text{m}$  deep). **Gastric glands** (simple tubular branched) empty into the bottom of the gastric pits. The base of gastric glands rests on a muscularis mucosa. The **submucosa** is quite prominent and contains numerous arteries, veins, lymphatics and nerves. In the stomach the **muscularis externa** consists of three layers: a discontinuous inner oblique layer, then an inner circular layer and an outer longitudinal layer. When the stomach is empty the surface is thrown into folds (**rugae**).

The stomach is divided into three histological regions (cardiac, body/fundus, pyloric) based on their anatomical location and appearance of the glands. The **cardiac** region of the stomach is a narrow rim of tissue around the esophageal opening. The cardiac glands are short tubular glands that are

coiled at the base. The glands consist mostly of mucus secreting cells. Parietal cells may be found in these glands. The fundus and **body** make up more than 90% of the stomach and have the same histological appearance. The **glands** of the body and fundus are straight tubular and have three regions: The upper third is the **isthmus** and empties into the **gastric pits**, the middle third is the **neck** and the bottom third is the **base**. There are five types of cells associated with the glands. **Regenerative cells** are found at the boundary between the isthmus and the gastric pit. These cells are few in number and not readily distinguished in routine preparations. These cells divide and migrate upwards to replenish the surface mucous cells and downward to replenish the rest of the cells in the gastric glands. **Mucous neck cells** are found in the isthmus and neck region. These cells are scattered among parietal cells and secrete an acidic form of mucus. **Parietal cells** are distinctive eosinophilic cells with a centrally located nucleus and secrete hydrochloric acid. The eosinophilia is due to the large quantity of mitochondria in these cells. Some parietal cells are also be found in the base of the gland. The primary cell type in the base is the **chief cell** which has a basophilic cytoplasm in its basal region. Chief cells secrete pepsinogen and gastric lipase. **Gastric enteroendocrine cells** are part of the diffuse neuroendocrine system (DNES) are few in number and secrete enteric hormones (these can not be identified with H&E). The pyloric region has short coiled tubular glands that only secrete mucus – chief cells and parietal cells are absent.

#### SMALL INTESTINE

One of the main functions of the small intestine is nutrient absorption. Specializations for increasing surface area for absorption involve three magnitudes of folds or projections.

1. Circular transverse folds (**plicae circulares or valves of Kerckring**) of the entire mucosa (with a core of submucosa) project permanently into the lumen. The plicae are prominent in the duodenum and jejunum and diminish in the later part of the ileum.
2. **Villi** are projections (evaginations) of the mucous membrane (with a core of lamina propria) into the lumen. The shape of villi varies in the different regions of the small intestine: They start as tall, narrow, finger-like projections in the duodenum and evolve to a short broad leaf-like projection in the distal ileum.
3. **Microvilli** are cytoplasmic projections (1-2

um in length) on the surface of the simple columnar epithelial cells. These surface projections make up the **striate border** of intestinal epithelium.

The second main function of the small intestine is digestion and is dependent on secretions from three types of glands:

1. Exocrine glands (liver and pancreas) deliver their secretions (bile and digestive enzymes) into the duodenum by way of the **cystic duct** and main **pancreatic ducts**.
2. **Submucosal glands**. Submucosal glands are only found in the duodenum (Brunner's glands). They secrete mucus and resemble the pyloric glands of the stomach.
3. **Intestinal crypts** (glands) are invaginations of the surface epithelium down into the underlying lamina propria.

Cell types found in the intestinal epithelium include:

1. **Simple columnar epithelium** absorptive cells have a microvillus (striate) border and are involved in nutrient digestion and absorption.
2. **Goblet cells** secrete mucin.
3. Columnar **crypt cells** transport secretory IgA
4. **Paneth cells** at the base of intestinal crypts produce antibacterial substances. These cells have very eosinophilic secretion granules due to their content of lysozyme.
5. **M cells** occur in regions where lymphoid nodules abut intestinal epithelium. Here the columnar cells are replaced by the cuboidal to squamous M cells. M cells belong to the mononuclear phagocytic system of macrophages and antigen presenting cells.
6. Stem cells are located in the base of the intestinal crypts
7. **Enteroendocrine cells** (DNES) produce hormones and are not readily distinguished in routine preparations.

The **lamina propria** forms the core of the villi and supports the intestinal glands, is highly vascular and rich in lymphocytes and plasma cells. The **muscularis mucosa** lies at the base of the glands and sends fibers into the core of the villi. The **sub-**

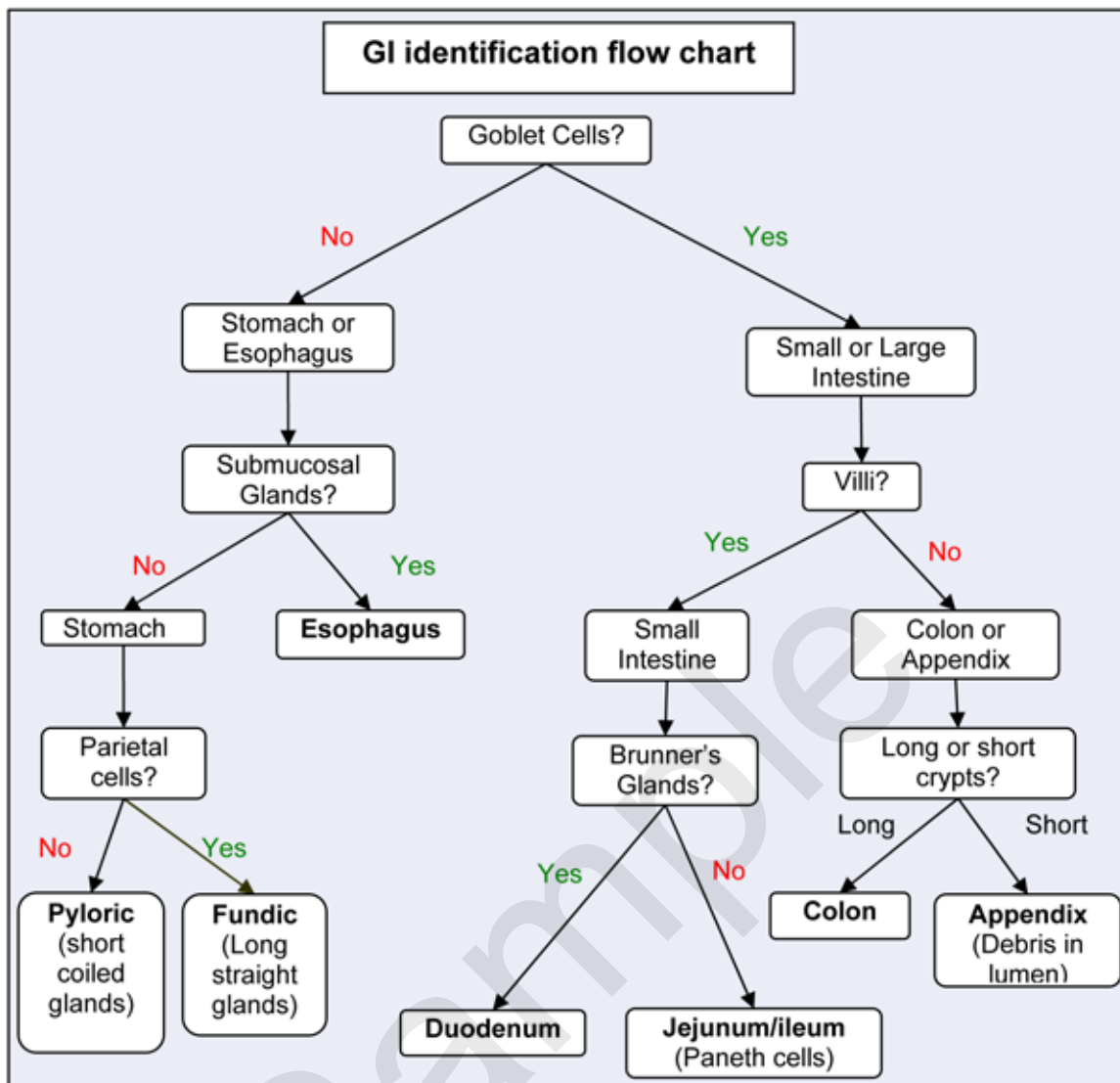
**mucosa** is irregular fibroelastic tissue with a rich lymphatic and vascular supply. **Meissner's submucosal** nerve plexus is found in this layer and controls the muscularis mucosa. In the duodenum submucosal glands are found. The **muscularis externa**, is responsible for peristalsis, and has an inner circular and outer longitudinal layer. **Auerbach's plexus** of nerves is found between the two muscle layers.

The small intestine is divided into three regions: duodenum, jejunum and ileum. The pyloric stomach transitions to the duodenum at the **pyloric sphincter** (thick inner circular layer of the muscularis externa). The **duodenum** is the shortest segment (25 cm) and receives secretions from the liver (bile) and pancreas (digestive enzymes). A distinguishing feature of the duodenum is the presence of **submucosal glands** (Brunner's glands, their appearance differs from pyloric glands only with respect to where they are located i.e. submucosal vs. mucosal). The **jejunum and ileum** have a similar appearance. Lymphoid tissue in the lamina propria progressively increases from the jejunum to the ileum. In the ileum, permanent clusters of lymphoid nodules (**Peyer's patches**) become a prominent feature. Villi become shorter, broader and have increasingly larger **lacteals** (blind ending lymphoid vessels in the core of villi) in the ileum. Frequency of goblet cells and Paneth cells increases as one progresses from the duodenum to the ileum.

#### LARGE INTESTINE

The main function of the large intestine is to re-absorb water and to consolidate and transport the fecal mass. The parts of the large intestine are the cecum, appendix, colon, rectum and anal canal. The cecum and colon are histologically indistinguishable. Having no villi, the inner surface is smooth and even. The **intestinal glands (crypts of Lieberkuhn)** are frequent and closely packed together. The glands are simple straight tubular glands and quite long (>600 µm). The two major cell types are **simple columnar absorptive cells** with striated border and numerous **goblet cells**. **Paneth cells** may or may not be present. **Enteroendocrine cells** may be seen at the base of the crypts. Lymphocytes are common in the lamina propria. The muscularis mucosa is found at the base of the glands. The submucosa is well developed with prominent blood and lymph vessels. **Meissner's** submucosal nerve plexus is easily seen in the colon. The **muscularis externa** consists of an inner circular layer and an unusual outer longitudinal layer. The outer layer is gathered into three distinct bundles (**taenia coli**) that are equally spaced around the gut. Between the muscle layers the numerous ganglia of **Auerbach's plexus** are

seen. The colon is mostly covered by a serosa. The **appendix** is a 4-6 cm blind ending diverticulum descending from the cecum. Its epithelium is similar to the colon, but with fewer goblet cells. The crypts are short (150-250 µm) in comparison to the colon. Enteroendocrine cells are found in the base of the crypts. Numerous lymphocytes and nodules are present in the lamina propria. When nodules are present M cells are frequently observed in the epithelium overlying the nodules. The muscularis mucosa is very thin. The muscularis externa is inner circular and outer longitudinal layers of smooth muscle. The appendix is covered by a serosa.

**OBSERVE AND NOTE:****TONGUE**

1. Striated muscle
2. Lingual (minor) salivary glands
3. Foliate and filiform papillae.
4. Taste buds
5. Taste pore

**ESOPHAGUS**

1. The mucosa consisting of:
  - a. Epithelium: stratified squamous non-keratinizing
  - b. Lamina propria (the connective tissue support for epithelium in mucous

membranes).

- c. Muscularis mucosa
2. Submucosa consisting of:
  - a. Submucosal glands with ducts passing through the mucosa
3. Muscularis externa: inner and outer layers
4. Ganglia of Auerbach's (myenteric) nerve plexus, located between the inner and outer muscle layers of the muscularis externa.

**CARDIOESOPHAGEAL JUNCTION**

1. Abrupt transition from stratified squamous non-keratinizing epithelium to a simple columnar epithelium.
2. Mucosa

- a. Lamina propria
- b. Muscularis mucosa
- 3. Gastric pits
- 4. Cardiac glands
  - a. Mucous cells
  - b. Parietal cells
- 5. Submucosa
- 6. Muscularis externa
- 7. Adventitia
- ii. Pyloric mucosal glands
- b. Submucosa
- 3. Duodenum
  - a. Mucosa
    - i. Villi
    - ii. Crypts (glands)
  - b. Submucosa
    - i. Submucosal glands (Brunner's glands)

**FUNDIC STOMACH**

1. Rugae
2. Muscularis mucosa
3. Muscularis externa
4. Gastric pits and glands
5. Four (five) types of cells characteristic of the stomach:
  - a. Simple columnar epithelium of the surface
  - b. Mucous neck cells
  - c. Parietal cells
  - d. Chief cells
  - e. Enteroendocrine cells cannot be easily recognized with H&E

**PYLORIC STOMACH**

1. Pits and glands
2. Short coiled mucosal glands
  - a. Glands consists primarily of cells that secrete mucus
    - i. Absence of parietal cells

**PYLORODUODENAL JUNCTION**

1. Sphincter
2. Pyloric stomach
  - a. Mucosa
    - i. Gastric pits

**DUODENUM**

1. Mucosa
  - a. Villi
  - b. Crypts (glands)
  - c. Surface absorptive cells
    - i. Brush border – microvilli
  - d. Goblet cells
  - e. Lamina propria
  - f. Muscularis mucosa
2. Submucosa
  - a. Submucosal glands (Brunner's glands)
3. Muscularis externa
  - a. Inner circular and outer longitudinal

**JEJUNUM/ILEUM**

1. Mucosa
  - a. Villi
    - i. Compare villi in duodenum, jejunum and ileum
    - ii. lacteals
  - b. Crypts (glands)
  - c. Surface absorptive cells
    - i. Brush border – microvilli
    - ii. Terminal web and terminal bar
  - d. Goblet cells



- e. Paneth cells
  - f. Lamina propria
    - i. Lymphocytes and plasma cells
    - ii. Lymph nodules (Peyer's patches)
  - g. Muscularis mucosa
  - h. Plicae circulares
  - 2. Submucosa
    - a. Absence of glands in submucosa
    - b. Connective tissue, blood and lymph vessels and nerves
  - 3. Muscularis externa
    - a. Inner circular and outer longitudinal
    - b. Auerbach's myenteric nerve plexus
- i. Lymphocytes, plasma cells, eosinophils
  - f. Muscularis mucosa
  - 2. Submucosa
    - a. Numerous blood and lymph vessels
    - b. Meissner's submucosal nerve plexus
  - 3. Muscularis externa
    - a. Inner circular layer, outer longitudinal layer (taenia coli)
    - b. Auerbach's myenteric plexus

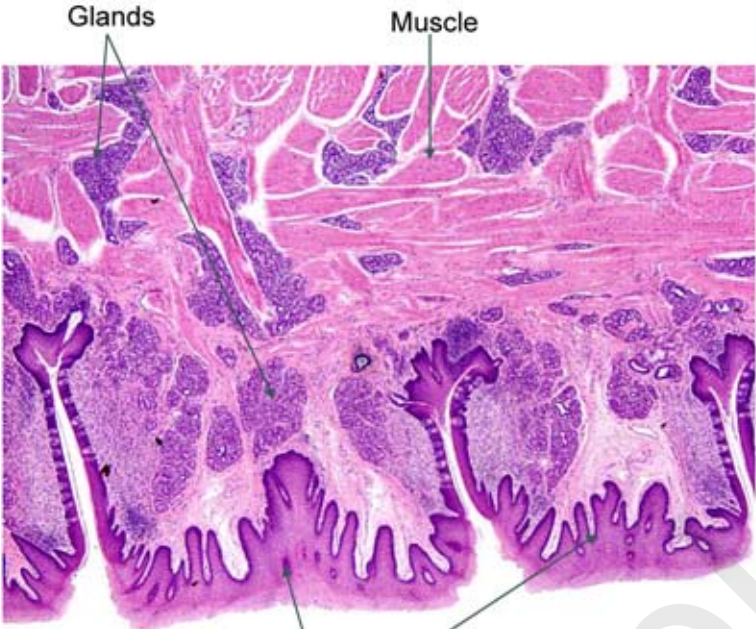
#### APPENDIX

- 1. Mucosa
  - a. Absence of villi
  - b. Short crypts
  - c. Surface absorptive cells
  - d. Few goblet cells
  - e. Lamina propria
    - i. Lymphocytes, plasma cells, eosinophils
    - ii. Lymph nodules (in some areas M-cells over lie nodule)
- f. Submucosa
- g. Muscularis externa

#### COLON

- 1. Mucosa
  - a. Absence of villi
  - b. Deep crypts (straight intestinal glands)
  - c. Surface absorptive cells (microvillus border, terminal web)
  - d. Numerous goblet cells
  - e. Lamina propria

Slide # 108 Tongue (H&E)

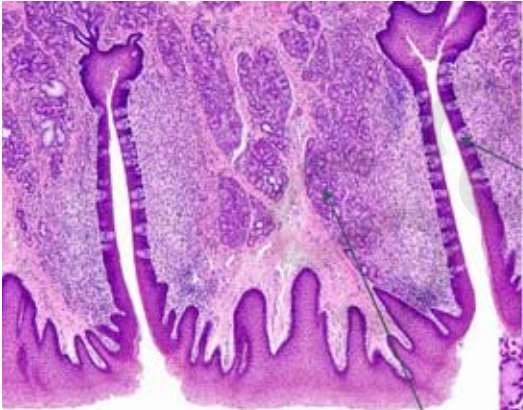


Glands

Muscle

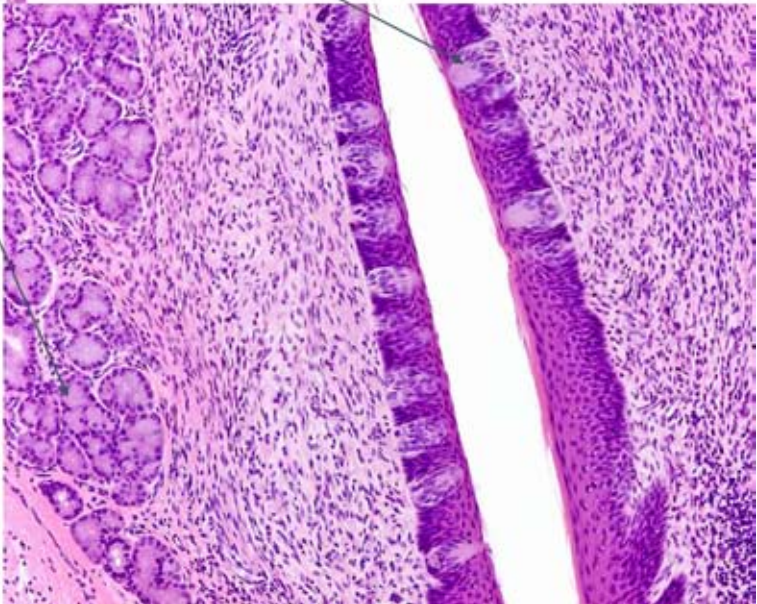
Foliate papillae

Slide # 108 Tongue (H&E) (foliate papillae)

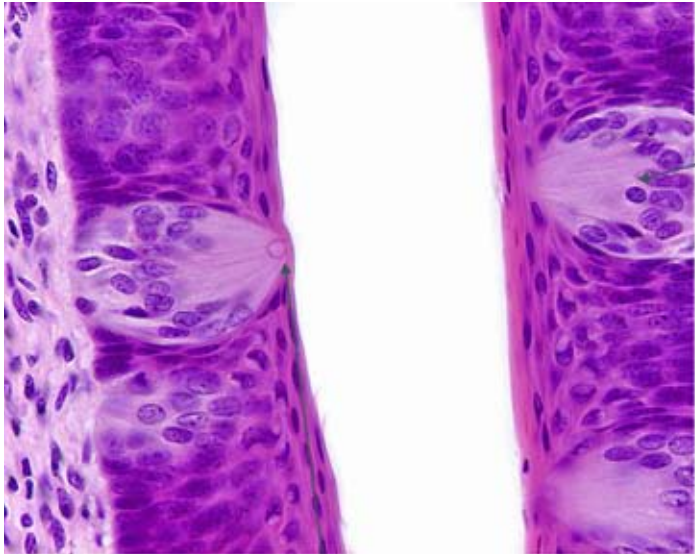


Taste buds

Lingual glands

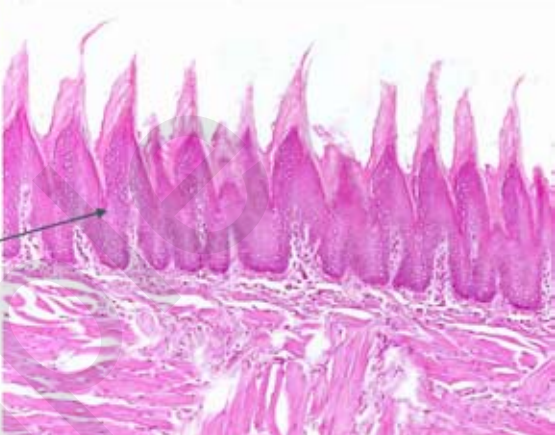




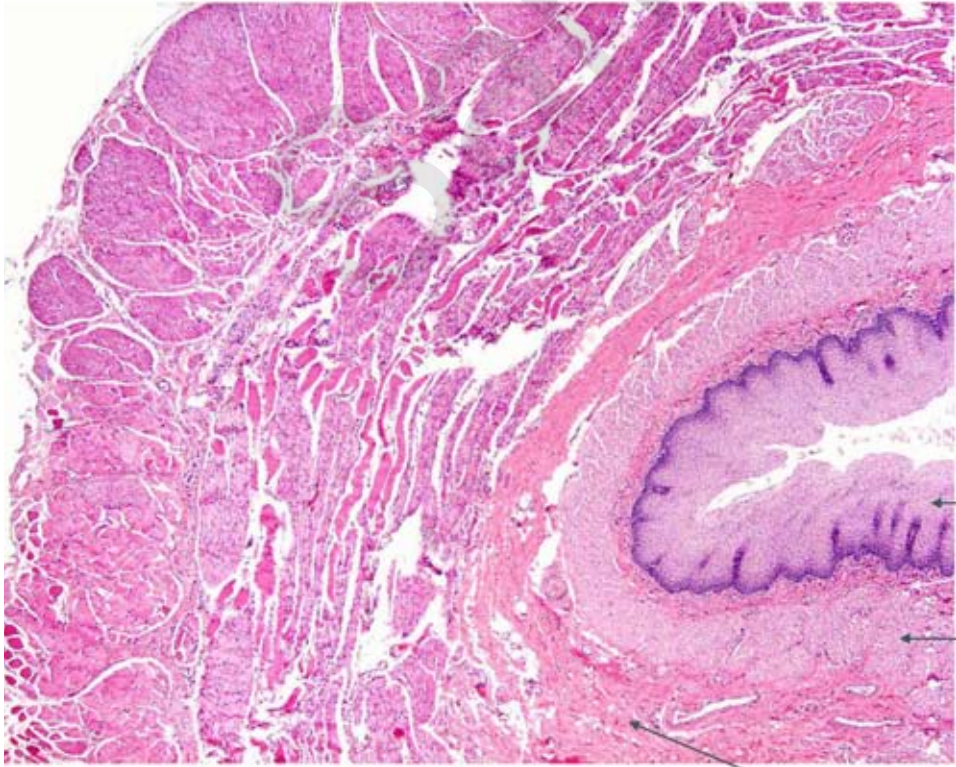


Slide # 108 Tongue (H&E)  
(taste buds)

Taste pore



Filiform papillae (mouse tongue)



Slide # 109  
Esophagus, Middle  
Third (H&E)



Mucosa

Epithelium

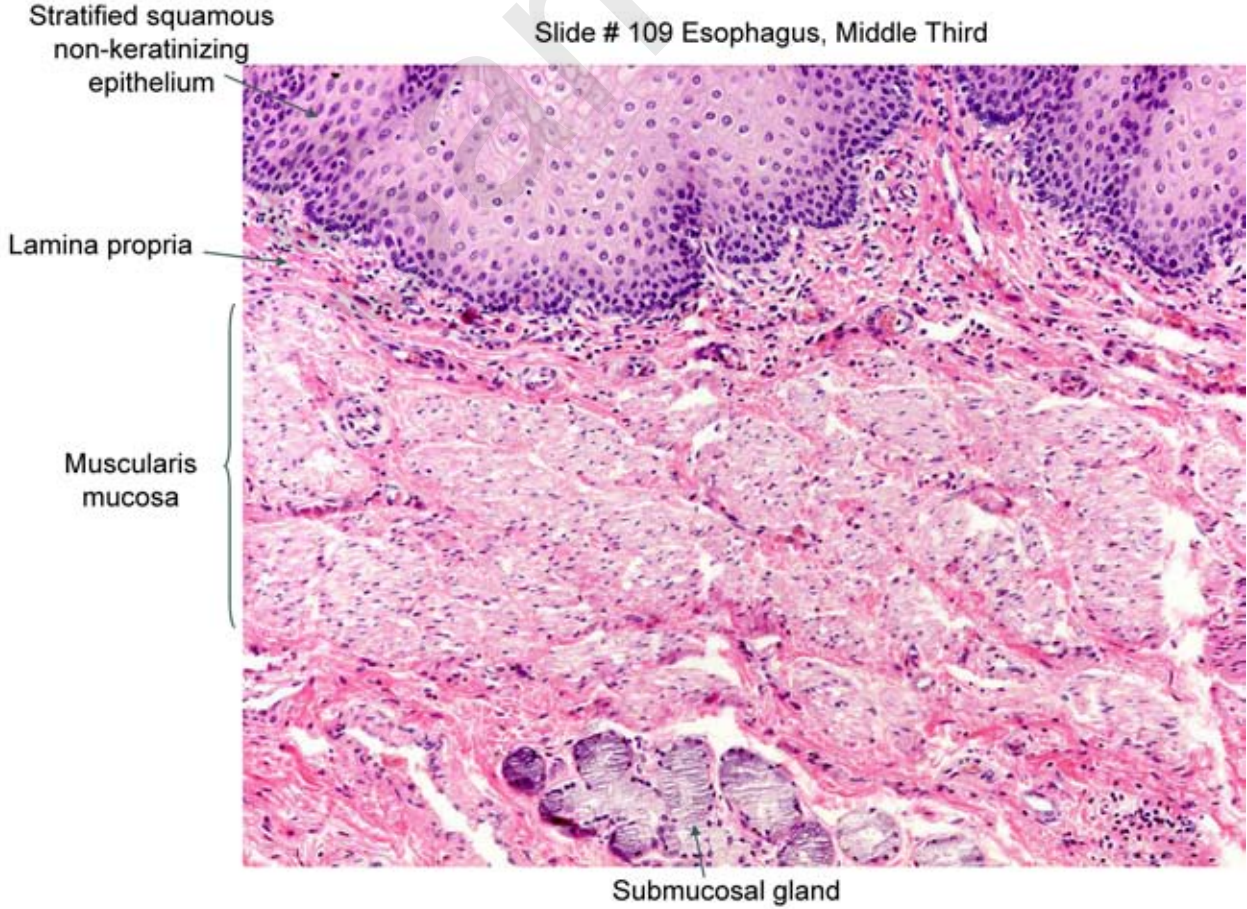
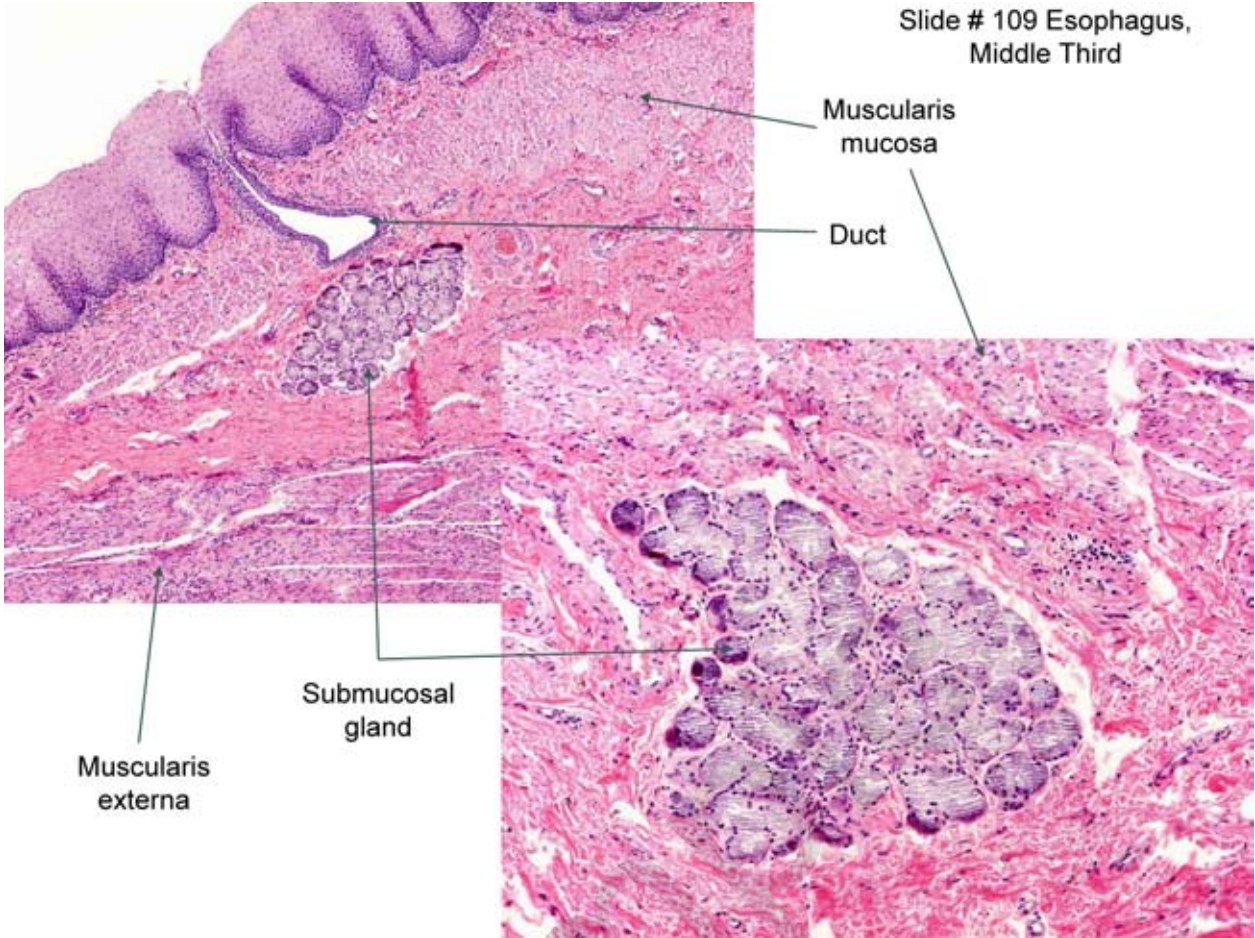
Lamina propria

Muscularis mucosa

Outer  
Inner  
Muscularis externa

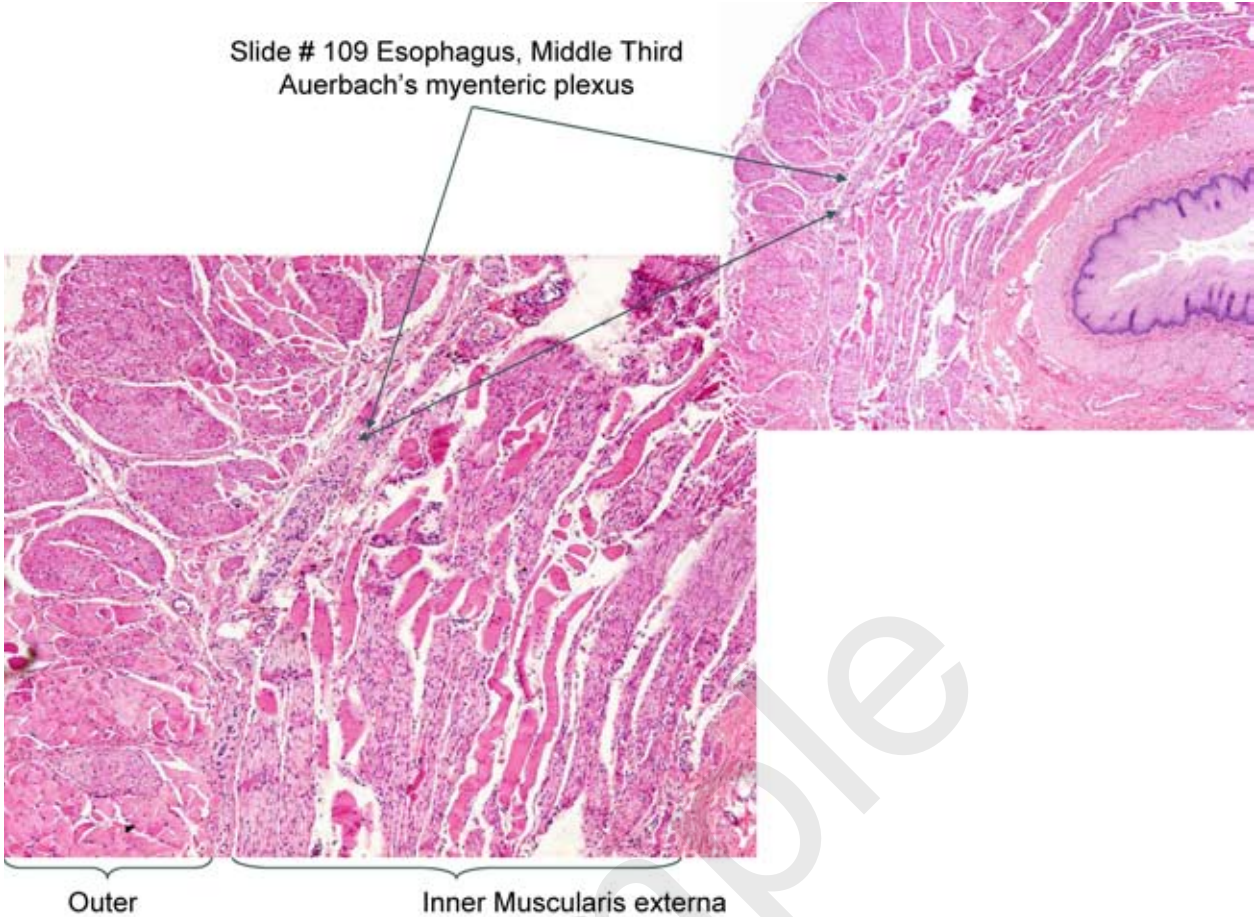
Submucosa



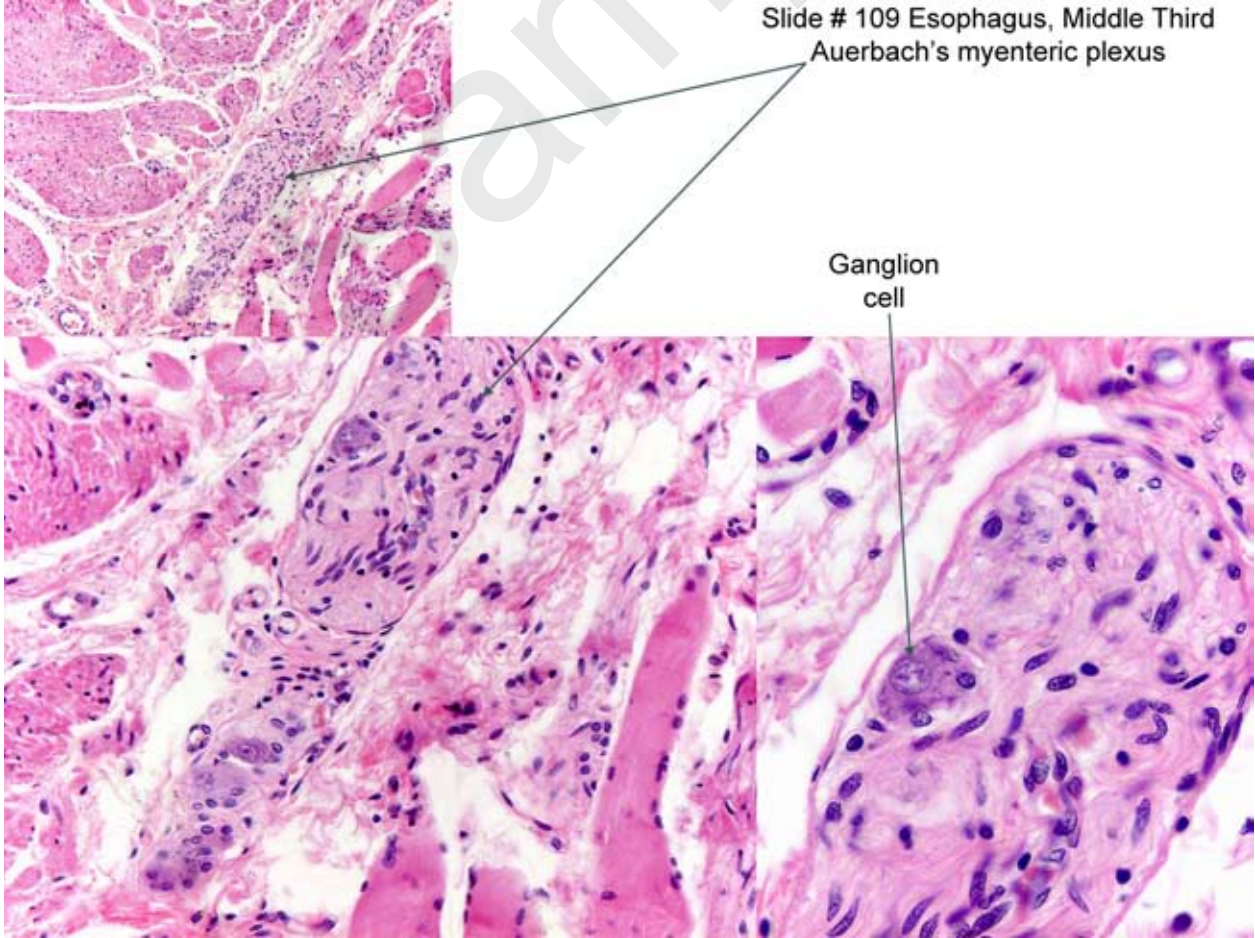




Slide # 109 Esophagus, Middle Third  
Auerbach's myenteric plexus

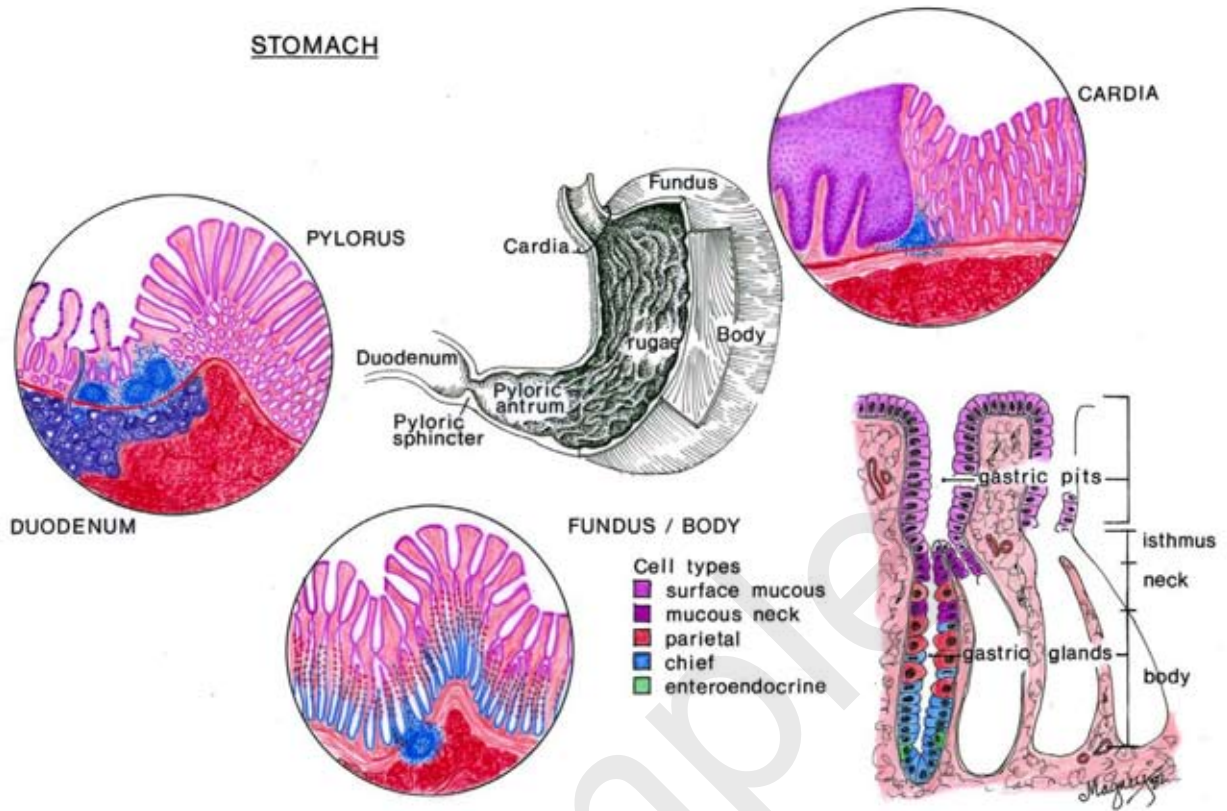


Slide # 109 Esophagus, Middle Third  
Auerbach's myenteric plexus





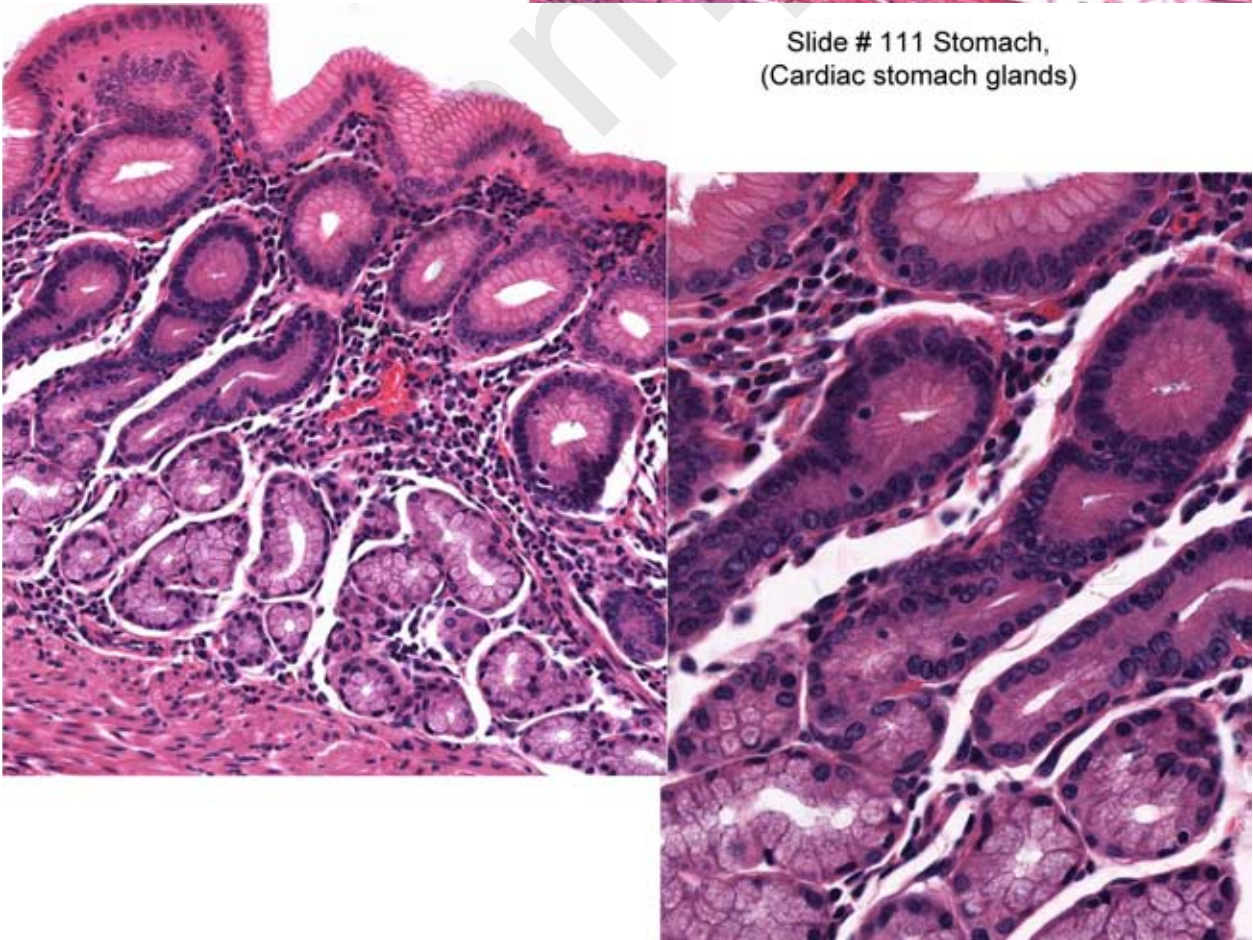
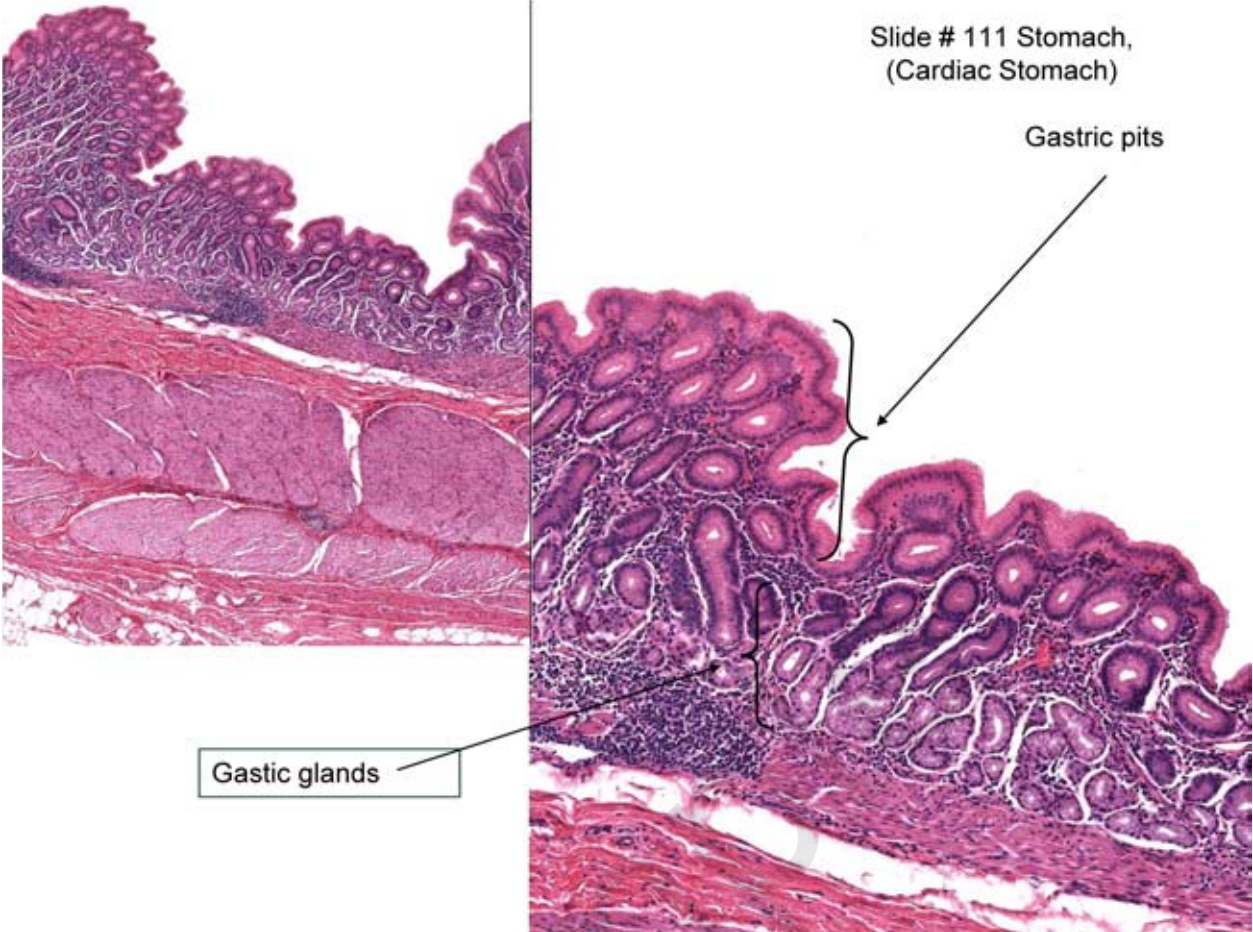
Organization of Stomach



Slide # 111 Stomach, Cardio-esophageal Junction (H&E)









Slide # 112 Fundic Stomach (H&E)

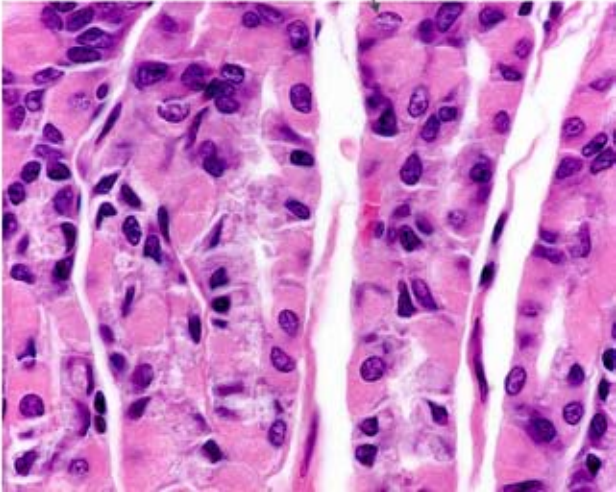
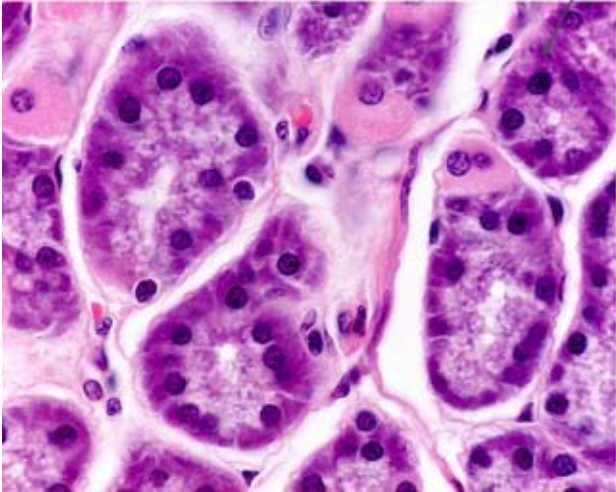
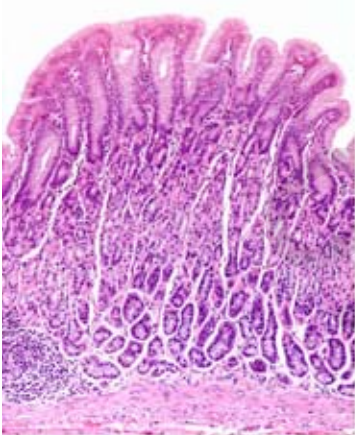


Rugae

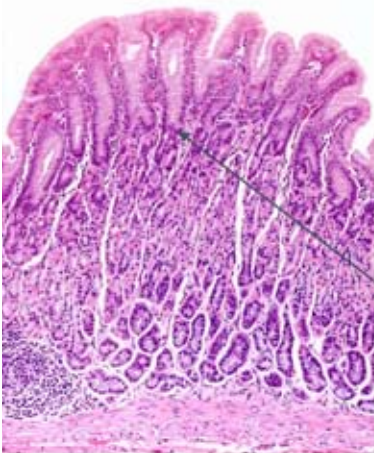
Muscularis mucosa

Muscularis externa

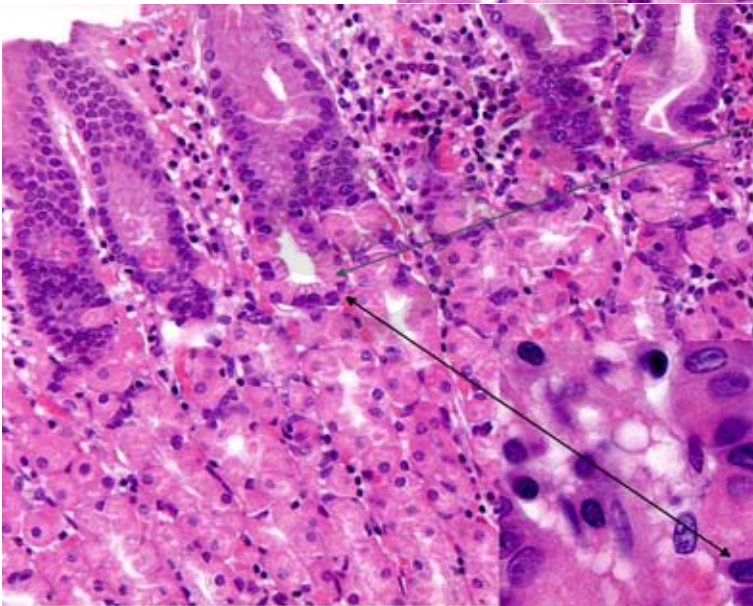
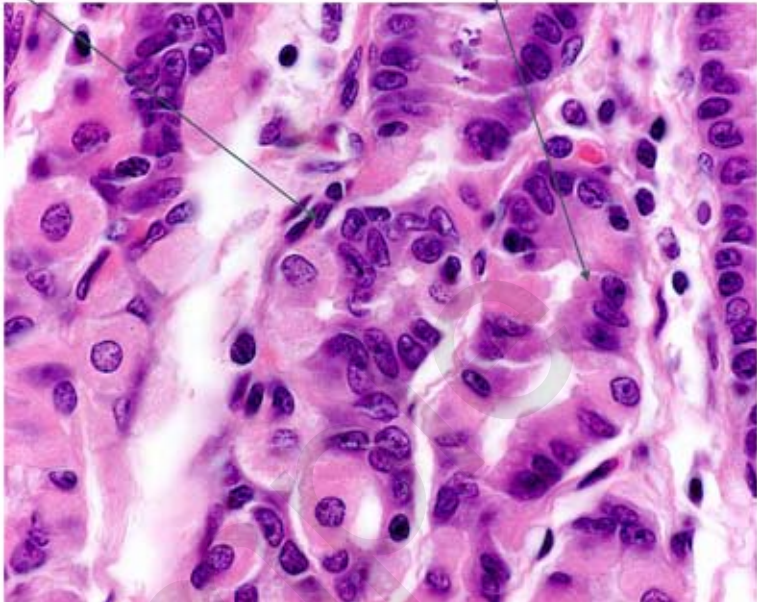
Slide # 112 Fundic Stomach (Chief & Parietal cells)



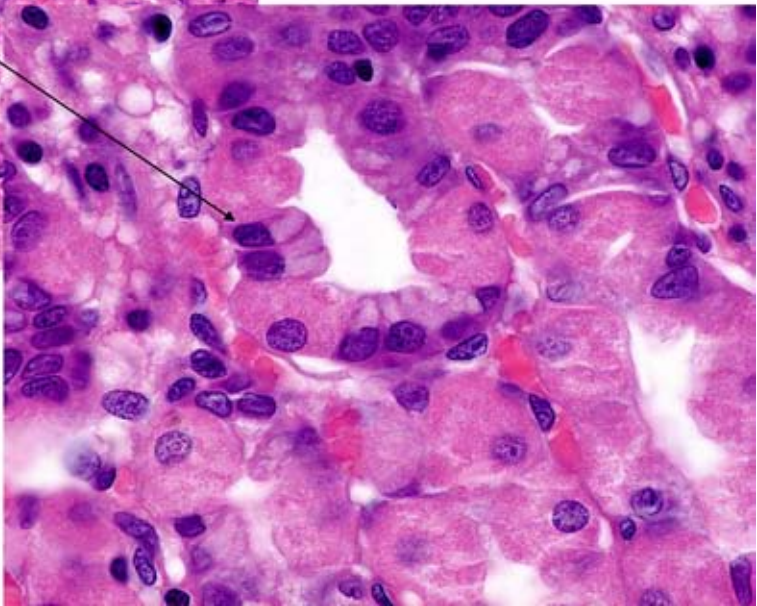
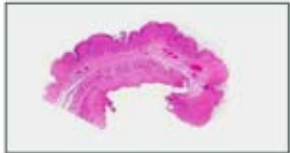




Slide # 112 Fundic Stomach  
(Mucous neck cells)

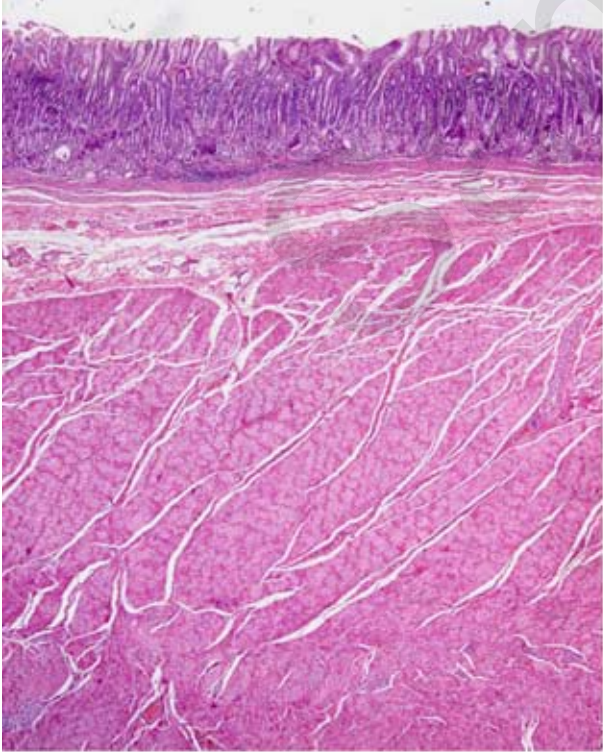
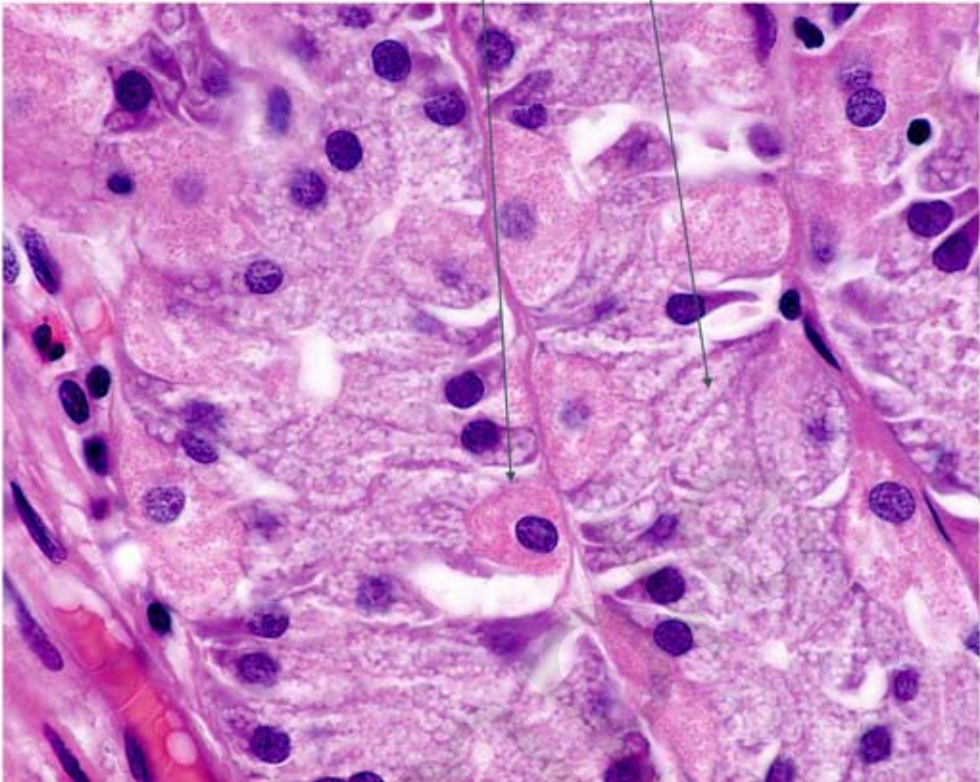


Slide # 113 Stomach Fundic (Mucous Neck cells)

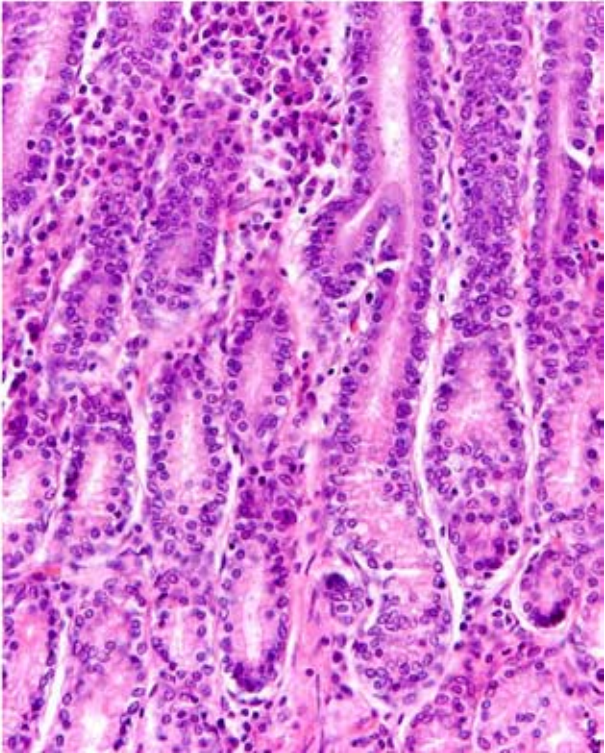
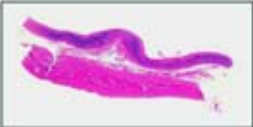




Slide # 113 Stomach Fundic  
(Parietal and Chief cells)

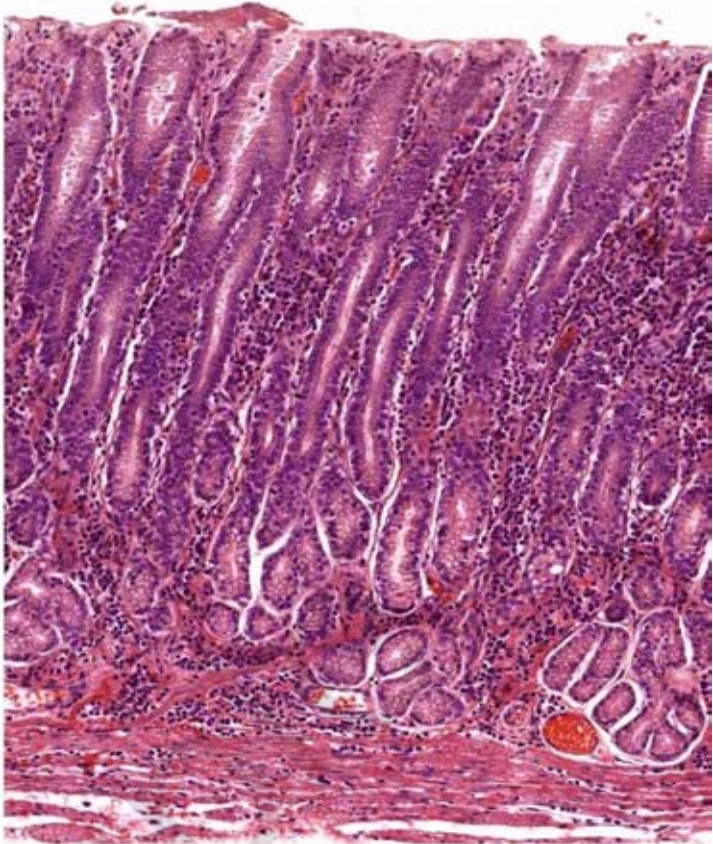
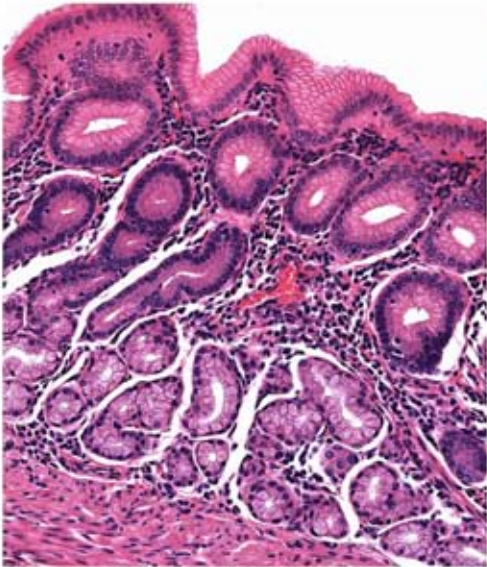


Slide # 115 Pyloric Stomach (H&E)

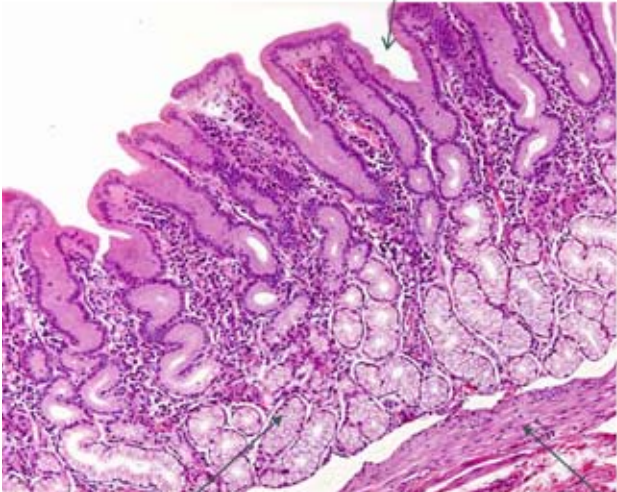




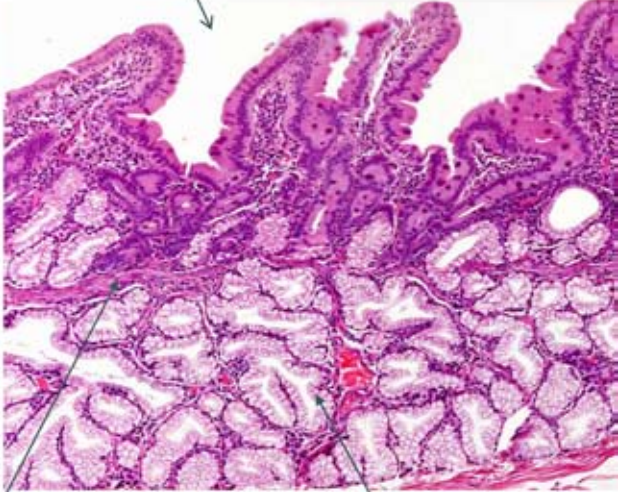
Slides 111&115 Pyloric & Cardiac Stomach



Slide # 116 Pyloroduodenal Junction (H&E)



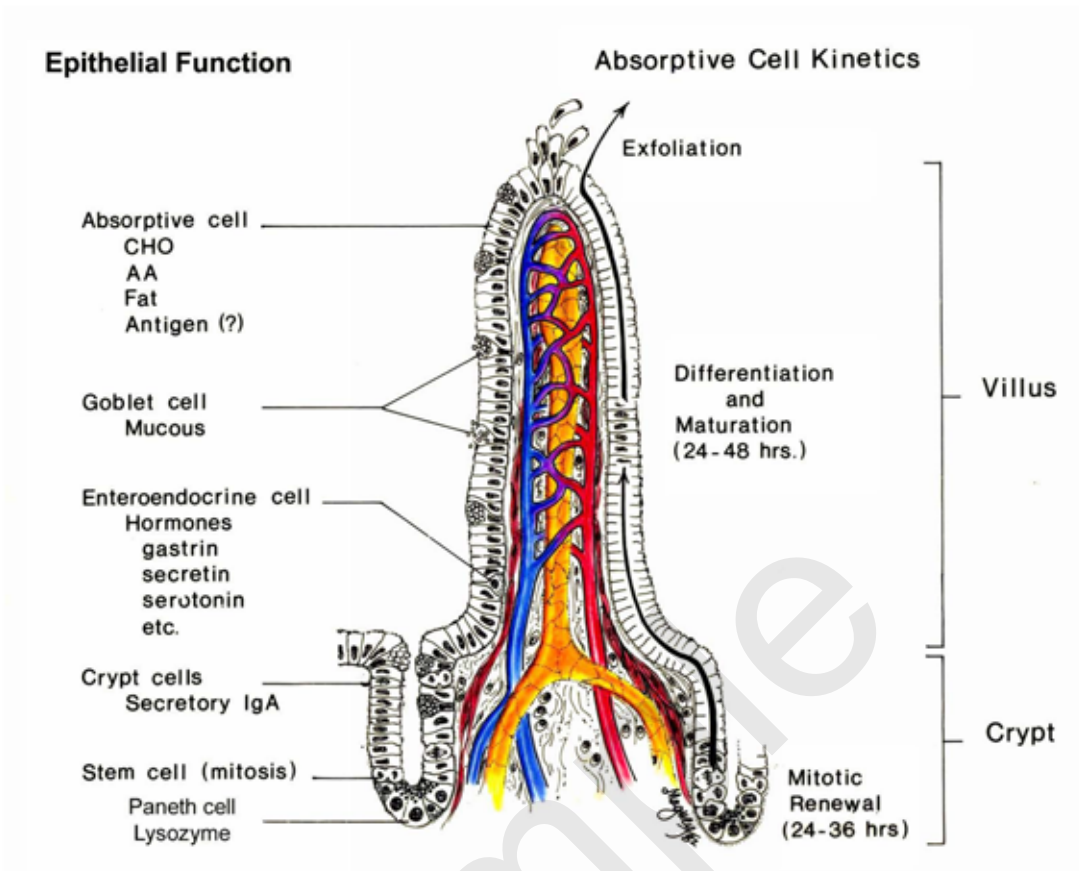
Gastric mucosal glands



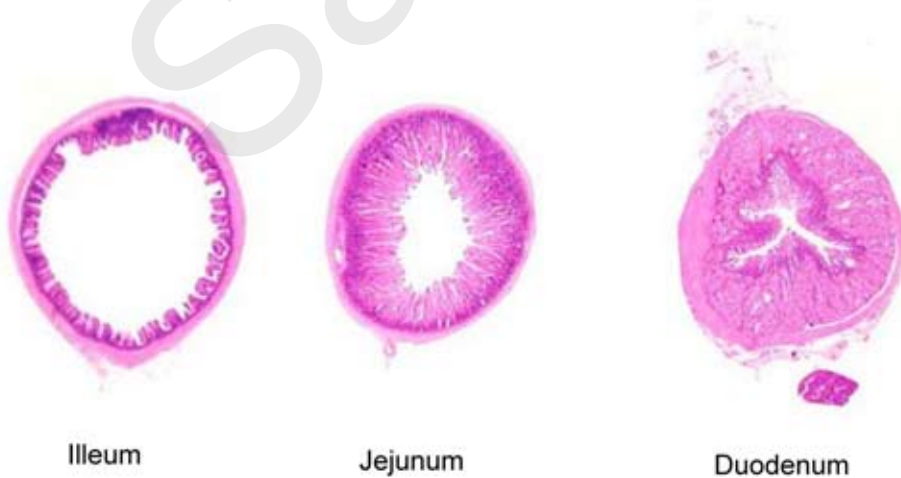
Muscularis mucosa

Brunner's submucosal glands

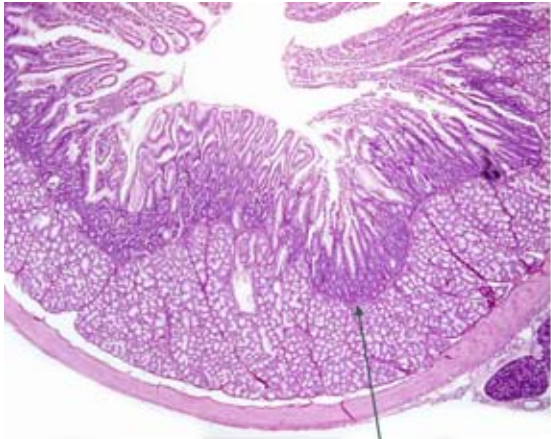
Intestine Structure and Function



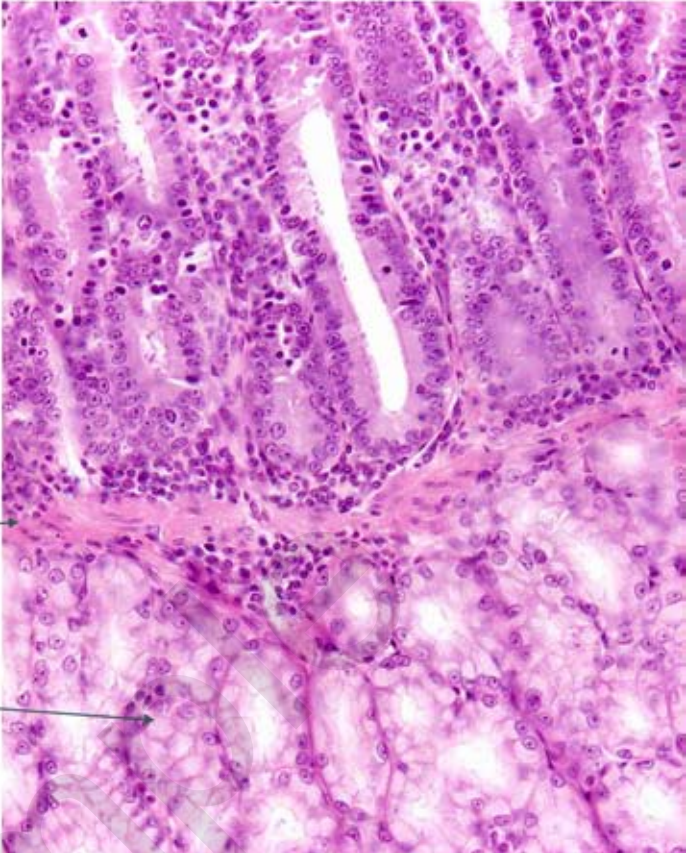
Slide # 118 Duodenum, Jejunum and Ileum (H&E)





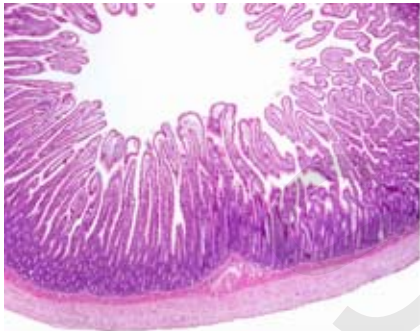


Slide # 118 Duodenum

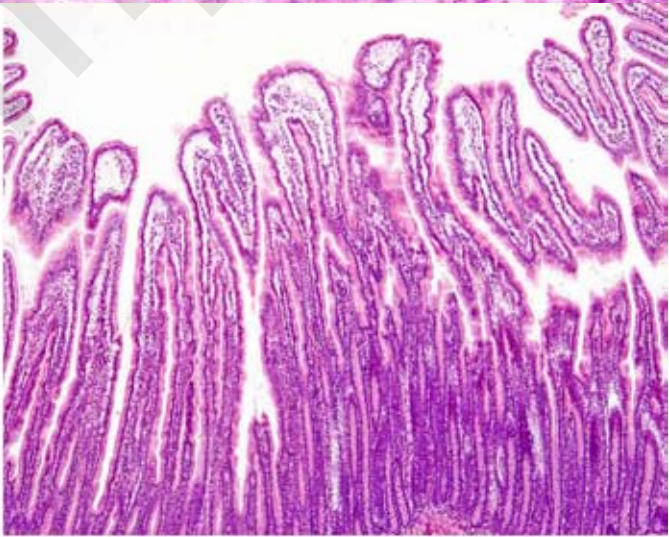


Muscularis mucosa

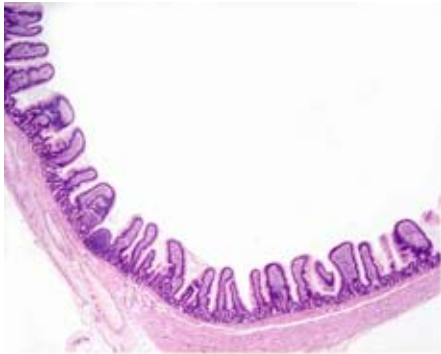
Brunner's submucosal glands



Slide # 118 Jejunum



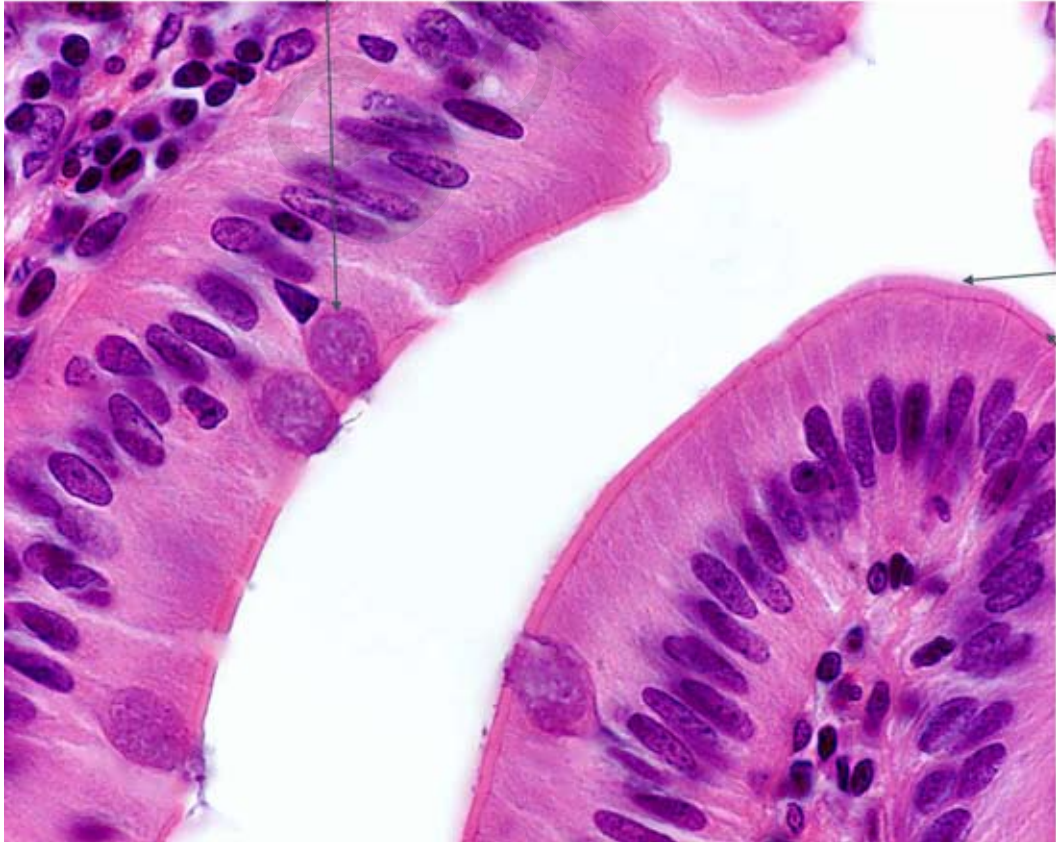




Slide # 118 Ileum (H&E)



Slide # 118 Duodenum, Jejunum and Ileum (surface epithelium)

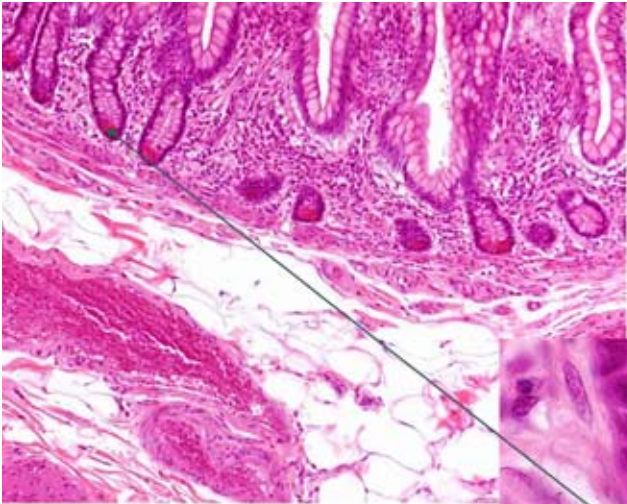


Goblet cells

Microvilli

Terminal web

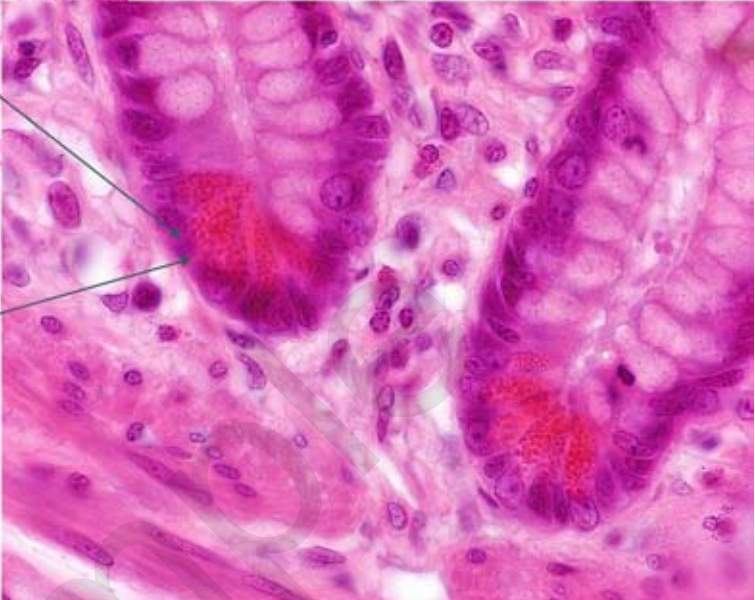




Slide # 119 Ileum (Paneth cells)



Paneth cells



Slide # 120 Ileum (H&E)

Villi

Lacteal (lymphatic vessel)

Plica circularis

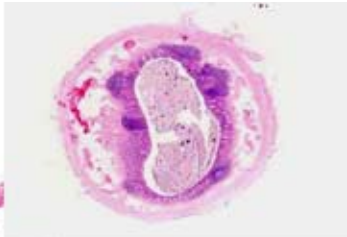
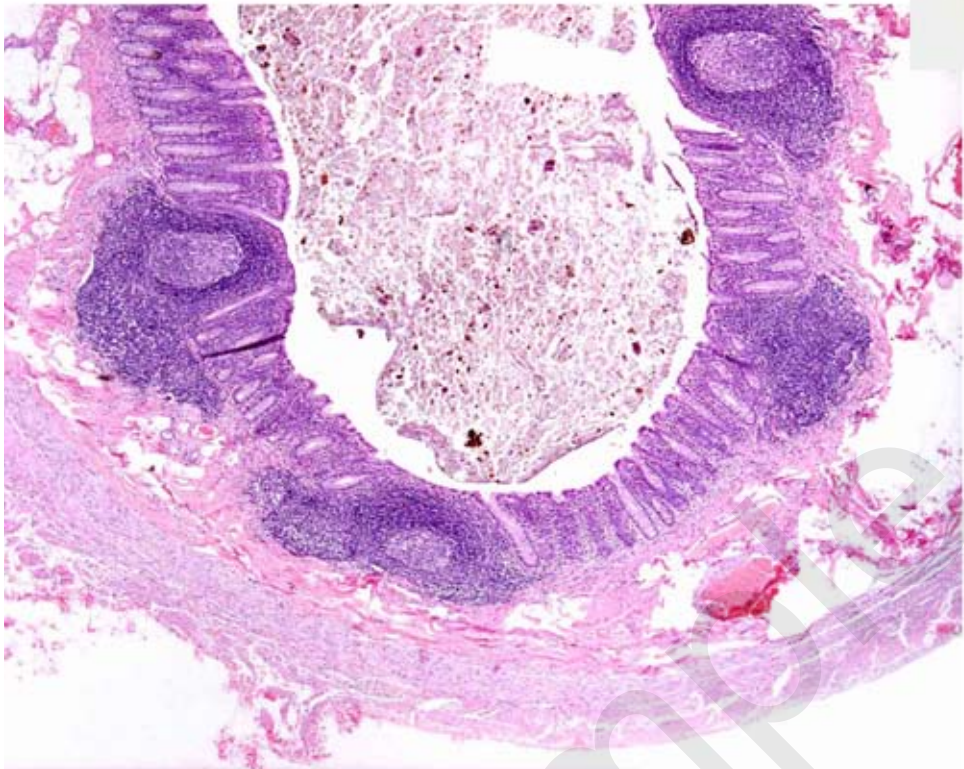
Peyer's patches (lymph nodules)

Goblet cells





Slide # 122 Appendix (H&E)



Slide # 123 Colon (H&E)



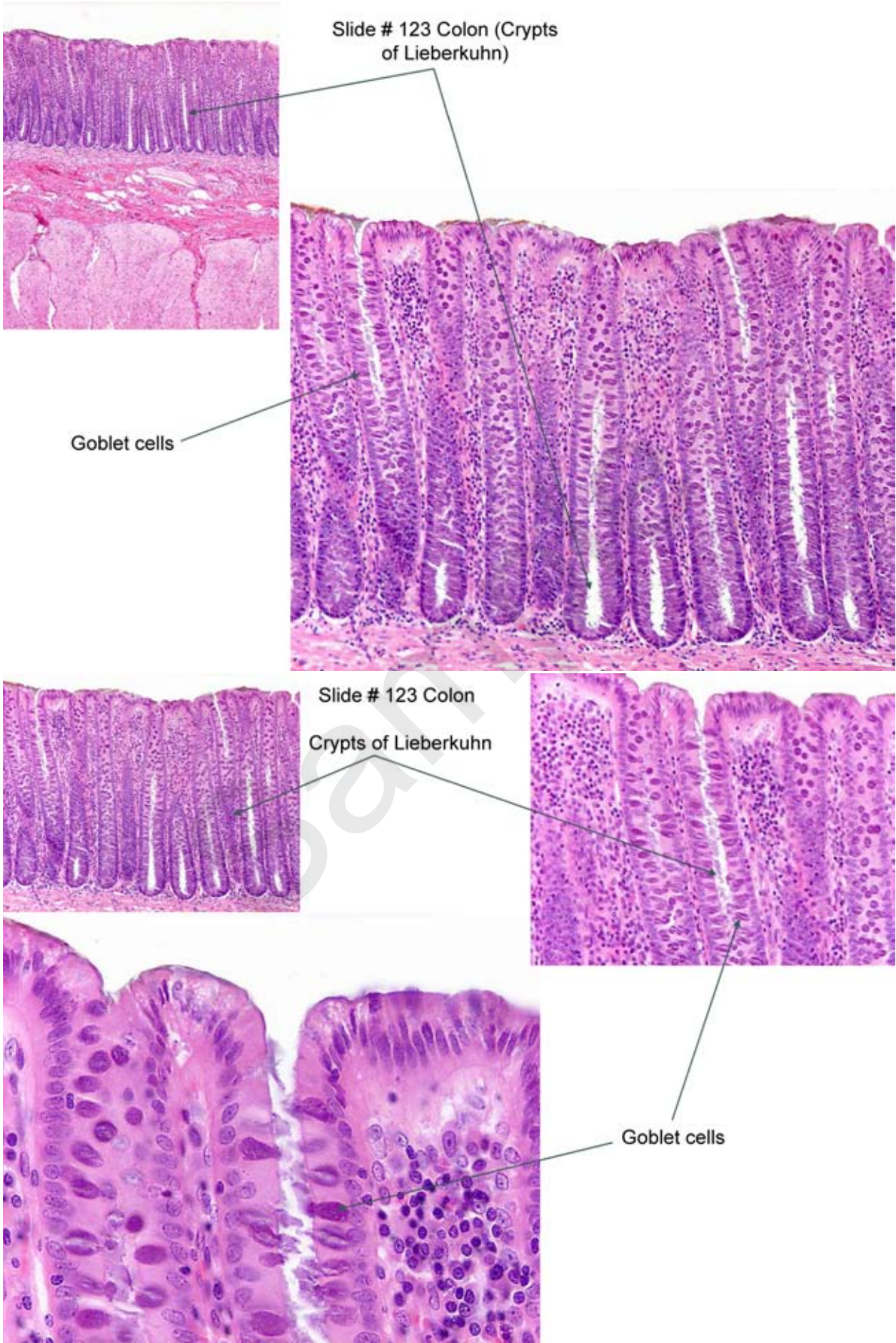
mucosa

Inner circular

Outer longitudinal (taenia coli)

Muscularis externa

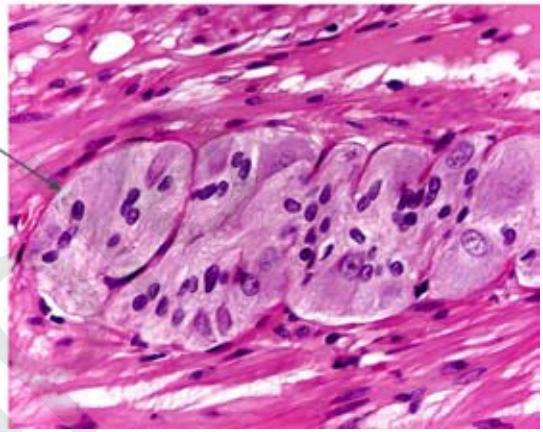
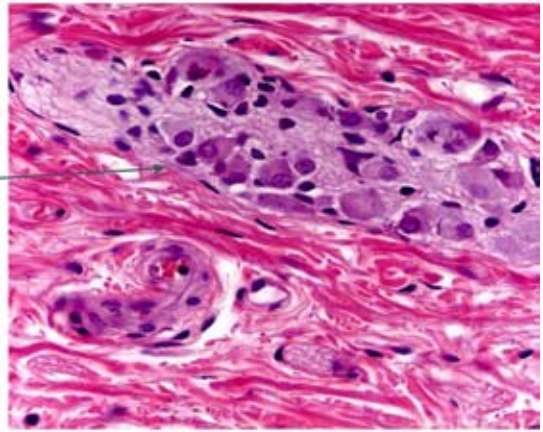




Slide # 123 Colon (Meisner's & Auerbach's Plexus)



Meisner's plexus



Auerbach's plexus

Samr



## INDEX

## A

A-band, 43-44, 48  
 absorptive cells, 224-225, 227-228  
 acidophils, 205, 207, 209, 211  
 acinar pancreas, 195  
 acini, 194, 196-197, 207  
 actin, 15, 43, iii  
 adenohypophysis, 205  
 adipocytes, 29-30, 35, 194, 207  
 adrenal cortex, 128, 206-207, 216-218  
 adrenal gland, 128, 206-207, 215-219  
 adrenal medulla, 206, 216, 219  
 adventitia, 127-130, 133-136, 142, 144-145, 223, 227, 233, 247, 265, 306, 331  
 afferent lymphatic, 158-159, 163-164  
 agranulocytes, 107  
 aldehyde fuchsin, 1, 198, 207, 221-222  
 alpha-cells, 206, 221  
 alveolar cells, 290, 292, 302-303, 307  
 alveolar duct, 290, 292, 301  
 alveolar macrophage, 290, 292  
 alveolar pore, 290  
 alveolar sac, 290, 292  
 alveolus, 16, 193, 289-290, 292, 301, 309, 344  
 ameloblasts, 84  
 ampulla, 305, 307, 322-323, 329, 331, 338, 346  
 anterior chamber, 343-345  
 anterior pituitary gland, 207, 209-211  
 antigen presenting cells, 157, 181, 224  
 aorta, 127, 130, 143-145  
 aortic valve, 127, 151-152  
 appendix, 223, 225, 228, 243  
 appositional growth, 61-62  
 arcuate arteries, 262, 308, 318  
 arcuate artery, 262, 264, 270, 278, 306, 308, 318  
 area cribrosa, 261  
 areolar tissue, 29-30, 35-36  
 arrector pili, 182-183, 186  
 arrector pili muscle, 182, 186  
 arteriole, 127-130, 138, 158-160, 174-177, 179, 247-248, 253, 261-264  
 artery, 127-129, 133-134, 136-144, 150, 158, 248, 261, 264, 270, 278, 306, 341  
 articular cartilage, 77, 79-80  
 atrioventricular node, 127  
 atrioventricular septum, 127  
 atrium, 43, 127, 130, 147-148  
 Auerbach's plexus, 86-87, 96-98, 223, 225, 228, 232, 245  
 autonomic nervous system, 85-86, 206  
 axon, 85-86, 90, 100-101, 182  
 axon hillock, 85-86, 90  
 azan, 1, 30, 33, 35,  
 azure granules, 107, 113-114

## B

band forms, 114, 119  
 basement membrane, 6, 15-16, 18, 20, 23, 25, 127-129, 159, 181-182, 193, 205, 261, 263, 289, 295, 299, 307, 329-330, 343  
 basilar membrane, 346  
 basophilia, 1, 5, 157, iv  
 basophilic erythroblast, 113-114  
 basophilic metamyelocytes, 122  
 basophilic myelocyte, 114  
 basophilic myelocytes, 122  
 basophilic normoblasts, 116-117  
 basophils, 107-108, 111-112, 114, 205, 207, 209, 211  
 beta-cells, 206-207, 221  
 bile canaliculi, 247-248, 254-255  
 bile ducts, 247  
 bile ductule, 247-248, 253  
 bladder, 16, 247, 258-259, 261-262, 265, 285-287,  
 blood, 1, 4-5, 15-16, 29, 43, 61-63, 107-109, 112-114, 127-128,  
 B-lymphocytes, 157-159  
 bone, 29, 61-63, 69-70, 72-82,  
 bony labyrinth, 346  
 Bowman's capsule, 16, 261, 263-264, 268, 276  
 Bowman's membrane, 343-344  
 Bowman's serous glands, 289  
 Bowman's space, 261, 264  
 brachiocephalic vein, 142-143  
 bronchi, 16, 289-292, 303  
 bronchiole, 289-292, 300  
 Bruch's membrane, 343-345  
 brush border, 15, 227, 261

## C

calcified cartilage, 81  
 calyx, 281-282  
 canal of Schlemm, 343-344, 350  
 canaliculi (bone), 62-63, 74  
 cancellous bone, 63, 69-70, 77  
 capillaries, 15, 128, 130, 132, 159, 181, 194, 205-207, 248, 261, 263-264, 307, 330-331, 343  
 capsule cells, 85-86, 91, 95, 159-160, 276  
 cardiac muscle, 43-44, 49, 51-53, 55-56, 58-59, 127  
 cardiac skeleton, 43-44, 55, 61, 127, 130, 151-152, 155  
 cardioesophageal junction, 226  
 cardiovascular system, 127,  
 carotid artery, 141-142  
 cartilage, 5, 29, 43, 61-68, 77, 79-81, 127, 289-291, 296, 298, 303,  
 cartilage histogenesis, 64  
 cell nest, 61-62, 66  
 cells of Boettcher, 346  
 cells of Claudius, 346

cells of Hensen, 346  
 central arteries, 158  
 central arteriole, 158-160, 174, 176-177, 179  
 central canal, 86, 89  
 central lymphoid organs, 157  
 central nervous system, 85  
 central vein, 247-248, 251-254  
 centroacinar cells, 193-194, 196-197  
 cerebellum, 9  
 cervical glands, 306, 308, 324  
 cervix, 306, 308, 324  
 chief cell, 224  
 chief cells, 205, 207, 215, 224, 227, 235, 237  
 cochlear nerve, 346  
 chondroblast, 61-62, 64-66, 292  
 chondrocyte, 5, 61-66  
 chondrogenic layer, 61-62  
 chorion, 307  
 choroid, 343-345, 348, 351  
 chromaffin cells, 206-207, 219  
 chromophils, 205-206  
 chromophobes, 205-207, 209, 211  
 cilia, 15-16, 20, 25, 295, iv  
 ciliary body, 343-344, 348, 350  
 ciliary glands, 344-345, 354-355  
 ciliated cells, 323  
 clear cells, 181, 205, 207, 215  
 cochlea, 346, 356  
 cochlear duct, 346, 356-357  
 collagen, 1, 5-7, 29-30, 33, 43, 61-62, 86,  
 collecting ducts, 261, 263-265, 282  
 collecting tubules, 261, 264, 269-271, 273, 279  
 collecting veins, 128, 178  
 compact bone, 62-63, 69-70  
 conjunctiva, 344-345, 353-355  
 connective tissue, 15, 29-30, 33, 35-38, 43,  
 convoluted tubules, 261, 263-264, 267-268, 274,  
 278-279  
 cornea, 343-344, 348  
 corneal-scleral junction, 343  
 corona radiata, 305, 313  
 coronary artery, 150  
 corpora amylacea, 330-331  
 corpora cavernosae, 330-331  
 corpus albicans, 305, 307  
 corpus cavernosum, 340-341  
 corpus hemorrhagicum, 305, 307, 315  
 corpus luteum, 305, 307, 316  
 corpus spongiosum, 330-331, 340  
 cortex (adrenal gland), 128, 206-207, 216-218  
 cortex (kidney), 157, 261-264, 267-268, 270-272,  
 278  
 cortex (lymph node), 157-159, 163-164, 166  
 cortex (ovary), 307  
 corticotropes, 205  
 crista ampullaris, 346-347, 358  
 crypt cells, 224  
 crypts of Lieberkuhn, 225, 244  
 cumulus oophorus, 305, 307, 313

## INDEX

cuticle, 182  
 cystic duct, 224

## D

decidua basalis, 307  
 decidua capsularis, 307  
 decidua parietalis, 307  
 dendrite, 85-86, 90  
 dendritic cells, 157-159  
 dense irregular connective tissue, 29, 36, 38,  
 127-128, 223, 247, 305-306, 308, 329, 343  
 dense regular connective tissue, 29, 36-37, 61,  
 330  
 dental papilla, 83  
 dental pulp, 84  
 dentin, 84  
 dermal papillae, 86, 181-182, 188  
 dermis, 29, 38, 86, 181-182, 184, 189-190, 309  
 Descemet's layer, 343  
 desmosomes, 15, 157, 181  
 diastole, 127  
 diffuse lymphocytic infiltrations, 158  
 distal convoluted tubule, 261, 263-264, 268, 274,  
 279  
 distributing arteries, 128  
 DNA, 1, 14  
 dorsal horn, 85-86, 89  
 dorsal root ganglion, 85-86, 88, 91-93  
 dorsal roots, 85  
 duct cells, 6, 183, 193, 197, 307  
 ducts of Bellini, 261, 264  
 ductus deferens, 329-331  
 dust cells, 157, 301-302

## E

ear, 61, 346, 356-358  
 efferent ductules, 329  
 efferent lymph vessels, 158  
 ejaculatory duct, 330  
 elastic artery, 127-130, 134, 141, 143-144  
 elastic cartilage, 61-62, 67-68, 289-291, 296  
 elastic fibers, 1, 29-30, 61, 86, 127-129, 181,  
 290-291, 306  
 elastic lamina, 127-130, 133-134, 145  
 elastic tissue, 29-30, 62, 127-129, 306, 343  
 elastin, 33-34  
 endocardium, 127, 130, 148-149  
 endochondral bone growth, 63  
 endocrine glands, 15, 128, 205, i  
 endometrium, 306, 308, 317, 320  
 endomysium, 43-44, 47, 50-51  
 endoneurium, 85-87, 93, 100  
 endosteum, 62-63  
 endothelial cell, 5, 15, 127-130, 158-160, 247-248,  
 263-264, 290, 331  
 enteroendocrine cells, 224-225, 227  
 eosin, 1, 30



eosinophilia, 1, 5, 193, 224, 261, 263, iv  
 eosinophilic metamyelocytes, 122  
 eosinophilic myelocytes, 122  
 eosinophils, 29-30, 41, 107-108, 111-112, 114, 122, 228  
 epicardium, 127, 130, 148-149  
 epidermis, 15, 181-182, 184, 189-190  
 epididymis, 329, 331, 336  
 epiglottic cartilage, 289  
 epiglottis, 61, 67-68, 289, 291, 294-296  
 epimysium, 43-44  
 epineurium, 86-87, 99  
 epiphyseal plate, 63, 77, 79  
 epithelial reticular cells, 157, 160, 169-171  
 epithelium, 15-16, 18-20, 22-27, 83,  
 erythropoiesis, 113  
 esophagus, 16, 26, 96-97, 223, 226, 230-232  
 euchromatin, 1, 6, iv  
 exocrine glands, 15, 193, 224, 290, i  
 exocrine pancreas, 193, 196  
 external elastic lamina, 128-130, 133-134  
 external root sheath, 182, 188  
 extracellular matrix, 29, 343, v  
 extraglomerular mesangium, 263, 272  
 extralobular ducts, 193-194, 197, 199  
 eye, 343-344, 348-353, iii  
 eyelid, 344-345, 354-355  
 eyelids, 344

## F

Fallopian tube, 305, 322-323  
 false vocal cords, 289  
 fascicle, 43, 48, 86  
 fat cells, 4, 7, 29-30, 38, 158, 206, 247  
 female reproductive system, 305, i  
 fetal liver, 247-248, 258  
 fetal lung, 292, 304  
 Feulgen, 1, 14  
 Feulgen stain, 14  
 fibria, 322  
 fibroblast, 5-7, 29-32, 43, 61, 85-87, 129, 182, 247, 263, 290, 305, 329-330, 343  
 fibrocartilage, 55, 61, 68  
 fibroelastic lamina propria, 289  
 fibrogenic layer, 61-62  
 fimbriae, 305  
 follicles, 182, 184, 186-188, 205, 207, 213, 305, 307, 311-314, 344-345  
 follicular cells, 205-207, 214, 305, 307  
 follicular phase, 305

## G

gall bladder, 247, 258-259, i  
 gastric glands, 223-224, 227, 234, 238  
 gastric pits, 223-224, 227, 234  
 gastrointestinal tract, 86, 223, i  
 germinal center, 158, 160, 165

## INDEX

germinal epithelium, 305, 329-330  
 gland cells, 5, 183, 193, 202-204, 207, 214-215, 344  
 glands of Littre, 331, 341  
 glans penis, 330  
 glassy membrane, 182, 188  
 glia, 85  
 glomerulus, 261, 263-264  
 glucagon, 206  
 glycogen, 1, 43, 127, 247-248, 255-256, 306  
 goblet cell, 15-16, 20, 24-25, 224-225, 227-228, 241, 244, 289-291, 295, 344  
 Golgi apparatus, 1, 11, 205  
 Golgi stain, 1, 10-11  
 gonadotropes, 205  
 Graafian follicle, 305, 312-313  
 granulocytes, 107  
 granulomere, 107  
 granulopoiesis, 113  
 granulosa, 305, 307, 312-313, 316  
 granulosa cells, 305, 307, 316  
 granulosa luteal cells, 307, 316  
 grey matter, 85  
 ground substance, 29, 61-62

## H

hair bulb, 182, 188  
 hair follicles, 182, 184, 186-188  
 Hassel's corpuscles, 157-158, 160  
 Haversian, 62-63, 70-74  
 Haversian canal, 63, 70-74  
 Haversian lamellae, 62-63, 70-71, 74  
 H-band, 43-44, 48  
 heart, 43, 127-130, 154  
 heart conduction system, 127  
 helicine artery, 341  
 helicotrema, 346, 356  
 hematopoiesis, 113, 247, 258, i  
 hematoxylin, 1, 12-13, 61  
 Henle's loop, 261, 263, 269, 271, 273, 279, 281  
 hepatic arteriole, 247-248, 253  
 hepatic ducts, 247  
 hepatic sinusoids, 247, 254-255  
 hepatic stellate cells, 247  
 hepatocytes, 247-248, 252, v  
 Herring bodies, 205, 207, 210, 212  
 heterochromatin, 1, 6, 43  
 high endothelial venules, 158-159, 166  
 high resistance channels, 128  
 horny cells, 181  
 hyaline cartilage, 61-62, 65-66, 289-291, 303  
 hyalomere, 107  
 hypodermis, 86, 181-182, 184, 189

## I

I-band, 43-44, 48  
 ileum, 223-225, 227, 241

immature bone, 63  
 infundibulum, 305, 307, 322-323  
 inlet vessels, 247  
 inner circumferential lamellae, 62, 73  
 inner enamel epithelium, 83  
 inner root sheath, 182  
 insulin, 1, 206-207  
 interalveolar septum, 290  
 intercalated disks, 43-44, 52-53  
 intercalated ducts, 193-194, 200  
 interlobar vessels, 261, 264  
 interlobular arteries, 262  
 interlobular ducts, 193-194, 196-197  
 internal elastic lamina, 128-129, 133-134  
 Interstitial cells of Leydig, 329, 331, 333  
 interstitial growth, 61-62  
 interstitial lamellae, 62-63, 70, 74  
 interterritorial matrix, 61-62  
 intervetebral disk, 68  
 intestinal crypts, 224-225, 228  
 intestinal glands, 224-225, 228  
 intralobular duct, 193, 197  
 intralobular ducts, 193-194, 196, 200, 309  
 intramembranous bone formation, 75-76, 82  
 intramembranous bone growth, 63  
 iris, 343-344, 348-349  
 islets of Langerhans, 193-195, 198, 206-207, 220-222  
 isthmus, 224, 305-306

## J

jejunum, 223-225, 227, 239-240  
 junctional complex, 15, 43, 193  
 juxtamedullary cortex, 164  
 juxtamedullary renal corpuscles, 262, 264

## K

keratin, 15-16, 26-27, 181  
 keratinocytes, 181  
 keratinosome, 181  
 keratohyalin granules, 181  
 kidney, 15-16, 107, 113, 157, 205, 261-264, 267-282  
 Kupffer cells, 157, 247-248, 257

## L

lacrimal gland, 344, 353  
 lacteals, 225, 227  
 lactiferous duct, 306, 326  
 lactiferous sinus, 307  
 lactotrope, 205-206  
 lacunae, 61-63, 70-74, 307  
 lamellae, 62-63, 70-71, 73-74  
 lamina propria, 29, 158, 223-228, 231, 247, 262, 265, 289, 291-292, 306, 308-309, 329, 331, 344  
 Langerhans cells, 157, 181, 207

## INDEX

Large intestine, 223, 225  
 larynx, 25, 289, 291, 297  
 lens, 343-345, 348-349, iii  
 Leydig cells, 329, 331, 333  
 limbus, 343-344, 346, 348  
 lipofuscin pigment, 43-44, 52, 86, 206, 218  
 Littre, 330-331, 341  
 liver, 8, 15, 128, 157, 224-225, 247-248, 250-258, i, v  
 liver hematopoiesis, 247, 258  
 liver lobules, 247-248, 250-251, 253  
 lobules, 157, 193-194, 247-248, 250-251, 253, 307, 309, 330  
 loose connective tissue, 29, 127, 129, 158, 307, 329, 331, 343  
 lung, 15-16, 127, 157, 290-292, 299-304  
 luteal phase, 305  
 lymph node, 4, 9, 40-41, 158-159, 162-167  
 lymph node cortex, 163, 166  
 lymph node medulla, 163  
 lymph nodes, 29, 157-158  
 lymph nodules, 158-159, 228, 289, 291  
 lymphatic vessel, 139, 158-159, 162, 223, 247-248  
 lymphocyte nuclei, 4  
 lymphocytes, 107-108, 110, 112, 124, 157-160, 223-225, 228, 306-307  
 lymphoid system, 157, i

## M

M cells, 224-225  
 macrophage, 29-32, 41-42, 157-160, 162-163, 224, 247-248, 263, 290, 292, 301, 305-306, 329, 331  
 macrophages, 157, 159, 224, 247-248  
 macula, 261, 263-264, 275, 279-280, 344, 346  
 macula densa, 261, 263-264, 275, 279-280  
 major calyces, 262  
 male reproductive system, 329, i  
 mammary gland, 305-306, 309, 325-327  
 mammatropes, 205  
 marginal zone, 159-160, 177  
 mast cells, 1, 29-30, 39-40, 329, 331  
 mature (Graafian) follicle, 305  
 mediastinum testis, 329, 335  
 medium and large veins, 128  
 medulla, 157-160, 163-164, 182, 206-207, 216, 219, 261-264, 267, 270-271, 278, 305  
 medulla (adrenal gland), 206-207, 216, 219  
 medulla (kidney), 157, 261-264, 267, 270-271, 278  
 medulla (lymph node), 157-159, 163-164, 305  
 medulla (ovary), 305  
 medullary cords, 158-159  
 medullary ray, 261, 263-264, 270, 272-273, 278, 282  
 medullary region, 157, 261  
 megakaryocytes, 114, 123



Meibomian glands, 344-345, 354-355  
 Meissner's corpuscles, 86, 182  
 Meissner's plexus, 86-87, 97-98, 223  
 melanin, 181, 189  
 melanocytes, 181, 183, 188  
 membranous labyrinth, 346  
 menstrual phase, 306  
 Merkle cells, 181  
 mesangial cells, 157, 263-264, 276  
 mesangium, 263, 272, 276-277  
 mesenchymal cells, 30-32, 63  
 mesentery nerves, 102-103  
 metamyelocytes, 119-120, 122  
 microvilli, 15-16, 20, 24, 224, 227, 241, 289, 307, 329, iv  
 minor calyces, 262  
 mitochondria, 1, 12-13, 63, 193, 205, 224, iv  
 modiolus, 346, 356  
 monocytes, 63, 107-108, 110, 112, 125, 157  
 mucoid connective tissue, 29  
 mucosa, 158, 223-228, 230-231, 233, 235, 238, 243, 247, 262, 289, 305-308, 330  
 mucous, 5, 15-16, 193-194, 202-204, 223-224, 226-227, 236, 289, 303, 306, 331, 344  
 mucous cells, 5, 15, 193-194, 202-204, 223-224, 227, 236  
 mucous glands, 193, 223-224, 227, 303, 306, 331  
 mucous neck cells, 224, 227, 236  
 multilaminar primary follicles, 307, 311, 314  
 muscle, 7, 15, 33, 37, 43-44, 47-53, 55-59, 86,  
 muscle fascicle, 43, 48  
 muscle insertion, 44, 50-51  
 muscular artery, 129, 133-134, 136-140  
 muscularis externa, 223, 225-228, 230-233, 235, 243  
 muscularis mucosa, 223-228, 230-231, 233, 235, 238, 243, 247, 305-306  
 myelin, 85-87, 100-101  
 myeloblast, 113-114, 119-120  
 myelocytes, 119-120, 122  
 myenteric plexus, 223, 226, 228, 232  
 myocardium, 127, 130, 149  
 myoepithelial cells, 193, 307, 343-344  
 myofibrils, 43-44, 50, 127  
 myometrium, 306-308, 317, 320  
 myoneural junctions, 43  
 myosin, 43, iii  
 myo-tendinous insertion, 43-44

## N

nasal cavity, 289, 291  
 nasopharynx, 289  
 nephron, 261, 263  
 nerve, 43, 85-87, 99-101, 128, 182,  
 nerve fascicles, 87, 99  
 neurohypophysis, 205  
 neuron, 85-86, 289  
 neutrophil, 113-114

## INDEX

neutrophilic band, 113-114, 120-121  
 neutrophilic band cells, 121  
 neutrophilic metamyelocyte, 113-114, 120  
 neutrophilic myelocyte, 113-114, 120  
 neutrophils, 29, 107-108, 112-114, 159  
 Nissl bodies, 86, 95  
 Nissl substance, 4, 85-86, 90  
 node of Ranvier, 86-87, 100-101  
 nodule, 158-159, 164, 172, 174, 177, 179, 228  
 non-striated muscle, 43  
 nucleolus, 4, 9-10, 85, 329  
 nucleus, 4, 9-10, 29, 43-44, 85-86,

## O

odontoblasts, 84  
 olfactory region, 289  
 oocytes, 305, 307  
 optic disk, 344-345, 352  
 optic nerve, 343-345, 352  
 ora serrata, 343, 345  
 oral epithelium, 83  
 organ of Corti, 346, 357  
 orthochromatic erythroblast, 113-114  
 orthochromatic normoblasts, 116-117  
 osseous spiral lamina, 346  
 ossified cartilage, 80  
 osteoblasts, 61-63, 76, 78, 81-82  
 osteoclasts, 63, 78-79, 81  
 osteocyte, 62-63, 70-74, 76, 82  
 osteocyte lacunae, 63, 70-74  
 osteoid, 62-63, 76, 82  
 osteon, 62-63  
 otoliths, 346  
 outer circumferential lamellae, 62-63, 73  
 outer enamel epithelium, 83  
 ovarian cycle, 305-306  
 ovary, 16, 305, 307, 311-316  
 oviducts, 305-306  
 ovulation, 305  
 oxyphils, 205-207, 215

## P

Pacinian corpuscle, 86-87, 104-105, 182, 192  
 palate, 291, 293-294  
 palatine tonsil, 172  
 palpebra, 344, 353-354  
 pancreas, 10, 16, 39, 128, 193-198, 206, 220-222, 224-225  
 pancreatic ducts, 16, 224  
 Paneth cells, 224-225, 227-228, 242  
 papillary layer, 181  
 paracortex, 158-159  
 parafollicular cell, 205, 207, 214  
 parasympathetic ganglion, 86-87, 96-98, 232  
 parasympathetic nerves, 86, 223  
 parathyroid gland, 205-207, 214-215  
 paratrabeular sinuses, 158

parietal cells, 224, 227, 235, 237  
 parotid gland, 193-194, 199-201  
 pars basalis, 308, 317, 321  
 pars distalis, 205  
 pars functionalis, 306, 308, 317  
 pars intermedia, 205  
 pars tuberalis, 205  
 PAS, 1, 43, 54-55, 127, 193, 247-248, 255-256  
 pasasympathetic ganglion, 97  
 pectinate muscle, 147  
 penicillar arteries, 159  
 penis, 329-331, 340-341  
 periarteriolar lymphocytic sheath, 158, 174, 179  
 peribiliary capillary, 253  
 perichondrium, 61-62, 64-66  
 pericyte, 128  
 perimysium, 43-44  
 perineurium, 86-87, 99  
 periodic acid Schiff, 1, 247  
 periosteum, 37, 51, 62-63, 79, 82  
 peripheral lymphoid tissues, 158  
 peripheral nerve, 85, 87, 99-101  
 peripheral nervous system, 85  
 Peyer's patches, 158, 225, 228, 242  
 pituicytes, 205, 207  
 pituitary gland, 205, 207-212  
 placenta, 305, 307, 309, 328  
 plasma cells, 29-30, 40, 114, 124, 157-159, 223-224, 228, 307  
 platelets, 107-108, 114  
 plicae circulares, 224, 228  
 pneumocytes, 290, 292, 302  
 podocytes, 261, 263-264, 276-277  
 polychromatic normoblasts, 116  
 polychromatic erythroblast, 113-114  
 portal canal, 247-248, 252-253  
 portal venule, 247-248, 253  
 post capillary venules, 128-129  
 posterior chamber, 343, 345  
 posterior pituitary gland, 205, 210, 212  
 PP-cells, 206  
 predermin, 84  
 primary nodule, 158-159, 164  
 primary nodules, 158-159  
 primary oocytes, 305, 307  
 primordial follicles, 305, 307, 311  
 proerythroblast, 113-114  
 proliferative phase, 306  
 promyelocyte, 113, 119-120  
 promyelocytes, 119-120  
 pronormoblasts, 116  
 prostate, 330-331, 339-340  
 proximal convoluted tubule, 261, 263-264, 267-268, 274, 278-279  
 pseudostratified columnar epithelium, 15-16, 20, 25, 289, 295, 297, 299, 303, 329-331, 344  
 pseudounipolar, 85  
 PTA stain, 49, 53, 56  
 pulp arteriole, 159, 174-177

## INDEX

pupil, 343-344, 348  
 Purkinje fibers, 44, 54, 56, 127, 130, 152-154

## R

radial arteries, 306, 308, 318  
 Rathke's cysts, 205, 207-208  
 RBC, 4, 7, 113, iii  
 reaction center, 174  
 red blood cells, 1, 5, 107-108, 158-159, 264  
 red pulp, 158-160, 173, 175-177  
 regenerative cells, 224  
 Reissner's vestibular membrane, 346  
 renal arteries, 262  
 renal columns, 261-262  
 renal corpuscle, 261-264, 267-268, 274-277, 279  
 respiratory bronchioles, 289-291, 300  
 respiratory epithelium, 16, 289, 291, 299  
 respiratory system, 15, 289, i  
 resting zone, 63, 78, 80  
 rete testis, 329, 331, 335  
 reticular fibers, 1, 29-30, 34, 43, 86, 128-130, 132, 158-159, 167, 181, 247, 290, 329  
 reticular layer, 181-182  
 reticular tissue, 29-30, 329  
 reticulocyte, 113, 116  
 retina, 343-345, 348, 351-352  
 retina layers, 345, 352  
 RNA, 1, 4, 8-10, 85, iv  
 root sheath, 182, 188  
 rugae, 223, 227, 235, 247

## S

saccule, 346-347  
 satellite cells, 85  
 scala media, 346  
 scala tympani, 346, 356-357  
 scala vestibuli, 346, 356-357  
 scalp, 182, 184-188  
 Schwann cell, 85-87, 100-101  
 sclera, 343-344, 348, 351  
 sebaceous gland, 182-183, 185-186, 344-345  
 secondary follicles, 305, 307, 312-313  
 secondary nodule, 158-159, 164  
 secretion granules, 193, 205, 224, iv  
 secretory phase, 306  
 semicircular canals, 346-347, 356  
 seminal vesicle, 329-331, 338-339  
 seminiferous germinal epithelium, 329  
 seminiferous tubules, 329-330, 332, 334  
 sero-mucous glands, 289, 291  
 serosa, 223, 225, 247, 305-306  
 serous cells, 193-194, 202-204, 289-290, 344  
 serous demilune, 203  
 serous glands, 193, 289  
 serous secretory cells, 193  
 Sertoli cells, 329-330, 333-335  
 sheathed arteriole, 159-160, 175



sheathed capillary, 177  
 silver stain, 128, 158, 167  
 simple columnar epithelium, 19, 24, 223-224, 226-227, 241, 247, 289, 306-308, 330, 346  
 simple cuboidal epithelium, 18-19, 23, 182, 193, 197, 205, 247, 261, 263, 289, 305, 307, 311  
 simple squamous epithelium, 16, 18, 23, 261, 263, 289, 343  
 sino-atrial node, 43, 127  
 sinuses, 158-159, 306, 331  
 sinusoids, 128, 159-160, 175, 177-179, 206-207, 217, 247-248, 254-255  
 skeletal muscle, 43-44, 47-51, 53, 58-59, 223, 289, 291, 306  
 skin, 15-16, 26-27, 29, 86, 103-105, 157, 181-182, 189-192,  
 small collecting veins, 128  
 small intestine, 223-225  
 smooth muscle, 7, 43-44, 49, 56-59, 127-129, 182, 223, 225, 247, 262-263, 289-292, 306-307, 309, 329-331, 343-344  
 soma, 85  
 somatostatin, 206  
 somatotropes, 205  
 space of Disse, 247-248  
 specific granules, 107, 113-114  
 spermatids, 329-330, 334  
 spermatocytes, 329-330, 334  
 spermatogonia, 329-330, 333-334  
 spermiogenesis, 334  
 spinal cord, 4, 85-86, 88-91  
 spiral ganglion, 346, 356-357  
 spleen, 128, 157-158, 160, 173-178  
 splenic artery, 158  
 splenic cords, 159-160  
 splenic sinusoids, 159, 175  
 spongy bone, 62, 69  
 stellate reticulum, 83  
 stereocillia, 329, 331, 346  
 stomach, 16, 193, 223-225, 227, 233-238  
 straight tubules, 261, 264  
 stratified cuboidal, 16, 193, 307, 309  
 stratified squamous epithelium, 25-27, 159, 181-182, 223, 226, 289, 291, 295, 297, 306, 308, 343-344  
 stratified squamous keratinized epithelium, 181-182, 344  
 stratum basalis, 181-182, 189-190  
 stratum corneum, 181, 189-190  
 stratum germinativum, 181, 190  
 stratum granulosum, 181, 189-190  
 stratum intermedium, 84  
 stratum lucidum, 181  
 stratum spinosum, 181, 189-190  
 striate border, 224  
 striate ducts, 193, 200  
 striated muscle, 43, 226  
 subcapsular sinus, 158-159, 165  
 sublingual gland, 193-194, 203-204

## INDEX

submandibular gland, 193-194, 201-203  
 submucosa, 223-228, 230, 233, 247  
 submucosal glands, 223-227, 238, 240, 330  
 surface mucous cells, 223-224, 227  
 sweat glands, 182, 184-185, 187, 190, 193, 345  
 sympathetic ganglion, 86, 88, 91, 95  
 syncytiotrophoblasts, 307, 328  
 systole, 127

## T

taenia coli, 225, 228, 243  
 tarsal glands, 345, 354-355  
 tarsal plate, 344-345, 355  
 tectorial membrane, 346, 357  
 tendon, 37, 50-51  
 territorial matrix, 66  
 terminal bar, 15-16, 20, 227  
 terminal bronchioles, 289-291, 300  
 terminal pulp capillaries, 159  
 terminal web, 15-16, 20, 227-228, 241  
 territorial matrix, 61-63  
 testis, 128, 329-335  
 theca externa, 305, 307, 313  
 theca interna, 305, 307, 313  
 theca luteal cells, 305, 316  
 thick skin, 27, 86, 103-105, 181-182, 190-192  
 thin skin, 26, 86, 181-182, 189, 289  
 thymus, 157, 160, 168-171  
 thyroid follicles, 207, 213  
 thyroid gland, 205-207, 213-214  
 thyrotropes, 205  
 T-lymphocytes, 157-159  
 toluidine blue, 1, 8-10  
 tonofilaments, 181  
 tonsil crypt, 172  
 tonsils, 158, 289  
 tooth development (bell stage), 83-84  
 trabeculae, 62, 157-160, 330-331  
 trabecular sinus, 159, 165  
 trabecular veins, 159-160, 178  
 trabecular vessels, 158-159, 176, 178  
 trachea, 25, 65-66, 289-291, 298-299  
 tracheal cartilage, 289, 298  
 trachealis muscle, 289, 291, 298  
 transitional epithelium, 15-16, 22-23, 262, 265, 283-287  
 tricuspid valve, 150  
 tubuli recti, 329, 331, 335  
 tunica adventitia, 127-130, 133-136, 142, 144-145  
 tunica albuginea, 305, 329-331, 340  
 tunica intima, 127-130, 133, 135, 144-145  
 tunica media, 127-130, 133, 135, 142, 144-145  
 type I pneumocytes, 290, 292, 302  
 type II pneumocytes, 290, 292, 302

## U

umbrella cells, 16, 22-23, 262, 265, 285-287

unilaminar primary follicles, 307, 311, 314  
 ureter, 16, 261-262, 265, 283-284  
 urethra, 261, 329-331, 340-341  
 urinary bladder, 16, 265, 285-287  
 urinary pelvis, 261  
 urinary pole, 261, 263-264, 268, 275-277, 280  
 urinary system, 261, i  
 uriniferous tubule, 261  
 uterine glands, 306, 308, 317-318  
 uterine tube, 305, 322-323  
 uterus, 16, 43, 305-308, 317-321  
 uterus (late secretory), 308, 319  
 uterus (menopausal), 321  
 uterus (menstrual), 308, 320-321  
 uterus (proliferative), 308, 317-318  
 uterus (secretory), 308, 319  
 utricle, 346-347

## V

vagina, 16, 305-306, 308, 325  
 valves of Kerckring, 224  
 vas deferens, 329, 331, 336-338  
 vas deferens (ampulla), 331, 338  
 vasa recta, 262, 264, 270-271, 278  
 vasa vasorum, 127, 129  
 vascular pole, 261, 263-264, 275-276, 280  
 vaso vasorum, 130, 142-143, 145  
 vein, 128, 135-137, 140-143, 146, 159, 247-248, 251-254  
 vein valve, 146  
 vena cava, 130, 145-146  
 ventral horn, 85-86, 89  
 ventral motor neurons, 89-90  
 ventral roots, 85  
 ventricle, 127, 130, 149, 289, 291  
 ventricular fold, 289  
 venule, 130, 138-139, 253  
 Verhoeff, 1, 30, 35, 67-68, 128, 291, iv  
 vestibular apparatus, 356, 358  
 vestibular membrane, 346, 356-357  
 vestibule, 289, 306, 346  
 villi, 224-225, 227-228, 307, 309  
 vitreous body, 343  
 vitreous chamber, 343  
 vocal cords, 289  
 vocal fold, 289, 291  
 vocal ligament, 291, 297  
 vocalis muscle, 289, 291, 297  
 Volkman canal, 73  
 Volkmann's canals, 62

## W

Wasserhelle cells, 205, 207, 215  
 white blood cells, 4-5, 107-108, 128  
 white pulp, 158, 160, 173-174, 176

## Z

Z-line, 43-44, 48  
 zona fasciculata, 206, 216, 218  
 zona glomerulosa, 206, 216-217  
 zona pellucida, 305, 307, 313  
 zona reticularis, 206, 216, 218-219  
 zone of calcification, 78, 80-81  
 zone of hypertrophy, 63, 78, 80  
 zone of ossification, 63, 78, 80-81  
 zone of proliferation, 63, 78, 80

## Slides

Slide 1 Lymph Node, 4  
 Slide 1 Nuclear Morphology & Cell Size, 3  
 Slide 1 Spinal Cord, 4, 90  
 Slide 3 Toluidine Blue, 8-10  
 Slide 2 Cells and Tissue: Size, Shape, Color, 5-7  
 Slide 9 Golgi Stain, 10-11  
 Slide 10 Iron Hematoxylin Stain, 12-13  
 Slide 12 Feulgen Stain, 14  
 Slide 16 Gut: Smooth muscle, 57-58  
 Slide 16 Simple Epithelia, 18-20  
 Slide 17 Stratified Epithelia, 21  
 Slide 18 Transitional Epithelium, 287  
 Slide 20 Pig Snout, 31-32, 64, 75-76, 83-84  
 Slide 20 Pig Snout Embryo, 64, 75-76, 83-84  
 Slide 21 Connective tissue H&E, 35  
 Slide 22 Connective tissue Verhoeff, 35  
 Slide 23 Connective tissue Azan, 35  
 Slide 23 Tendon: Muscle insertion (Azan), 51  
 Slide 24 Connective Tissue H&E, 33  
 Slide 24 Mesentery, 38, 41, 102, 132-139, 162-163  
 Slide 24 mesentery Lymph Node, 41, 162-163  
 Slide 24 Mesentery nerves, 102  
 Slide 24 Vessel: Smooth muscle, 57  
 Slide 25 Connective Tissue Verhof, 33  
 Slide 25 Mesentery (Verhof), 33, 134-135, 137-139  
 Slide 26 Connective Tissue Azan, 33  
 Slide 26 Mesentery (Azan), 42, 102-103, 134, 136-137  
 Slide 26 Mesentery nerves (azan), 102-103  
 Slide 29 Endochondral Bone Formation, 77-79  
 Slide 29 Muscle Attachment, 37  
 Slide 29 Tendon: Muscle insertion, 51  
 Slide 30 Tendon: Muscle insertion, 50  
 Slide 31 Liver (Trypan Blue), 256-257  
 Slide 33 Blood Smear, 109, 112  
 Slide 34 Bone Marrow Smear, 115  
 Slide 36 Epiglottis (H&E), 67-68  
 Slide 38 Epiglottis, 294-296  
 Slide 39 Epiglottis (Verhof), 67-68, 296  
 Slide 40 Intervetebral Disk: Fibrocartilage, 68  
 Slide 43 Epiphysis - Cancellous and compact Bone, 69  
 Slide 43 Skill - Cancellous and compact bone, 69-70



Slide 44 Ground bone, 73-74  
 Slide 45 Decalcified bone, 72  
 Slide 46 Endochondral Bone Formation, 79-82  
 Slide 46 Intramembranous bone formation, 82  
 Slide 47 Spinal Cord, 88-89, 91  
 Slide 50 Dorsal Root Ganglion, 91-92  
 Slide 51 Dorsal Root Ganglion (Azan), 93  
 Slide 52 Peripheral Nerve, 99-101  
 Slide 53 Smooth Muscle, 56  
 Slide 54 Cardiac Muscle, 51-53  
 Slide 55 Skeletal Muscle, 47-49  
 Slide 56 Skeletal, Cardiac and Smooth Muscle (PTA stain), 49, 53  
 Slide 57 Skeletal Muscle Teased, 50  
 Slide 58 Cardiac Skeleton, 55, 155  
 Slide 58 Cardiac Skeleton (PAS), 53, 55, 155  
 Slide 58 Purkinje Fibers, 54, 153-154  
 Slide 58 Purkinje fibers (PAS), 54  
 Slide 59 Sympathetic Ganglion, 95  
 Slide 61 Popliteal Artery and Vein, 140-141  
 Slide 62 Popliteal Artery and Vein, 140-141  
 Slide 63 Brachiocephalic Vein, 142-143  
 Slide 63 Carotid Artery, 141-142  
 Slide 65 Aorta, 143-145  
 Slide 65 Vena Cava, 146  
 Slide 66 Aorta (Verhof), 144-145  
 Slide 66 Vena Cava (Verhof), 145-146  
 Slide 67 Vein Valve, 146  
 Slide 69 Pectinate Part of Right Atrium, 147  
 Slide 69 Smooth part of Left Atrium, 148  
 Slide 70 Left Ventricle, 149  
 Slide 70 Right Ventricle, 149  
 Slide 71 Coronary Artery, 150  
 Slide 71 Tricuspid Valve and Coronary Artery, 150  
 Slide 72 Coronary Artery (Verhof), 150  
 Slide 73 Aortic Valve, 151-152  
 Slide 74 Cardiac Skeleton, 152  
 Slide 74 Purkinje Fibers, 56, 152-153  
 Slide 76 Lymph Node, 164-166  
 Slide 78 Reticular fibers, 34  
 Slide 79 Thymus, 168-171  
 Slide 81 Palatine Tonsil, 172  
 Slide 84 Spleen, 176-178  
 Slide 85 Spleen, 173-175  
 Slide 86 Scalp, 184-187  
 Slide 87 Scalp, 188  
 Slide 88 Hair Follicle, 186  
 Slide 88 thin skin, 189  
 Slide 90 Thin Skin, 26, 189  
 Slide 91 Thick Skin, 27, 103-105, 190-192  
 Slide 94 Parotid Gland, 199-201  
 Slide 95 Submandibular Gland, 201-203  
 Slide 96 Sublingual Gland, 203-204  
 Slide 109 Esophagus, 26, 96-97, 230-232  
 Slide 110 Trachea, 298  
 Slide 119 Simple columnar epithelium, 23-24  
 Slide 120 Simple columnar epithelium, 24  
 Slide 123 Colon, 97-98, 243-245  
 Slide 125 Liver (6 mos. Fetus), 257-258

## INDEX

Slide 126 Liver, 250-252  
 Slide 127 Liver (Azan), 253-255  
 Slide 128 Liver (PAS), 255-256  
 Slide 130 Gall Bladder, 258-259  
 Slide 131 Pancreas, 195-197, 220  
 Slide 132 Pancreas (Azan), 198  
 Slide 133 Pancreas (Aldehyde Fuchsin), 198, 221-222  
 Slide 134 Nasal Conchae and Palate, 293  
 Slide 134 Palate, 293-294  
 Slide 135 Larynx, 25, 297  
 Slide 136 Trachea, 25, 65-66, 298-299  
 Slide 136 Trachea, Hyaline Cartilage, 65-66  
 Slide 137 Lung (fetal), 304  
 Slide 139 Lung, 303  
 Slide 140 Fetal Kidney, 267-269  
 Slide 141 Kidney, 270-277  
 Slide 141 Simple epithelium, 23  
 Slide 142 Kidney, 278-281  
 Slide 142 Kidney (Azan), 278-281  
 Slide 143 Kidney, 281-282  
 Slide 146 Ureter, 283-284  
 Slide 147 Bladder, 285  
 Slide 149 Pituitary Gland, 208-210  
 Slide 150 Pituitary Gland (Azan), 210-212  
 Slide 151 Thyroid Gland, 213-214  
 Slide 154 Parathyroid Gland, 214-215  
 Slide 155 Adrenal Cortex, 218  
 Slide 155 Adrenal Gland, 215-219  
 Slide 155 Adrenal Medulla, 216, 219  
 Slide 160 Ovary, 311-312  
 Slide 165 Uterus (proliferative), 317-318  
 Slide 166 Uterus (late secretory), 319  
 Slide 167 Uterus (menstrual), 320-321  
 Slide 170 Uterus (menopausal), 321  
 Slide 171 Fallopian Tube, 322-323  
 Slide 172 Cervix, 324  
 Slide 173 Vagina, 325  
 Slide 174 Mammary Gland, 325-327  
 Slide 175 Placenta, 328  
 Slide 178 Testis (adult), 333-335  
 Slide 178 Testis (neonate), 332-333  
 Slide 181 Vas Deferens, 336-337  
 Slide 182 Seminal Vesicle, 338-339  
 Slide 183 Prostate, 339-340  
 Slide 184 Penis, 340-341  
 Slide 185 Epididymis, 336  
 Slide 207 Cervix, 324  
 Slide 211 Pancreas, 221  
 Slide 214 Urinary Bladder, 287  
 Slide 218 Mammary Gland, 327  
 Slide 224 Uterine Tube, 323  
 Slide 226 Eye, 352  
 Slide 227A Eye, 348-350  
 Slide 227B Eye, 353  
 Slide 229 Eye, 351-352  
 Slide 230 Ear, 356-358  
 Slide 231 Eyelid, 354-355  
 Slide 245 Heart Purkinje Fibers, 154

