Plate 10.204 Appendix

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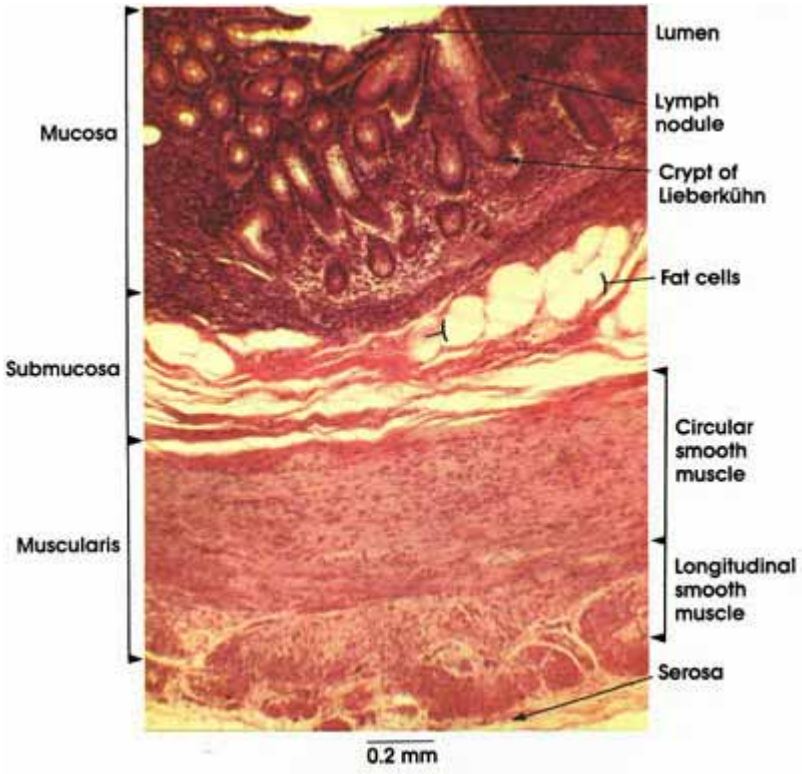
APPENDIX



Human, 10% formalin, H. & E., 50 x.

The histologic structure of the appendix resembles that of the colon. The overall diameter and the lumen are, however, much smaller than that of the colon; the lumen is often obliterated by debris.

Mucosa: Consists of the lining columnar epithelium (which lacks villi), simple tubular intestinal glands (crypts of Lieberkühn), muscularis mucosae, and numerous and conspicuous lymph nodules.

Submucosa: Thick and rich in fat cells.

Muscularis: Relatively thin and composed of two layers of smooth muscle: inner circular and outer longitudinal.

Serosa: Loose areolar connective tissue coat continuous with the mesentery that surrounds the appendix.

Plate 10.198 Lamina Propria

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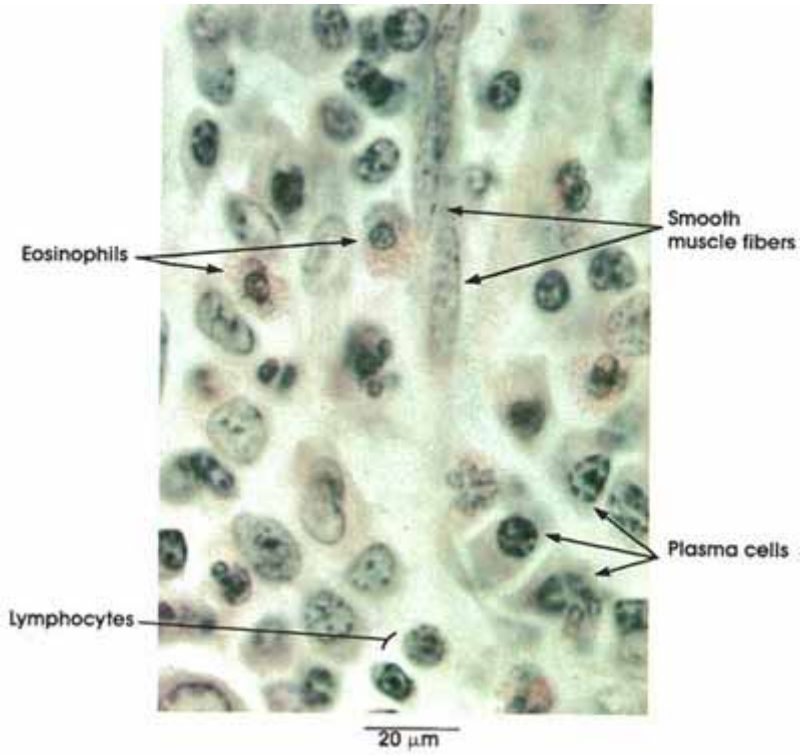
LAMINA PROPRIA
Duodenum



Rhesus monkey, Helly's fluid, H. & E., 612 x.

Lamina propria forms the connective tissue core of the villus and fills the spaces between glands. Primarily a reticular tissue framework with numerous lymphocytes, eosinophils, and plasma cells. Single smooth muscle fibers derived from the muscularis mucosae are oriented longitudinally. Eosinophilic leucocytes and lymphocytes migrate from blood vessels. The lymphocytes seen here are of the small variety, which are immunologically competent. The abundant plasma cells manufacture most of the antibody proteins.

Plate 10.197 Duodenum

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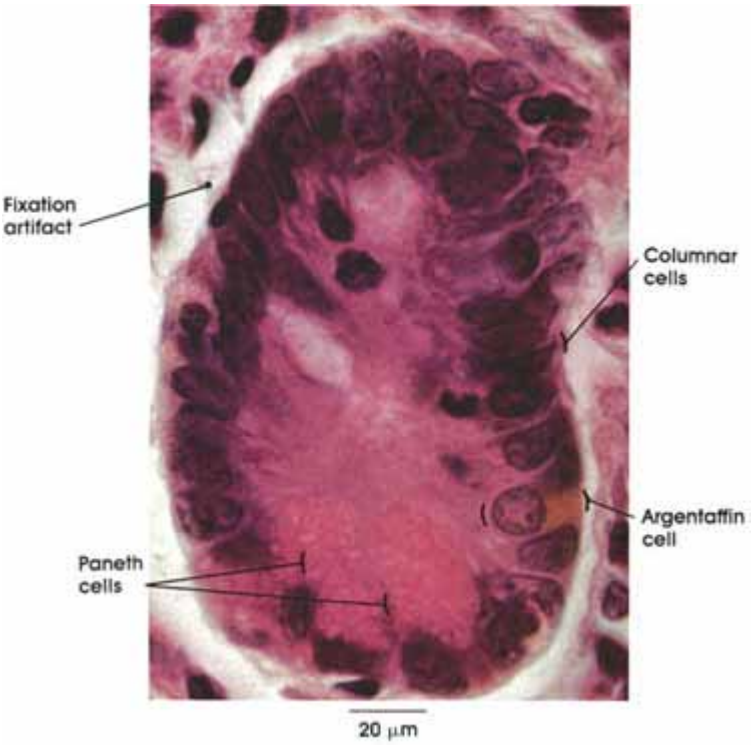
DUODENUM
Intestinal gland lamina propria



Human, 10% formalin-Zenker fixation, H. & E., 612 x.

Intestinal glands are simple tubular glands located in the mucous membrane. These glands are surrounded by a cell-rich connective tissue, the lamina propria. Intestinal glands of Lieberkühn secrete the so-called intestinal juice (succus entericus).

Columnar cells: Shorter than the columnar absorbing cells of the villi. Poorly developed striated border. Source of the surface epithelial cells at the apex of the villus.

Argentaffin cell: Also known as enterochromaffin cells. Fairly common in duodenum. Located among epithelial cells lining the crypts of Lieberkühn (intestinal glands). Contain fine granules stainable by silver salts (argentophilic) and by dichromate, and located in the abluminal portion of the cell between the nucleus and the basement membrane. Argentaffin cells are identified with the production of serotonin (5-hydroxytryptamine), which is secreted into the lamina propria rather than the intestinal lumen. Serotonin is a powerful stimulant of smooth muscle, resulting in contraction, and may play a role in stimulating peristaltic activity of the intestine.

Paneth cells: Coarsely granular cells in the depth of the intestinal gland. Acidophilic granules apically placed. The base of the cell is dark staining and basophilic. Acidophilic granules accumulate during fasting and disappear during digestion. The exact function of this cell is not established, but it has been suggested that it may secrete digestive enzymes (lipoenzyme or a peptidase, or both, and antibacterial lysozyme).

Plate 10.196 Duodenum

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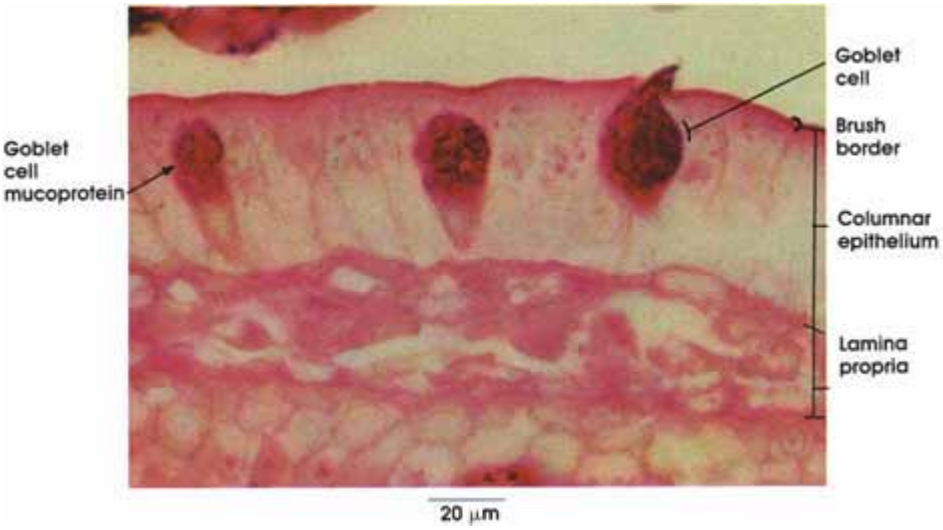
DUODENUM



Helly's fluid, periodic acid-Schiff* stain, 612 x.

The method used in this preparation stains protein polysaccharicles (mucin) that are synthesized and excreted by goblet cells. The striated border and goblet cells are very well outlined, whereas the absorptive columnar epithelium and the lamina propria are not as intensely stained. The relatively unstained basal portion of the goblet cell represents the nuclear region and its surrounding narrow stem of cytoplasm

Plate 10.192 Duodenum and Jejunum

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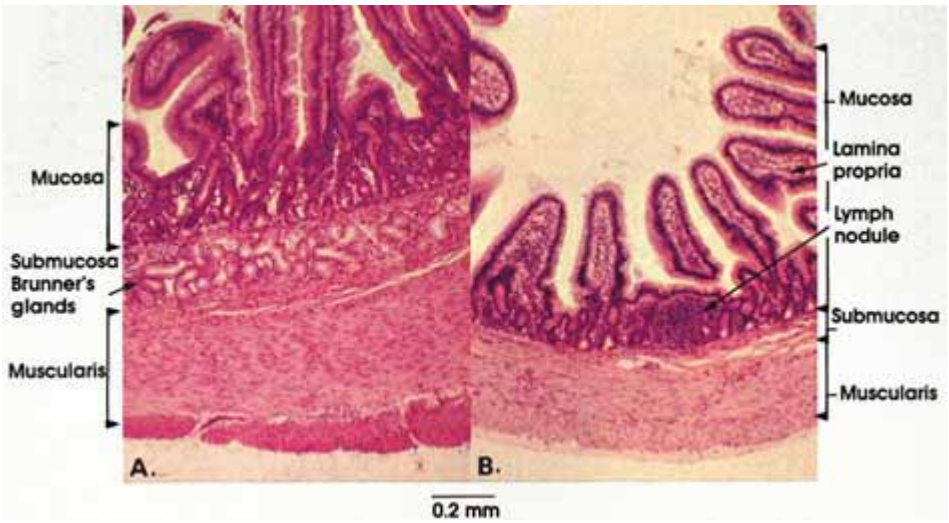
DUODENUM AND JEJUNUM
Cross section



Human, 40% formalin, H. & E., 50 x.

The basic pattern and arrangement of layers in the intestinal wall are seen in both the duodenum (A) and jejunum (B). In each, there is a mucosa, submucosa, muscularis, and an adventitia or a serosa.

The mucosa has finger-like projections, the villi, lined by simple columnar epithelium. Villi of the duodenum tend to be flattened, whereas those of the jejunum are more rounded. The core of the villus is composed of loose connective tissue, blood vessels, a lymphatic vessel, smooth muscle fibers, and other cells of the connective tissue (see Plates 29, 194, and 198). This portion of the mucosa is named the lamina propria. The lamina propria terminates at the muscularis mucosae, which is composed of a band of smooth muscle fibers a few layers thick. Located within the mucosa are simple tubular intestinal glands, the crypts of Lieberkühn, and lymphatic nodules. Lymphatic nodules are found more frequently in the jejunum than in the duodenum.

The submucosa is composed of loose connective tissue and contains, in the duodenum but not the jejunum, the compound tubular mucous glands of Brunner. They are a continuation of the pyloric glands found in the stomach.

The muscularis contains an inner circular and an outer longitudinal layer of smooth muscle fibers. The two layers are separated by reticular and collagenous connective tissue containing nerve fibers and parasympathetic ganglion cells (Auerbach's plexus).

Surrounding the muscularis is the serosa, which consists primarily of loose connective tissue containing nerves, blood and lymphatic vessels, and a mesothelium. Wherever the intestine is not bound to the posterior abdominal wall, i.e., retroperitoneal, the intestine has a suspending mesentery covered with mesothelium. When the intestine is

retroperitoneal, it does not have a mesentery or a mesothelial covering and the outermost layer is called adventitia. Most of the duodenum is retroperitoneal, whereas the entire jejunum is intraperitoneal.

Plate 10.193 Duodenum and Jejunum

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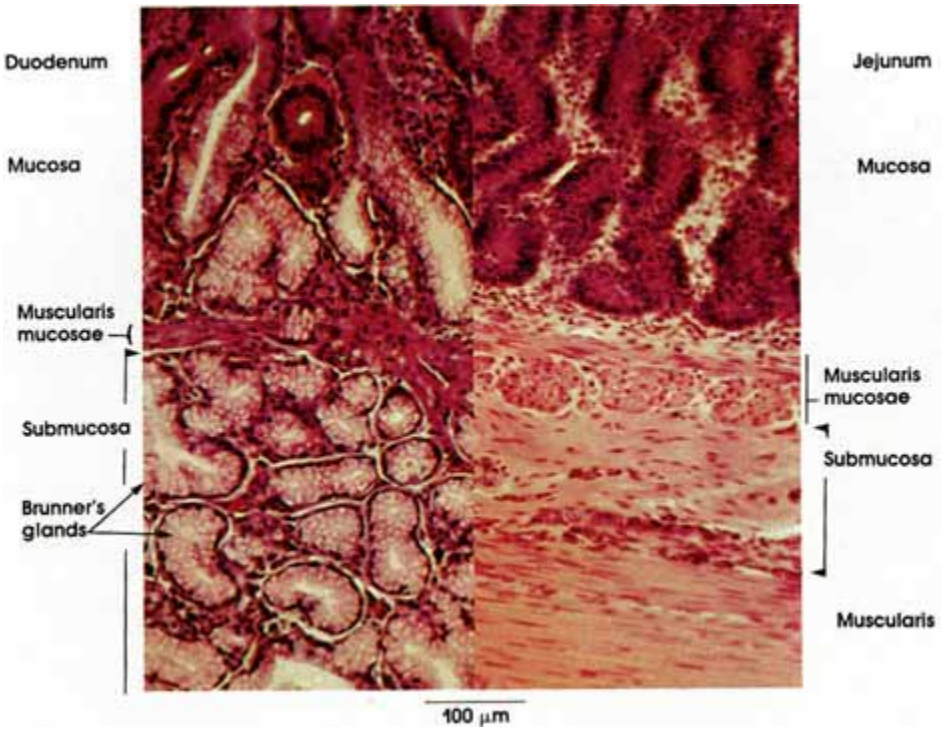
DUODENUM AND JEJUNUM
Submucosa



Human, 10% formalin, H. & E., 162 x.

In this plate, the structure of the duodenum, and the jejunum can be compared. Both segments contain simple tubular glands composed of columnar epithelium separated by the connective tissue of the lamina propria. In the duodenum, note the presence of Brunner's glands in the submucosa, which are diagnostic for this segment of the small intestine. Brunner's glands are compound tubular and are composed of low columnar cells that secrete mucus. The secretory cells closely resemble the cells of the pyloric glands, which also secrete mucus.

Although these glands were first described in 1679 by J. J. Wepfer, Johann Brunner's father-in-law, credit is given to Brunner, the Swiss anatomist, who drew attention to them in his dissertation in 1687.

Plate 10.194 Duodenum

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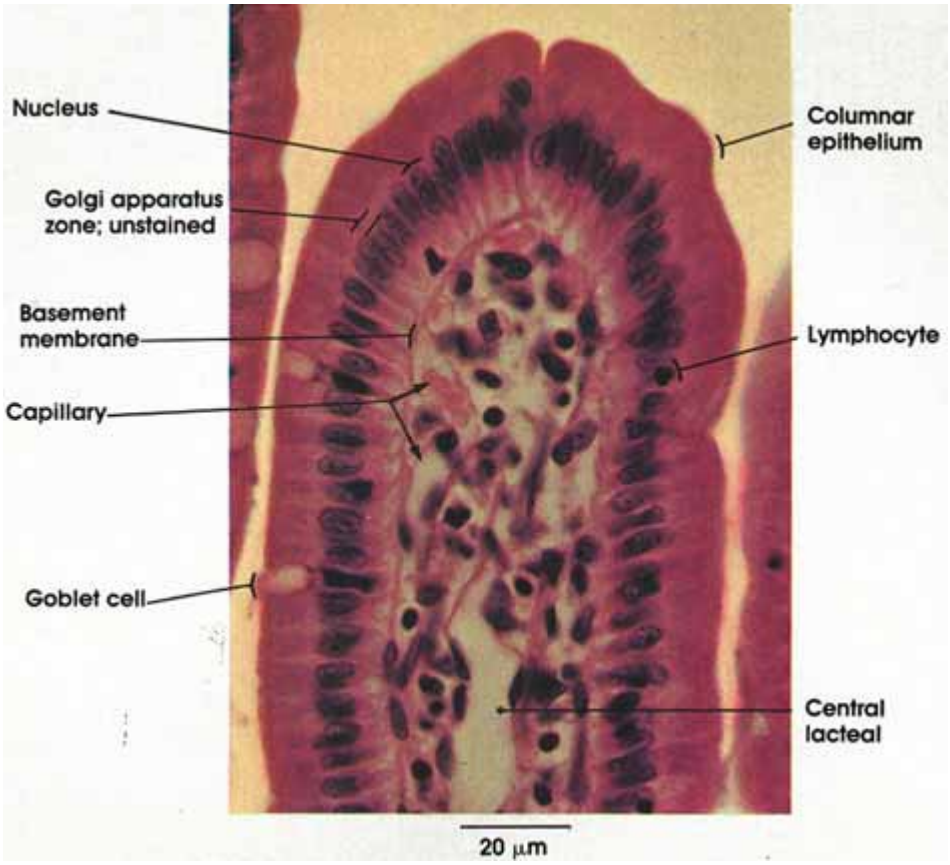
DUODENUM
villus



Cat, Helly's fluid, H. & E., 612 x.

The word *villus* is of Latin origin, meaning shaggy hair or a tuft of hair. The intestinal villi project from the intestinal wall like hairs or the nap on cloth. The term villus was first coined for the intestinal projections by Berengarius, an Italian anatomist, in 1524.

Columnar epithelium: Covers the surface of the villus. Surface of the epithelium has a striated border (microvilli by electron microscopy) to increase its absorptive surface. Products obtained from the extracellular digestive process, salts, vitamins, and other

substances are carried through the cytoplasm of these cells and delivered to the connective tissue to enter the blood vessels or lymphatics. The surface epithelia[cells are being continuously shed from the apex of the villus (extrusion zone) and replaced by migrating cells from the bottom of the crypts (Plates 29 and 198).

Nucleus: Ovoid, located in the lower half of the columnar cell.

Golgi apparatus zone: Relatively pale area in this preparation. Specific stains are needed to demonstrate the Golgi apparatus, which lies between the nuclei and free surface.

Lymphocytes: One of the cell types commonly found in the lamina propria. Seen migrating into the epithelial layer to be extruded into the lumen. See Plates 29 and 198.

Goblet cell: Dispersed among the columnar absorptive epithelial cells. They appear empty because some mucin is lost during the preparation of the specimen. The residual mucin stains poorly with the H. & E. stain. Nucleus is basally located. Compare the small number of goblet cells in this preparation with their abundant number in another region of the intestine (Plate 207).

Basement membrane: A delicate membrane that supports the epithelium. Composed primarily of reticular fibers embedded in an amorphous protein polysaccharide ground substance.

Central lacteal: A lymph vessel situated near the center of the villus. Note its endothelial lining. The lacteals become distended during absorption of fat.

Capillary: Capillaries of the villus form a network that lies underneath the basement membrane of the lining epithelium.

Plate 10.195 Duodenum: Villi

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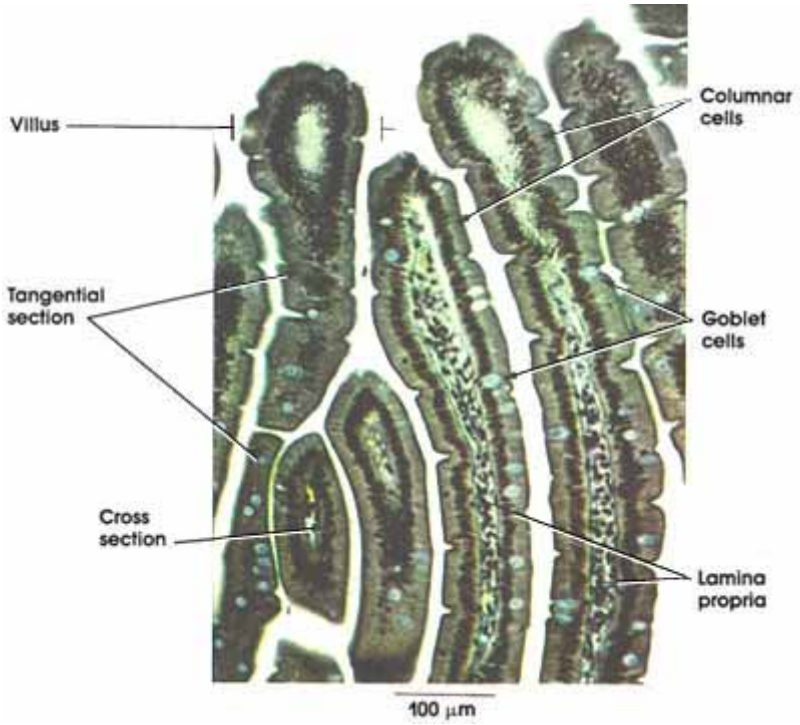
DUODENUM
Villi



Helly's fluid, Mallory's stain, 162 x.

Finger-like projections of the mucosa into the intestinal lumen characterize the small intestine. Note the simple columnar absorptive epithelial covering with basally located nuclei and the delicate basement membrane. Interspersed among the columnar absorptive cells are goblet cells, which are unicellular mucous glands. The core of each villus is composed of loose, delicate connective tissue (lamina propria).

Plate 10.199 Jejunum: Cross Section

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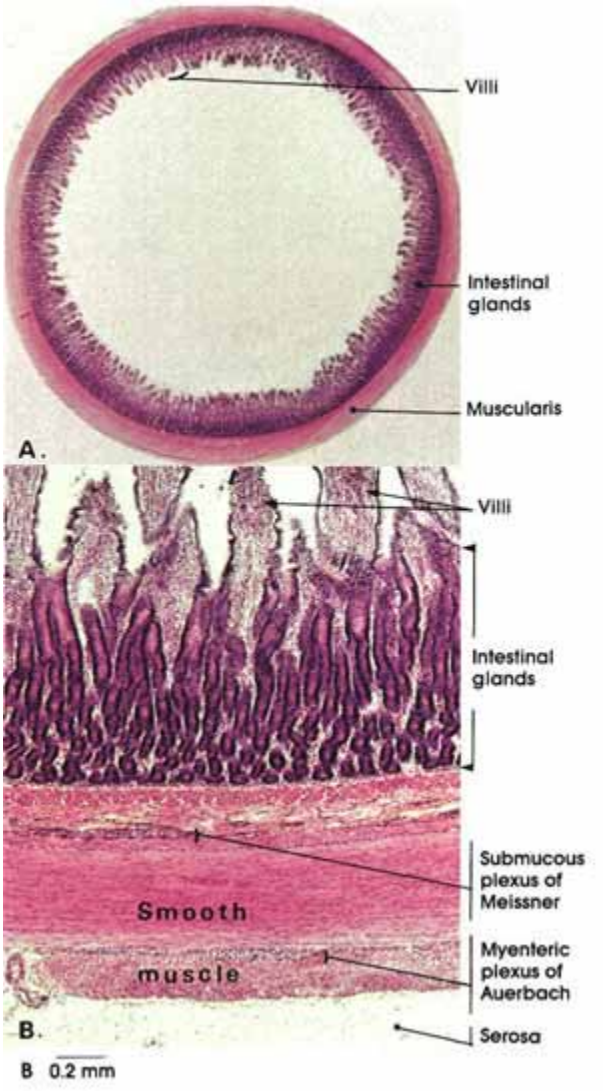
JEJUNUM
Cross section



Cat, 10% formalin, H. & E., A. 3.8 x.; B. 40 x.

A, Low magnification plate of a cross section of the jejunum. Note the prominent finger-like villi projecting into the lumen and the darker intestinal glands beneath them. The prominent muscularis is seen outside the intestinal glands.

B, Higher magnification, showing some details of the structure of the jejunal wall. Each villus is covered by simple columnar epithelium; the connective tissue composing its core also fills spaces between intestinal glands. Note that the epithelium covering the villi continues into the intestinal glands. New cells are formed in the depth of these glands and migrate upward to the surface of the villi.

Note the plexus of Meissner in the submucosa and the myenteric plexus of Auerbach between the two layers of the muscularis. These plexuses contain autonomic ganglia that receive preganglionic parasympathetic fibers from the vagus nerve and sacral outflow. Postganglionic fibers pass to the muscles and vessels of the gut wall and stimulate

muscular contraction and intestinal secretion. The two layers of the muscularis (inner circular and outer longitudinal) are well defined. The serosa is a connective tissue sheath on the outside of the intestinal wall, covered by mesothelial cells.

Plate 10.201 Jejunum

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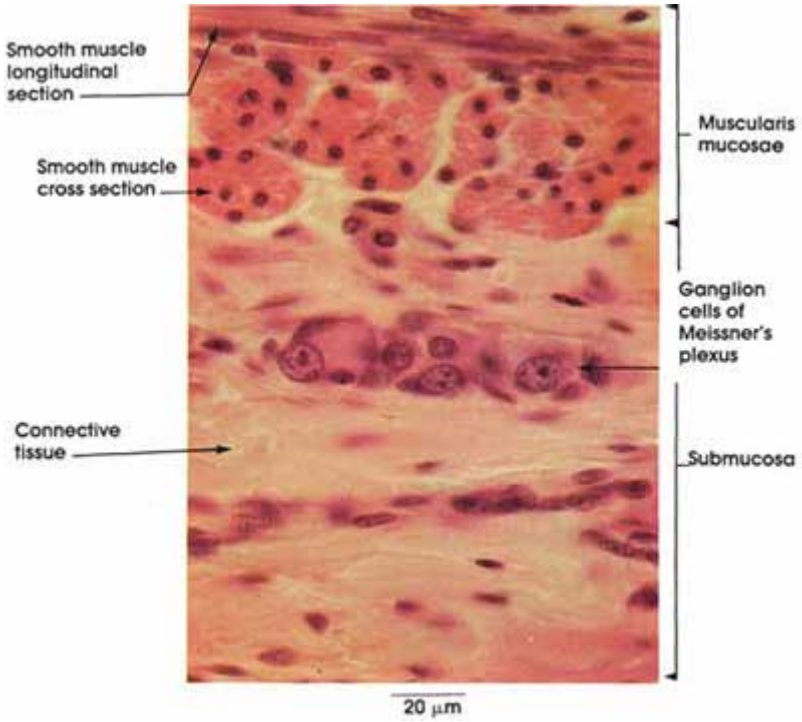
JEJUNUM
Muscularis mucosae submucosal plexus of Meissner



Cat, 10% formalin, H. & E., 612 x

This is a section of part of the wall of the jejunum showing the muscularis mucosae and submucosae. In the muscularis mucosae, note the two layers of smooth muscle: inner circular and outer longitudinal. The submucosa is composed of loose connective tissue and contains the ganglion cells of Meissner's plexus. These cells receive preganglionic parasympathetic vagal fibers. Postganglionic parasympathetic fibers pass to the muscles of the gut wall and glands. They excite muscular (peristaltic) activity and intestinal secretion. Sympathetic postganglionic nerve fibers, which are also present, inhibit these functions.

Plate 10.200 Jejunum

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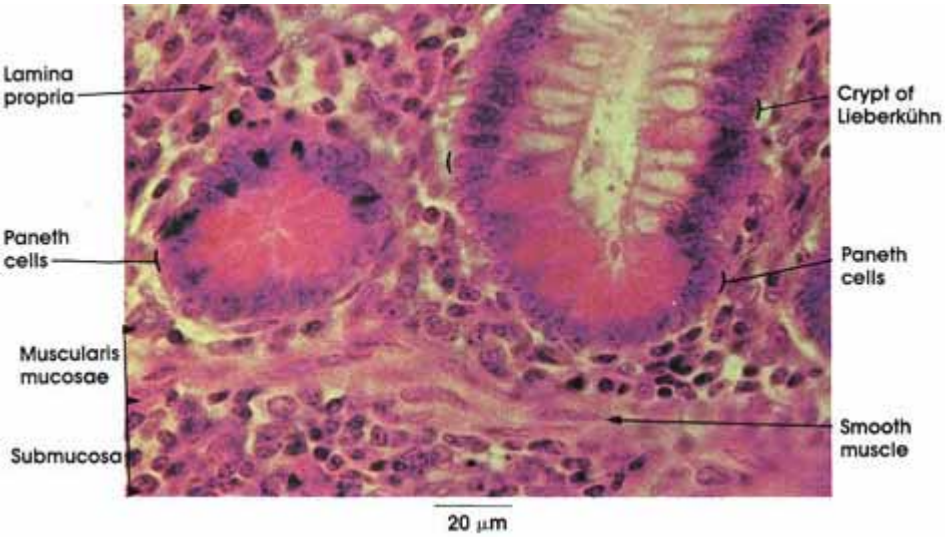
JEJUNUM



Human, 10% formalin, H. & E., 612 x.

Crypt of Lieberkühn*: Simple tubular intestinal glands in the mucosa that extend through the lamina propria to the level of the muscularis mucosa. The simple columnar epithelium of these glands is continuous with the surface epithelium lining the villi. Undifferentiated epithelial cells of the crypts give rise to the surface epithelial cells covering the villi. In addition to goblet cells, Paneth cells are found in the crypts. The latter contain coarse acidophilic granules that probably represent zymogen. See Plate 197. These cells are located in the depth of the crypt.

Smooth muscle: Circularly arranged in the muscularis mucosae.

Lamina propria: Connective tissue stroma filling the spaces between the crypts. Also see Plates 29 and 198.

Submucosa: Connective tissue coat, containing an abundance of lymphocytes.

*Lieberkühn was an eighteenth-century German anatomist

Plate 10.202 Ileum

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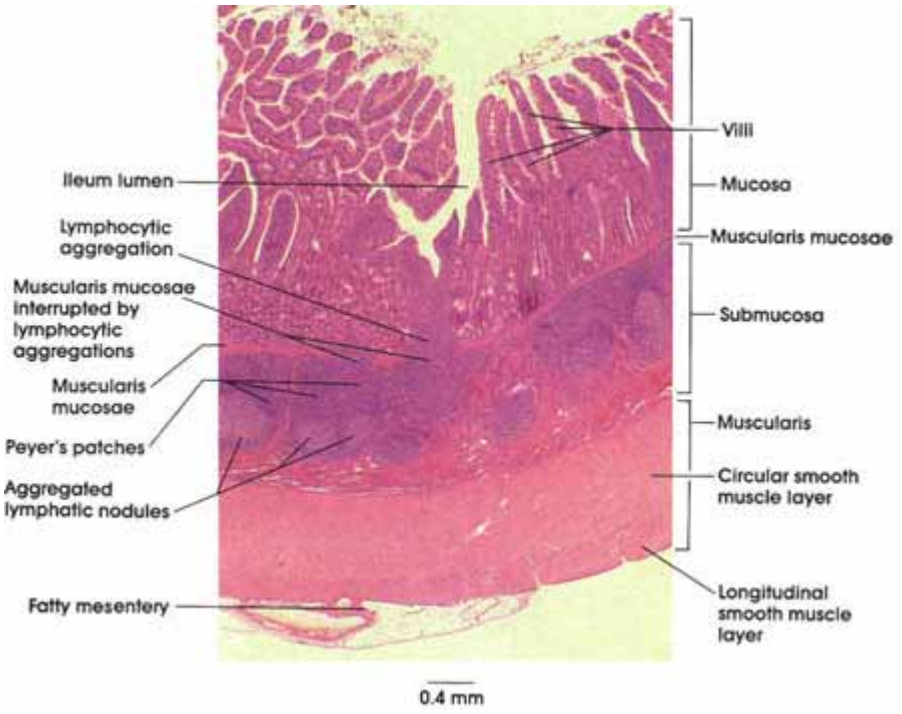
ILEUM
Peyer's patches



Human, 10% formalin, H. & E., 20 x.

The ileum is the distal segment of the small intestine and differs from the other two segments in several ways. The duodenum is characterized by submucosal (Brunner's*) glands, which are absent from the jejunum and ileum. The jejunum may or may not have any submucosal lymphocytic aggregations. The submucosa of the ileum, however, normally does have aggregated lymphocytic nodules (Peyer's* patches) as well as extensive lymphocytic infiltration of the lamina propria. As a further comparison, the epithelial lining and submucosae of the different segments of the small intestine show a progressive increase in the number of goblet (mucous) cells and lymphatic tissue aggregates from duodenum to ileum.

*Both Brunner and Peyer were seventeenth-century Swiss anatomists.

Plate 10.215 Liver

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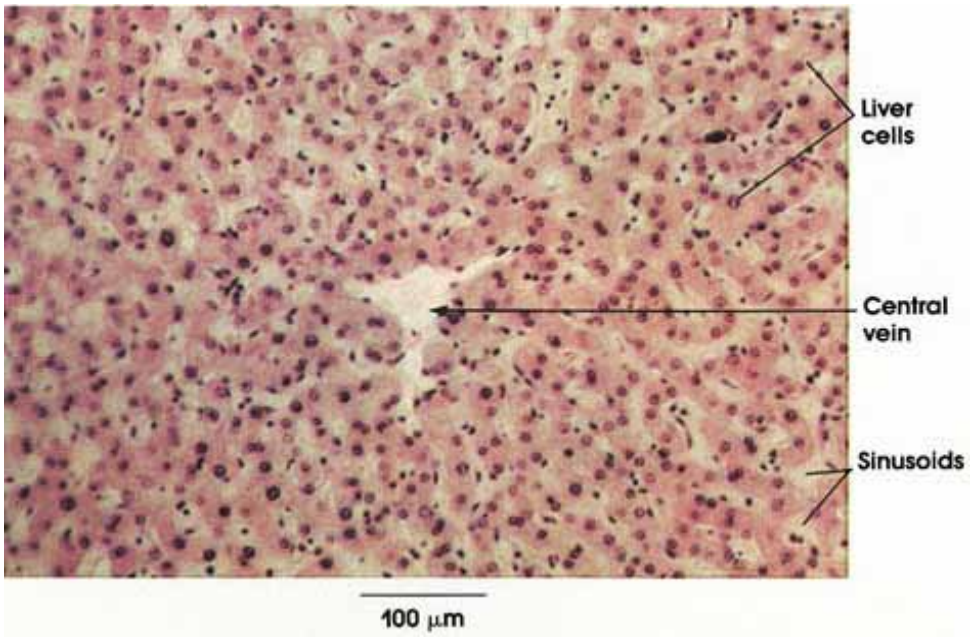
LIVER



Human, 10% formalin, H. & E., 162 x.

The liver is essential to life, and, although it is the largest gland in the body, only a fraction of its total mass is required. The liver can be considered both an exocrine gland, secreting bile via a system of bile ducts into the duodenum, and an endocrine gland, synthesizing and releasing a variety of organic compounds into the blood stream. The importance of the liver can be appreciated by considering the blood supply to the organ. The liver receives blood directly from the digestive tract, which is rich in absorbed carbohydrates, amino acids, salts, and vitamins; from the pancreas, containing the hormones insulin and glucagon; and from the spleen, breakdown products of red blood cell destruction. The liver metabolizes digestion products, synthesizes other substances for use or storage elsewhere, stores glycogen and fat, maintains blood glucose levels, synthesizes blood proteins, degrades or detoxifies harmful substances and eliminates them in the bile, and secretes bile, which plays an important role in the digestive process.

Liver cells: Polyhedral cells with a round central nucleus. Arranged in cords and plates radiating in a spoke-like manner from the central vein.

Central vein: Forms the axis of the hepatic lobule. Receives blood from the hepatic sinusoids and drains into intercalated (sublobular) veins.

Sinusoids: Form an extensive fenestrated system of vascular channels that radiate from the central vein. Lined with endothelial cells and Kupffer phagocytic cells. Receive blood from the interlobular branches of the portal vein and hepatic artery at the periphery of the lobule. Blood flows toward the center of the lobule and is drained by the central vein.

Plate 10.216 Liver

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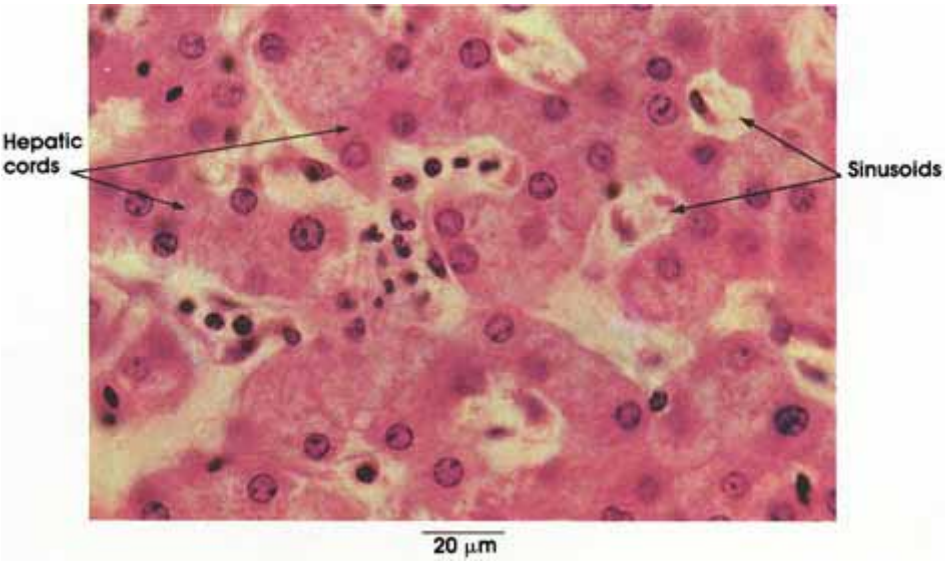
LIVER



Human, 10% formalin, H. & E., 612 x.

Plate 10.220 Gallbladder

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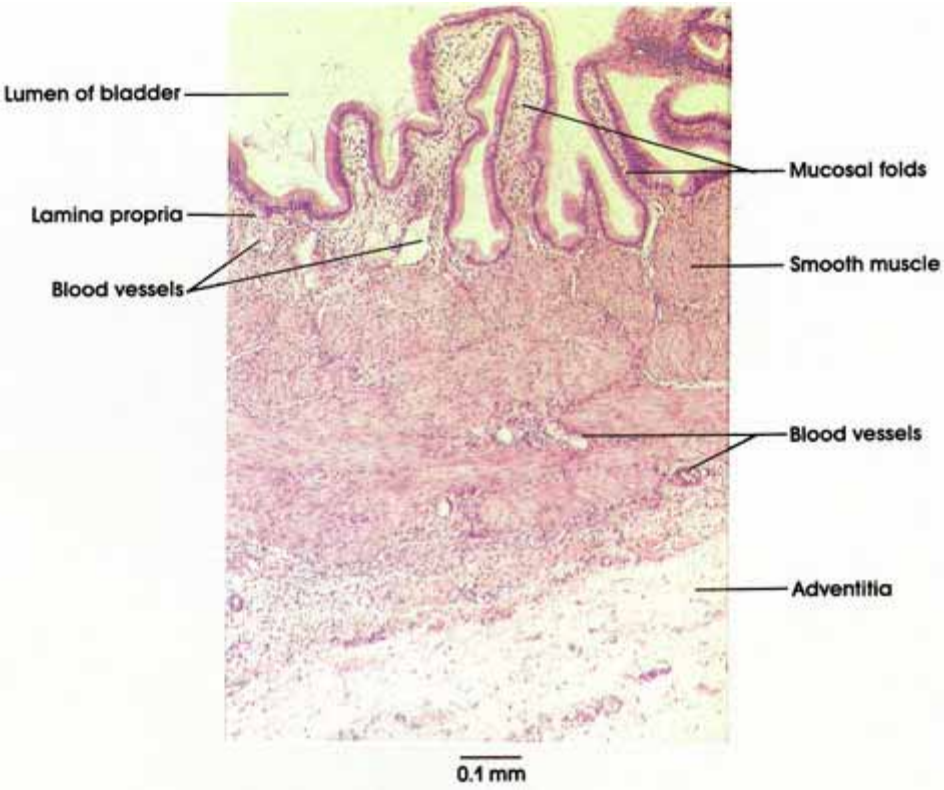
GALLBLADDER



Human, 10% formalin, H. & E., 87 x.

The wall of the gallbladder consists of the following layers; (1) a mucosa composed of simple columnar epithelium, (2) a typical and unremarkable lamina propria, (3) a layer of smooth muscle, (4) an outer connective tissue layer, and (5) a typical serosa (where the free surface of the gallbladder contacts the peritoneum; otherwise, it is an adventitia).

Note the abundant folds of the mucosa, suggesting that the organ was empty and contracted when fixed for study, and the epithelium, which is a typical absorbing epithelium with microvilli but with the added ability to secrete small amounts of mucus.

The lamina propria contains loose connective tissue and small blood vessels.

The muscularis is relatively thin when the bladder is filled with bile but appears thick in this illustration because it is contracted. The smooth muscle is orientated circumferentially.

The main function of the gallbladder is to store and concentrate bile (by reabsorbing water) through what is called sodium pump activity.

Gallbladder contraction is induced by the hormone cholecystokinin, which is produced by enteroendocrine cells (so-called, I cells) located in the mucosal epithelium of the jejunurn and ileum. The secretion of cholecystokinin is initiated by dietary fats. A listing of these

remarkable and uncommon cell types is given in the introductory material at the beginning of this section.

Plate 10.219 Liver: Phagocytic Kupffer Cells

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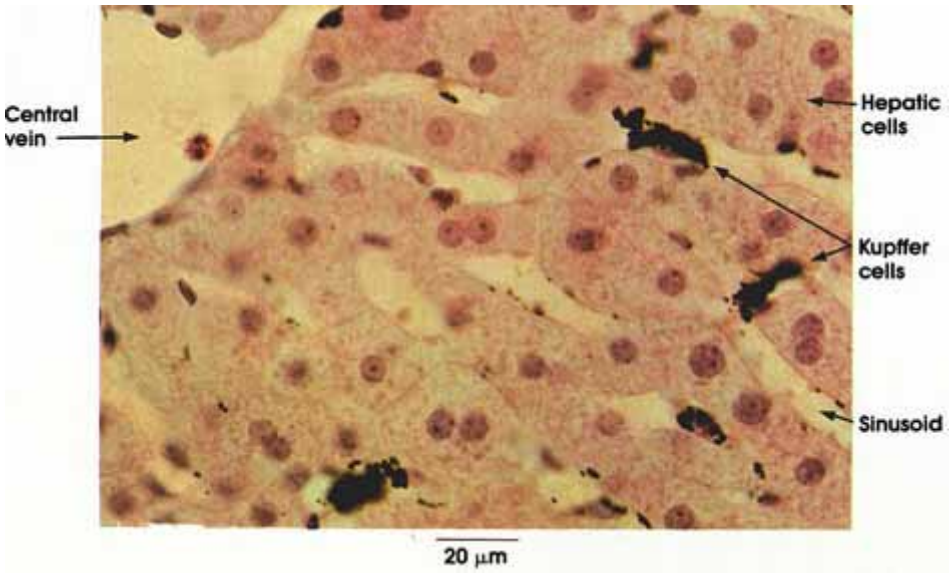
LIVER
Phagocytic Kupffer cells



Rabbit, 10% formalin, H. & E., 612 x.

Hepatic cells: Arranged in cords. Note the binucleate hepatic cells.

Central vein: In the center of the lobule. Receives blood from the sinusoids.

Kupffer cells: Reticuloendothelial cells in the walls of the sinusoids of the liver were described by Kupffer, a German anatomist, in 1876. His observations led to a better understanding of the so-called reticuloendothelial (macrophage) system. The Kupffer cells belong to the group of mixed macrophages. They act to clear the blood of foreign particles, aging and damaged red blood cells, and other cellular debris. They are also said to play a role in fat metabolism, conservation of iron, and in the formation of bile pigment. These cells are prominent because they have ingested colloidal gold.

Plate 10.217 Bile Canaliculi

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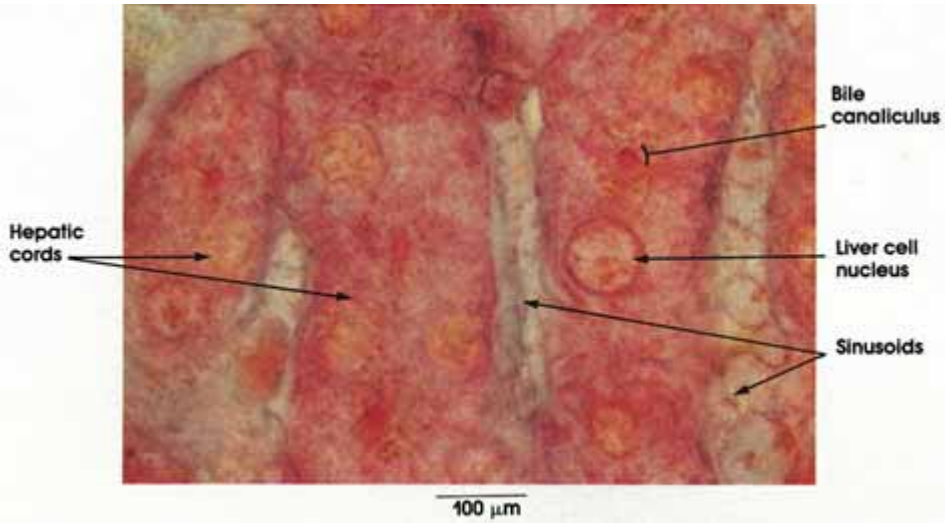
BILE CANALICULI
Liver cells



Human, Zenker's fluid, Mallory's stain, 1416 x.

Liver cell nucleus: Large and centrally placed.

Bile canaliculi: Seen in cross section, these are channels between rows of cells within hepatic cords. Bile flows toward the periphery of the lobule to enter the system of bile ducts and gallbladder.

Plate 10.218 Liver: Bile Canaliculi

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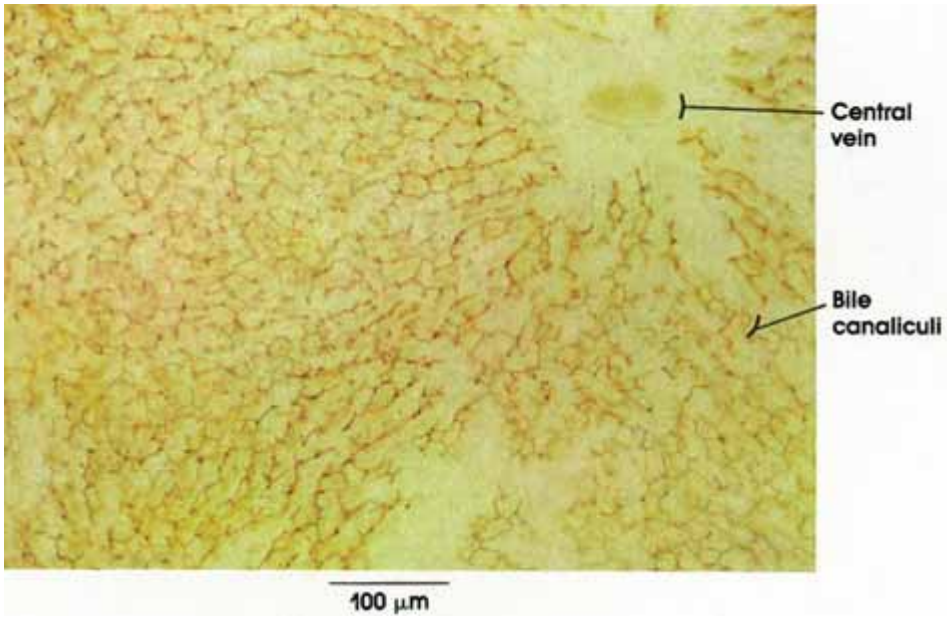
LIVER
Bile canaliculi



Rabbit, Golgi method, rapid process, 162 x.

Bile is secreted by the hepatic cells and is composed of water, bile salts, bile pigments, cholesterol, lecithin, fat, and inorganic salts. Bile secreted into the duodenum produces an acceleration in the action of pancreatic and intestinal lipases and facilitates the absorption of fats from the intestine. Bile salts are absorbed during digestion and returned to the liver for reutilization. It is believed that the bile salts are secreted twice during the digestion of a single meal (enterohepatic circulation).

Plate 10.213 Pancreas

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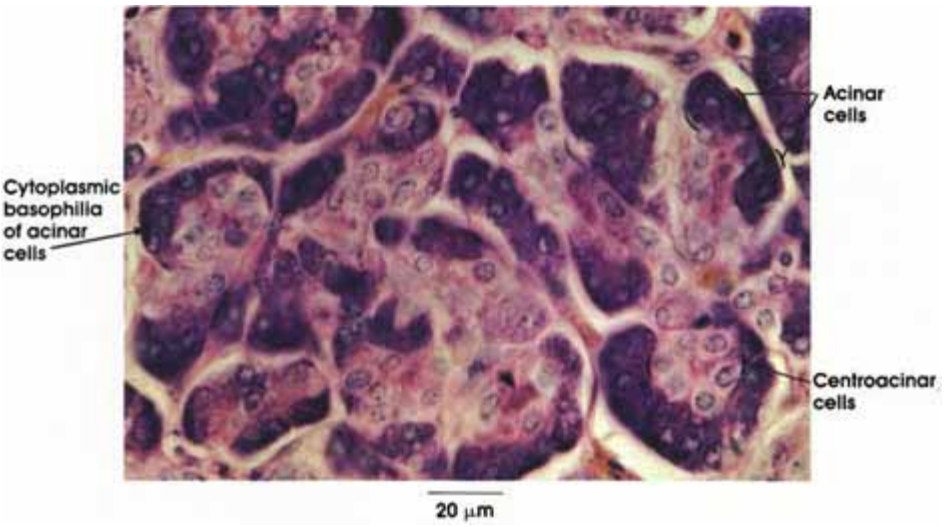
PANCREAS
Acinar and centroacinar cells



Human, 10% formalin, toluidine blue and eosin stains, 612 x.

Acinar cells: Cells forming the alveoli or acini of the pancreas. Pyramid-shaped cells arranged around a central lumen. Alveoli are packed close together with intervening delicate connective tissue. Cytoplasm of individual acinar cells is densely basophiiic, and the nucleus is spherical and basally located. The cytoplasmic basophilia (RNA) is a reflection of the specialization of these cells for protein synthesis and secretion of zymogen.

Centroacinar cells: Belong to the duct system. Smaller than the surrounding acinar cells. Centroacinar cells stain lighter than acinar cells and are squamous to cuboidal. Centroacinar cells occur only in the pancreas.

Plate 10.207 Colon

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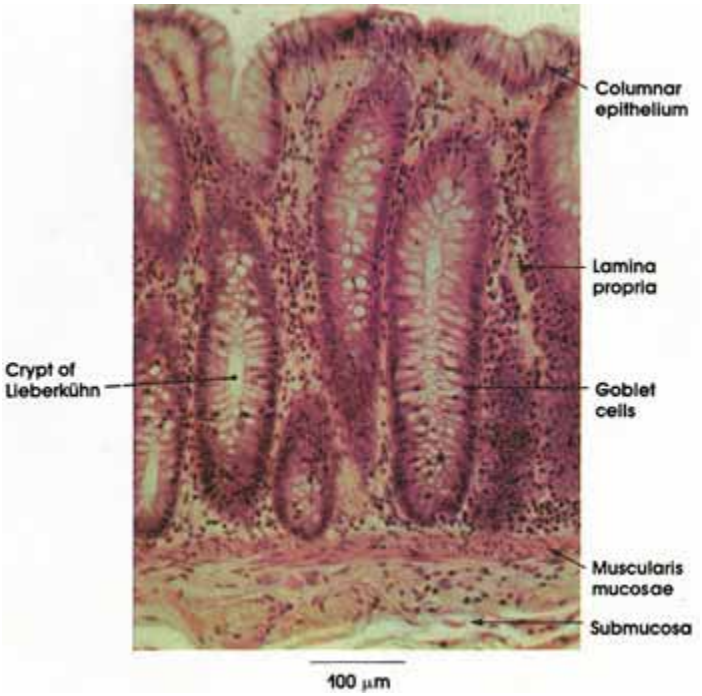
Peer Review Status: Externally Peer Reviewed

COLON



Human, 10% formalin, H. & E., 162 x.

Columnar epithelium: Tall columnar epithelium lines the absorbing surface of the colon. Goblet cells are interspersed among the columnar absorbing cells. These columnar cells are primarily concerned with the absorption of water and possibly other substances (e.g., vitamins) from the colon.

Goblet cells: Interspersed among the superficial columnar cells. They are very numerous in the depth of the crypts. Produce the copious mucus needed in the colon to facilitate passage of dehydrated undigested materials through the digestive tract.

Lamina propria: Connective tissue (rich in plasma cells, lymphocytes, eosinophils, and other cells) located between glands.

Muscularis mucosae: Note the two layers of smooth muscle (inner circular and outer longitudinal).

Submucosa: Loose connective tissue stroma containing vessels and nerves.

Crypts of Lieberkühn: The name of the simple tubular glands opening into the intestine. They were described by Johann Lieberkühn in a memoir on the small intestine published at Leyden in 1745. Although named after him, they were first noted by Malpighi in 1688.

Plate 10.208 Rectum and Anal Canal

Ronald A. Bergman, Ph.D., Adel K. Afifi, M.D., Paul M. Heidger, Jr., Ph.D.
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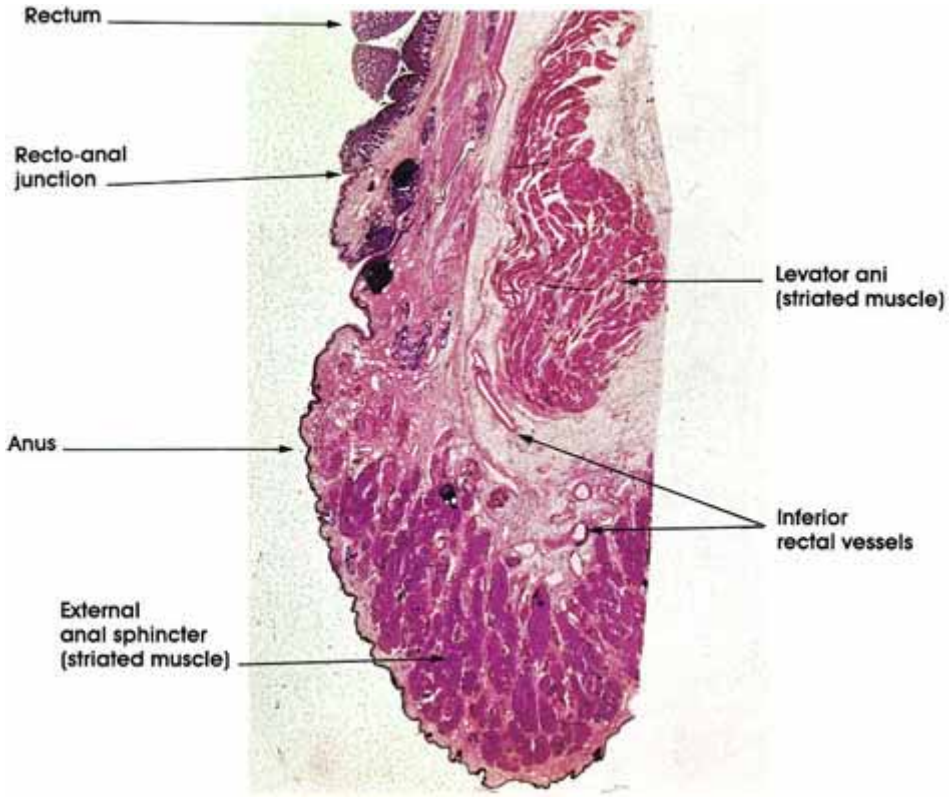
RECTUM AND ANAL CANAL



Cat, 10% formalin, H. & E., 5.4 x.

This plate shows the changes that take place at the recto-anal junction. Note the transition in the type of epithelium from the simple columnar of the rectum to a stratified epithelium in the anal canal. The non- keratinized stratified squamous epithelium of the anal canal changes into epidermis at the anal orifice. The external anal sphincter surrounds the whole length of the anal canal and keeps the anal canal and anus closed. During defecation, the sphincter is relaxed. Note the levator ani muscle at the recto-anal junction. This striated muscle fuses with the longitudinal smooth muscle coat of the rectum. Inferior rectal vessels supply the muscles and skin of the anal region.

Plate 10.190 Stomach: Fundus

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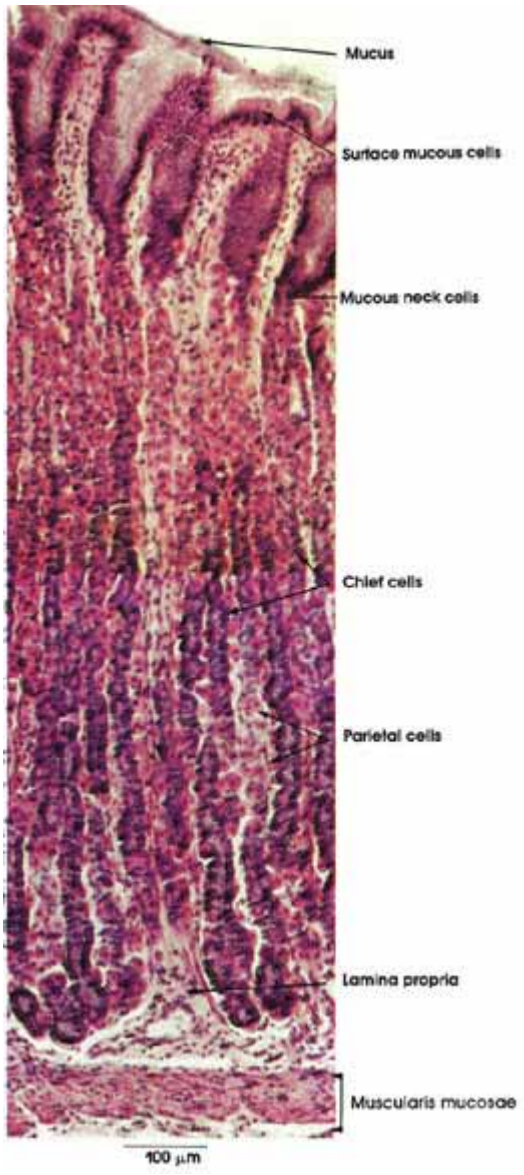
STOMACH
Fundus



Dog, 10% formalin, H. & E., 162 x.

Although this figure is labeled fundus, it shows the characteristic glands found in most of the wall of the stomach. The term *fundic* as applied to this type of gland is a misnomer, since it is not limited to the fundus of the stomach but is found throughout most of the stomach wall except the cardiac and pyloric ends. Another term applied to these glands is gastric. The fundic or gastric glands are simple (sometimes slightly branched), long tubular glands that extend throughout the mucosa down to the muscularis mucosae. Note the secreted mucus covering the surface of the epithelium and the surface mucous cells with their characteristic basal nuclei and clear cytoplasm. Fundic or gastric glands contain chief and parietal cells, as well as mucus-secreting cells of the narrow neck

region known as mucous neck cells. The former are the more abundant and have basally located nuclei and basophilic cytoplasm. They secrete pepsinogen. The parietal cells are larger and less abundant than the chief cells among which they are scattered. Their cytoplasm is eosinophilic and nuclei are centrally placed. They secrete HCl and, in humans, intrinsic or antipernicious anemia factor that binds and enhances the absorption of vitamin B_{12} by the ileum.

The lamina propria is scanty and fills in the narrow spaces between glands. The muscularis mucosae is thin and arranged in layers. Delicate muscular strands extend between glands.

Plate 10.191 Stomach: Chief and Parietal Cells

Ronald A. Bergman, Ph.D., Adel K. Afifi, M.D., Paul M. Heidger, Jr., Ph.D.
Peer Review Status: Externally Peer Reviewed

STOMACH
Chief and parietal cells

Rhesus monkey,
glutaraldehyde-osmium fixation,
toluidine blue stain, 1416 x.

Chief cells: Most numerous of gastric gland cells. Cuboidal or pyramidal in shape. Nucleus in basal half of the cell Rich in cytoplasmic ribonucleic acid. Synthesizes zymogen granules containing pepsinogen.

Parietal cells: Larger than chief cells, oval or polygonal in shape. Nuclei are spherical and centrally located. Cytoplasm is finely granular due to an abundance of mitochondria. Parietal cells secrete the hydrochloric acid of gastric juice and the antipernicious anemia factor.

Plate 10.188 Esophagus

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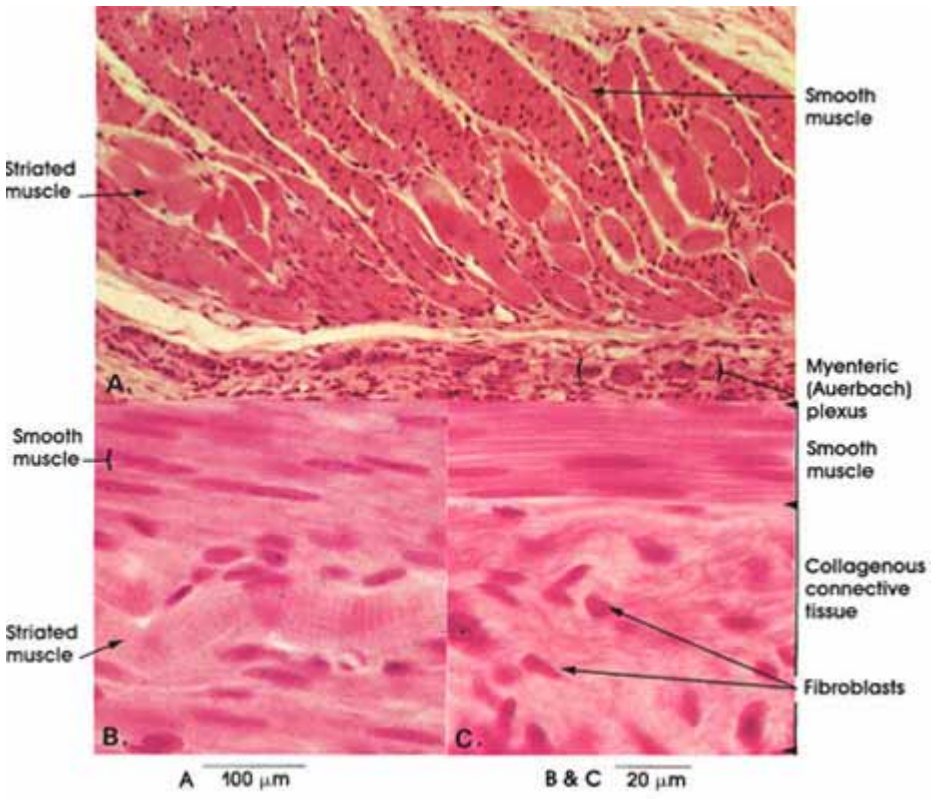
ESOPHAGUS
Muscularis externa



Dog, 10% formalin, H. & E., A. 162 x., B. & C. 612 x.

The external muscular coat of the esophagus is made up entirely of skeletal muscles in the upper third, of skeletal and smooth muscles in the middle third (A and B), and of purely smooth muscle in the lower third (C). Outside the muscle layer is a layer of collagenous connective tissue with fibroblasts, the adventitia (C) The orientation of

muscle fibers also varies. Typically, an inner circular and outer longitudinal layer exist, but many bundles are arranged obliquely or in a spiral fashion. Between the two layers of muscle is a nerve plexus associated with numerous small ganglia, the myenteric plexus of Auerbach (A). This is mainly a parasympathetic (vagus nerve) plexus along with some postganglionic sympathetic nerves. it is named after Leopold Auerbach, a German anatomist, who described it in 1862.

Plate 10.189 Esophagus-Stomach Junction

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ESOPHAGUS-STOMACH JUNCTION
Longitudinal section

Dog, Helly's fluid, H. & E., 162 x.

Stratified squamous epithelium: Non-keratinized, it lines the esophagus. Indented by connective tissue papillae.

Epithelial transition: From the stratified squamous epithelium of the esophagus to the columnar epithelium of the stomach. Note that the transition is abrupt and that only the basal cells of the esophagus continue into the stomach.

Columnar epithelium: Tall simple columnar with basal nuclei. Continuous with the basal layers of esophagus epithelium. These cells secrete protective mucus constantly.

Plate 10.205 Mucosa

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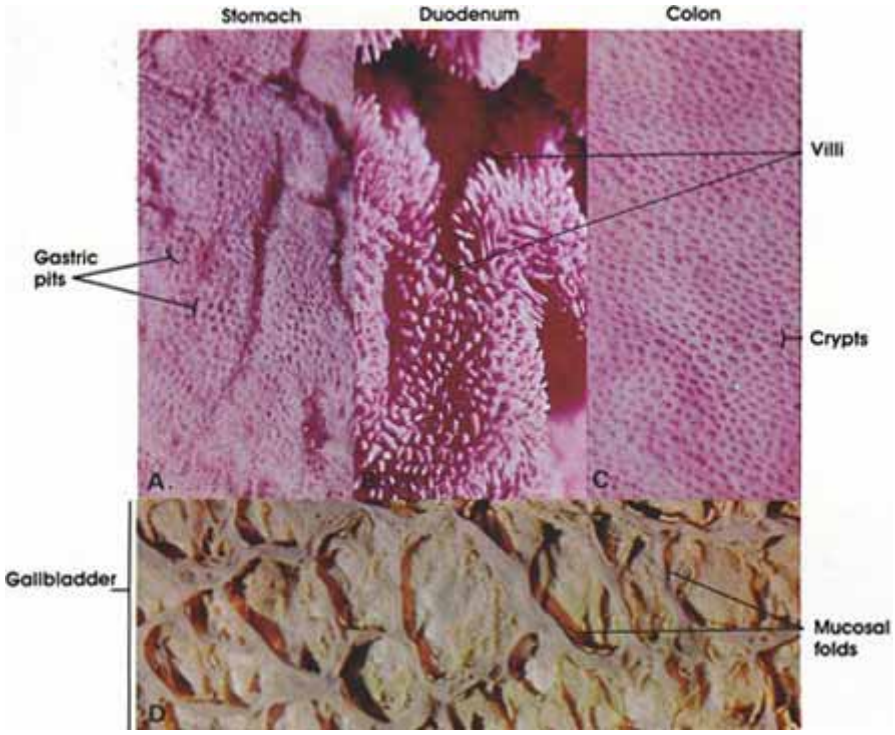
MUCOSA
Surface view



Human, 10% formalin, A., B., C., carmine stain, D., unstained, 10 x.

Striking differences in the surface of the mucosa of the stomach, duodenum, colon, and gallbladder are illustrated in this plate.

The mucosal surface of the stomach contains numerous cylindrical openings, the gastric pits. The cells lining the gastric pits secrete their products into the lumina of the gastric pits and the secretions flow onto the surface of the mucosa. In contrast, the surface of the intestinal mucosa is thrown into folds (the plicae circularis), with fingerlike projections, the intestinal villi, which characterize the small intestine. The villi and mucosal folds markedly increase the surface area of the absorptive and secreting surfaces of the small intestine. The surface of the colon (large intestine) lacks villi and is pitted like the stomach. Tubular glands (crypts of Lieberkühn) extend from the surface through the thickness of the mucosae. The mucosal surface of the gallbladder is also thrown into numerous folds, giving it a honeycomb appearance.

Plate 10.187 Ground Tooth

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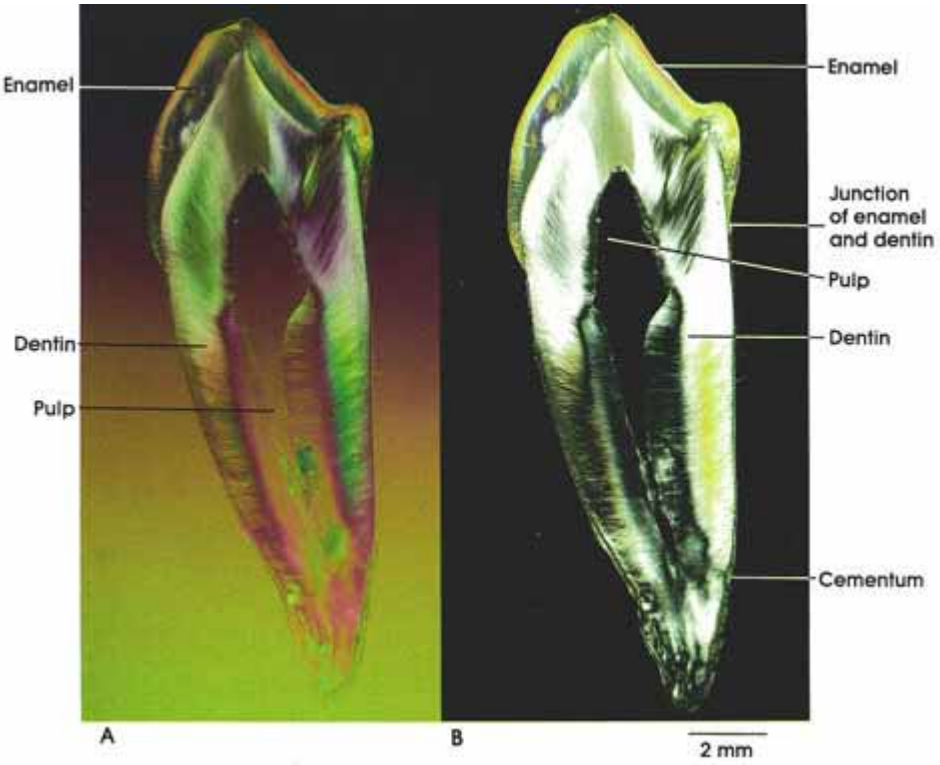
GROUND TOOTH



Human, ground nondecalcified, unstained, dark field, 6.0 x.

The striking refractility of a finely ground tooth is due to the highly ordered alignment of calcified collagenous connective tissue that forms the tooth. Both Figures A and B were photographed with cross- polarized light. The use of a 1/4 wave compensator plate was used in A to give the interference colors.

Thinly ground specimens such as this one were studied as early as 1678 by Leeuwenhoek.*

Plate 10.183 Developing Tooth

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DEVELOPING TOOTH

Cat, 10% formalin, H. & E., 50 x.

Internal enamel epithelium: A single layer of columnar cells, which become the enamel- producing ameloblasts.

External enamel epithelium: A single layer of cuboidal epithelium.

Enamel pulp: A collection of loosely arranged branching cells. Also called stellate reticulum.

Dental papilla: Proliferation and condensation of mesenchyme, which constitutes the primordium of the enamel pulp.

Dental follicle: It is also called the dental sac and is composed of mesenchyme surrounding the dental papilla and enamel organ. The part adjacent to the dental papilla forms the future periodontal membrane. Its peripheral part becomes the periosteum of the wall of the future alveolus.

Mandibular bone: In which the tooth is embedded.

Plate 10.209 Parotid Gland

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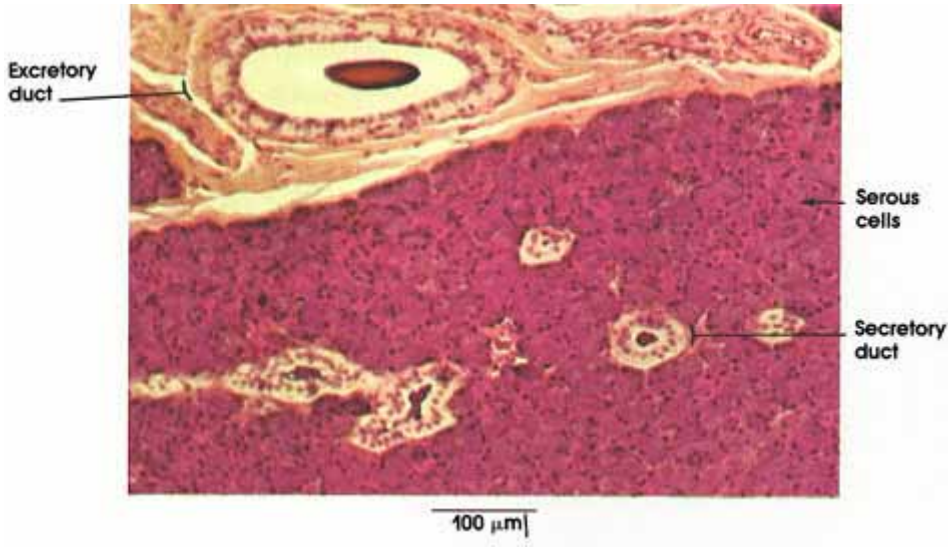
PAROTID GLAND



Human, 10% formalin, H. & E., 162 x.

Salivary secretion is essential to the swallowing process and for taste. In addition, the salivary secretion continuously rinses the oral cavity and is antimicrobial. Digestion begins in the mouth, where the food is mixed with saliva, and continues in the stomach, within the bolus of chewed and moistened food, until the acid gastric juices penetrate the bolus. The parotid gland produces about one fourth of the daily output of 1 liter of saliva. In man and dog, the watery secretion of parotid gland acini is modified by the striated ducts through the absorption of sodium and chloride, producing a saliva hypotonic with respect to blood. With increased flow of saliva, the reabsorption of these salts fails to keep pace, and the sodium concentration increases. The epithelium of the parotid ducts also excretes iodide into the saliva.

The secretion of salivary glands is dependent upon their innervation, and each major gland is supplied by both sympathetic and parasympathetic nerves. Although the specific role of the sympathetic innervation is still uncertain, it would appear that, under normal circumstances, the sympathetic fibers are inhibitory and parasympathetic stimulation is secretory.

Plate 10.186 Tooth (In Situ)

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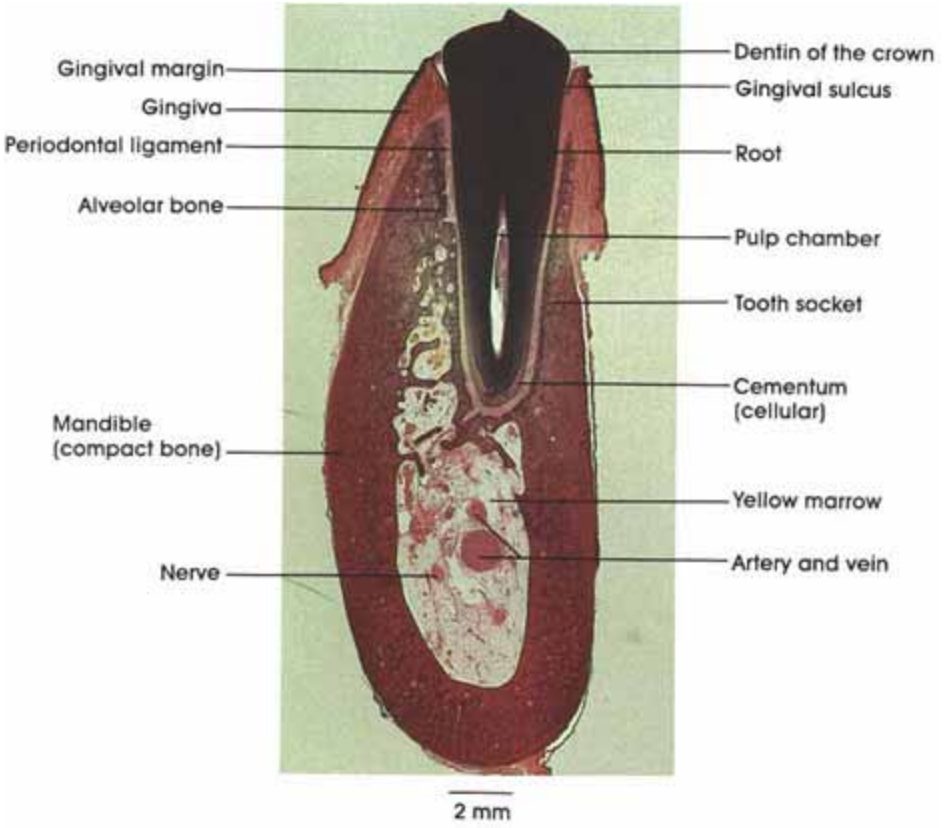
TOOTH (IN SITU)
Mandible



Cat, 10% formalin, decalcified, 4.6 x.

This in-situ decalcified tooth section illustrates many features of tooth structure. Realize that the enamel has been removed during the process of decalcification.

Note the crown (i.e., that part that projects above the gingiva) and root (i.e., that part located in the osseous alveolar socket).

Note the named parts of the gingiva: the superior free margin and the free gingival sulcus. The junctional epithelium of the gingiva ends by joining the cementurn and periodontal ligament. If the junction between the parts fails to remain sealed, infection of the periodontal tissues occurs (gingivitis), possibly leading to serious periodontal disease.

The alveolar bone (or tooth socket) functions as the insertion for periodontal ligament fibers, which join tooth to bone.

Human teeth never directly fuse with the alveolar bone, but rather, the tooth is suspended from the bone by the periodontal ligament.

Cementum, which forms the outer surface of the root, is composed of calcified collagenous fibrils, glycoproteins, and glycosaminoglycans.

Plate 10.212 Sublingual Gland

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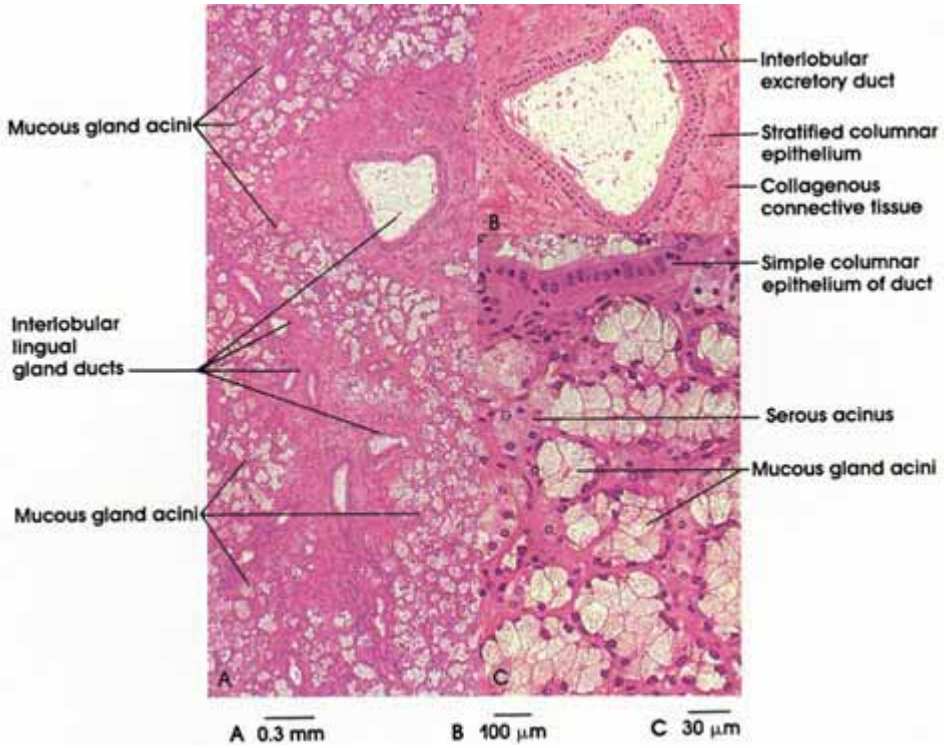
SUBLINGUAL GLAND



Rhesus monkey, glutaraidehyde fixation, H. & E.,
A. 28 x; B. 55 x; C. 222 x.

The sublingual gland is a branched tubuloacinar gland and is a mixed gland composed predominantly of mucous acini. The gland also contains a variable number of acini containing serous cells and serous demilunes in different parts of the gland. The mucous gland cell secretes viscid mucigen, which is rich in sulfated polysaccharide. The serous cells secrete a watery product rich in sulfated glycoproteins.

Note the large duct with its stratified columnar epithelium and other smaller ducts with a simple columnar epithelium.

Characteristically the mucous gland cells have a poorly staining apical cytoplasm, and the nuclei are heterochromatic and flattened against the basal cell membrane.

Plate 10.211 Submandibular Gland

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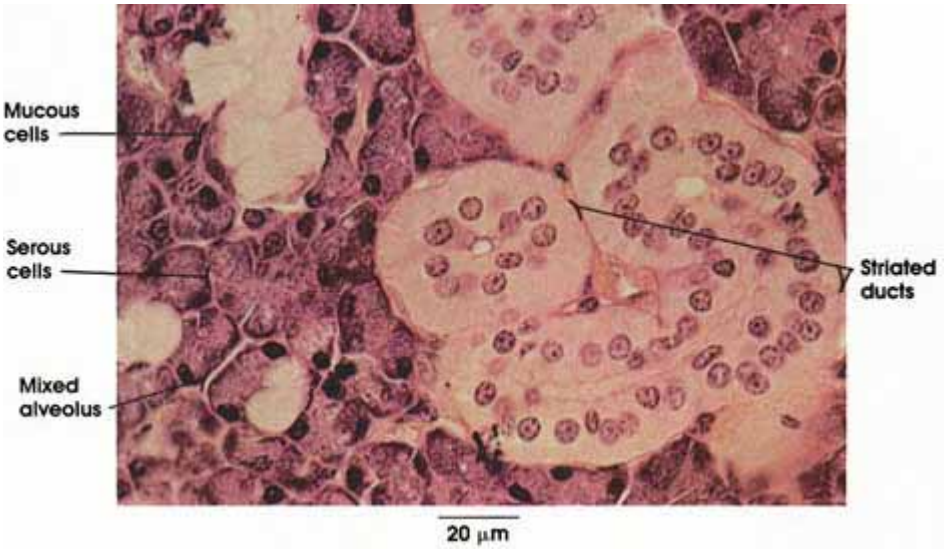
SUBMANDIBULAR GLAND
Striated ducts



Human, Zenker's fluid, H. & E., 612 x

Mucous cells: Nuclei flattened and pushed to the basal part of the cell by secretory droplets. Purely mucous alveoli are not frequent in human submandibular gland.

Serous cells: Pyramidal in shape, darkly staining, with indistinct cell boundaries. Nuclei are more rounded and are pushed to the base of the cell by secretory droplets (zymogen granules) in some cells.

Mixed alveolus: Made up of serous and mucous cells. In mixed alveoli, serous cells cap mucous alveoli (so-called demilune) or line terminal portions of mucous alveoli.

Striated ducts: So-called because of prominent basal striations. These ducts are long and very conspicuous in sections of the submandibular gland. Lined by columnar cells with apically placed nuclei. Electron microscopy reveals the striations to be invaginations of the basal plasma membrane, with rows of elongated mitochondria in the pockets thus formed. The striated ducts play a role in secretion and absorption of salts and thereby modify the composition of the saliva produced by the secretory cells. The secretory product enters the oral cavity near the frenulum of the tongue. The submandibular gland produces about two thirds of the daily output of 1 liter of saliva. The saliva from this gland is a viscid solution containing mucin, salts, and the enzyme amylase.

Plate 10.182 Lingual Glands

Ronald A. Bergman, Ph.D., Adel K. Afifi, M.D., Paul M. Heidger, Jr., Ph.D.
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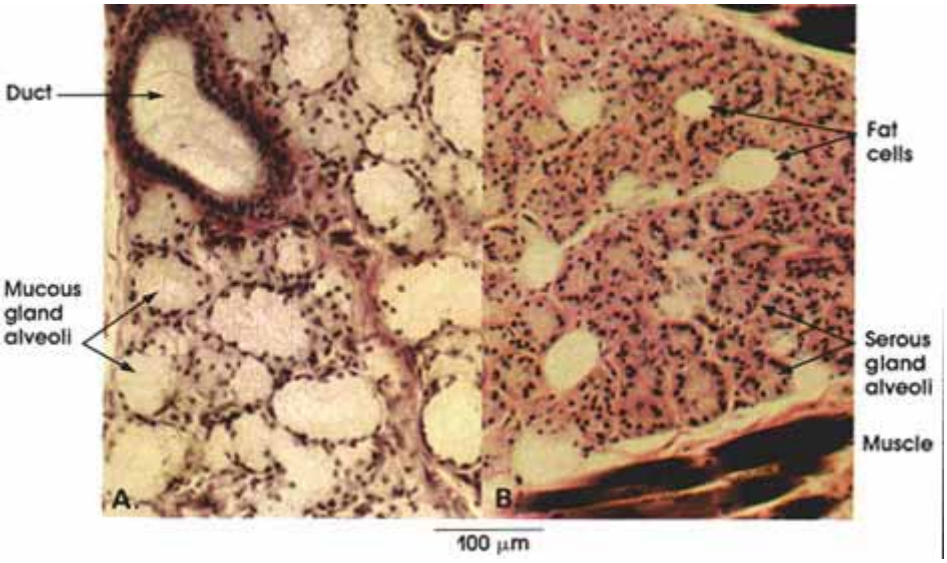
LINGUAL GLANDS
A. Mucous gland
B. Serous gland



Human, Zenker's fluid, iron hematoxylin and aldehyde fuchsin stains, 162 x.

The tongue has three groups of glands: serous, mucous, and mixed serous and mucous.

Mucous glands are interspersed between muscle bundles and serous glands. Their ducts terminate on the surface of the tongue. The mucous glands are most numerous in the root of the tongue. Their ducts open into the crypts of the lingual tonsil.

The serous glands (of von Ebner) are located in the region of the vallate papillae. They extend the muscle layer as shown in this figure. Ducts open into trenches of vallate papillae. Fat cells are scattered among the alveoli. The secretion of these glands moistens the epithelium and taste buds and flushes the trenches around the vallate papillae. These are important functions for taste discrimination.

Note the inferior alveolar nerve and blood vessels in the yellow (non-hematopoietic, fatty) bone marrow of the mandible.

Plate 10.178 Tongue

Ronald A. Bergman, Ph.D., Adel K. Afifi, M.D., Paul M. Heidger, Jr., Ph.D.
Peer Review Status: Externally Peer Reviewed

TONGUE
Fungiform and filiform papillae

Human, Zenker's fluid, phosphotungstic acid hematoxylin, 26 x.

Fungiform papillae: Mushroom-like. Larger but much less frequent than filiform papillae. Has a stratified squamous non-cornified epithelial covering and a highly vascularized connective tissue core giving it a red hue in the living state. Although not seen here, the epithelium may contain taste buds. Small secondary papillae are formed beneath the superficial epithelial cover of the primary connective tissue papillae.

Filiform papillae: Threadlike. Smaller and much more numerous than the fungiform variety. Epithelial lining is keratinized stratified squamous and is devoid of taste buds. Thin connective tissue core.

Nerve fibers: Thinly myelinated sensory fibers that arborize under the epithelium.

Fat cells: Part of the fatty (adipose) tissue underlying the lamina propria.

Collagenous connective tissue: A fibrofatty connective tissue, which forms a bed for glands and skeletal muscle fibers and serves to anchor them.

Serous gland acini: Mixed serous and mucous glands are scattered among the connective tissue and muscle fascicles in the anterior two thirds of the tongue close to its ventral surface. Their ducts open onto the ventral surface of the tongue.

Plate 10.177 Tongue

Ronald A. Bergman, Ph.D., Adel K. Afifi, M.D., Paul M. Heidger, Jr., Ph.D.
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TONGUE

Human, Zenker's fluid, phosphotungstic acid hematoxylin stain, 5.6 x.

The epithelium of the dorsal surface of the tongue has three types of papillae: fungiform, filiform, and circumvallate (vallate).

The tongue is innervated by four cranial nerves, the fifth or trigeminal, the seventh or facial, the ninth or glossopharyngeal, and the twelfth or hypoglossal. The trigeminal nerve supplies the anterior two thirds of the tongue and is concerned with general sensibility. The facial nerve serves the same region but is concerned with taste or gustatory sensibility. The posterior one third of the tongue is innervated by the glossopharyngeal nerve serving both general and gustatory sensibility. The hypoglossal nerve is the motor nerve supplying the striated (somatic) skeletal musculature of the tongue. General sensibility refers to touch, pressure, pain, temperature, sense of position, and movement. Taste or gustatory sense, smell, sight, hearing, and awareness of head position and movement are termed the special senses.

Fungiform papillae: These are few in number, scattered among the filiform papillae. Larger than the filiform papillae. Wider at the top than at the base, resembling a mushroom, hence their name. Epithelial covering may possess taste buds.

Filiform papillae: Threadlike papillae much more numerous and smaller than fungiform papillae. Each papilla is made up of a thin core of vascularized connective tissue covered by a cornified stratified squamous epithelium. They do not have taste buds.

Vallate papillae: Large, surrounded by moats. Stratified squamous non-cornified epithelium covers a connective tissue core and contains taste buds. The serous or

gustatory glands of von Ebner are closely associated with vallate papillae and empty into and flush the circumvallate groove.

Mucous gland: Pure mucous glands occur in the root and in the posterior part of the tongue. Their ducts open onto the dorsum of the tongue.

Striated muscle: The core of the tongue contains interlacing bundles of striated fibers that run in three planes: longitudinal, transverse, and vertical.

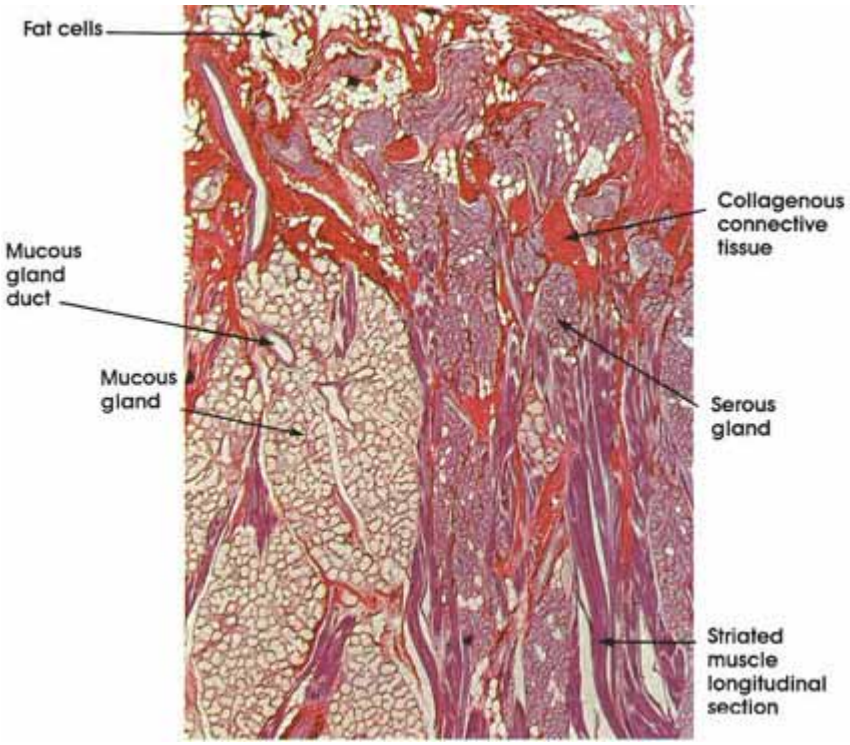
Fat cells: Part of the areolar fatty tissue in which muscles of the tongue are embedded.

Artifact: Spaces between muscle bundles are artifacts of fixation and/or embedding of the tissue prior to sectioning.

Plate 10.180 Tongue: Mucous and Serous Glands

Ronald A. Bergman, Ph.D., Adel K. Afifi, M.D., Paul M. Heidger, Jr., Ph.D.
Peer Review Status: Externally Peer Reviewed

TONGUE
Mucous and serous glands



Human, Zenker's fluid, phosphotungstic acid hematoxylin stain, 26 x.

Mixed serous and mucous glands (glands of Nuhn*) are found in the anterior two thirds of the inferior surface of the tongue. They are shown here intermixed with striated muscle fibers, collagenous connective tissue, and fat.

Fat cells: Appear empty because their lipid content has been lost in tissue preparation.

Collagenous connective tissue: Surrounds and supports the glands and encompasses muscle fibers to form fascicles.

Mucous glands: Embedded between muscle fascicles. Appear lightly stained.

Mucous gland ducts: Several are seen in this figure. They open primarily on the surface of the tongue.

Serous glands: Scattered among muscle fascicles. The cytoplasm stains more deeply here than in mucous glands.

Striated muscle longitudinal section: Interlacing muscle fibers of the tongue run in three directions: longitudinal, transverse, and vertical. The muscle fibers located between glands are inserted in the dense connective tissue beneath the surface epithelium.

*Nuhn was a nineteenth-century Heidelberg anatomist.

Plate 10.181 Foliate Papilla

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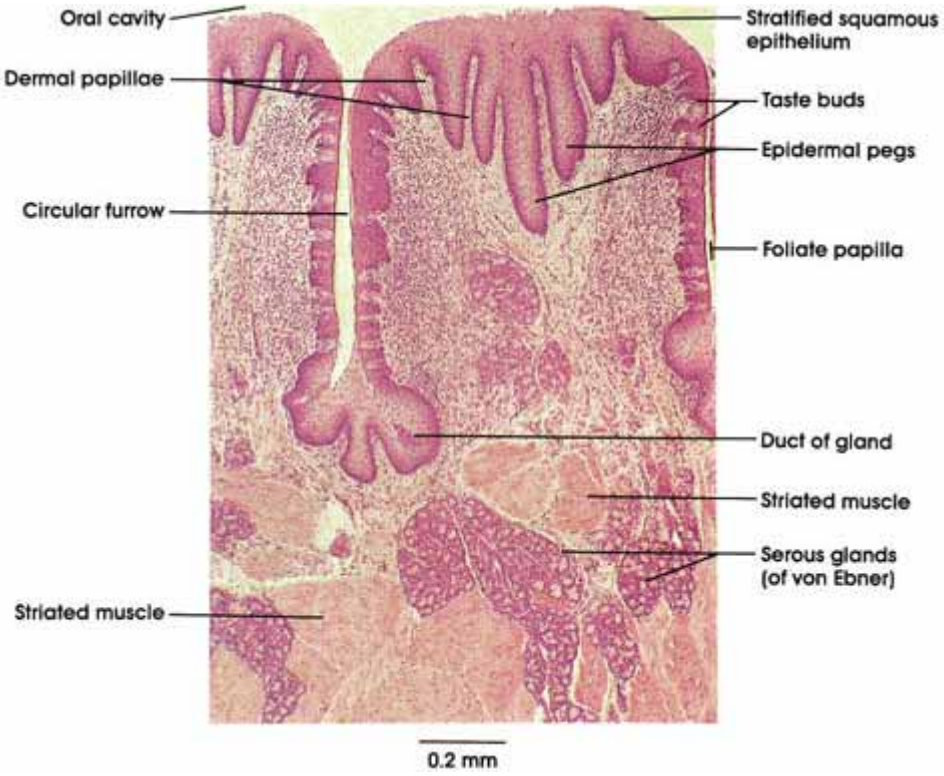
Peer Review Status: Externally Peer Reviewed

FOLIATE PAPILLA



Rabbit, 10% formalin, H. & E., 66 x.

Foliate papillae are not found in man and primates, but they are well developed in lagomorphs where they occur on the posterolateral sides of the tongue. Deep epidermal pegs of non-keratinized stratified squamous epithelium are frequently seen in this kind of papilla. The sides of the papilla are straight and contain numerous taste buds that open into the furrow surrounding the papilla. The serous glands of von Ebner* open into the base of the furrow to flush out taste provoking stimuli.

*von Ebner was a nineteenth-century Viennese histologist.

Plate 10.206 Vermiform Appendix

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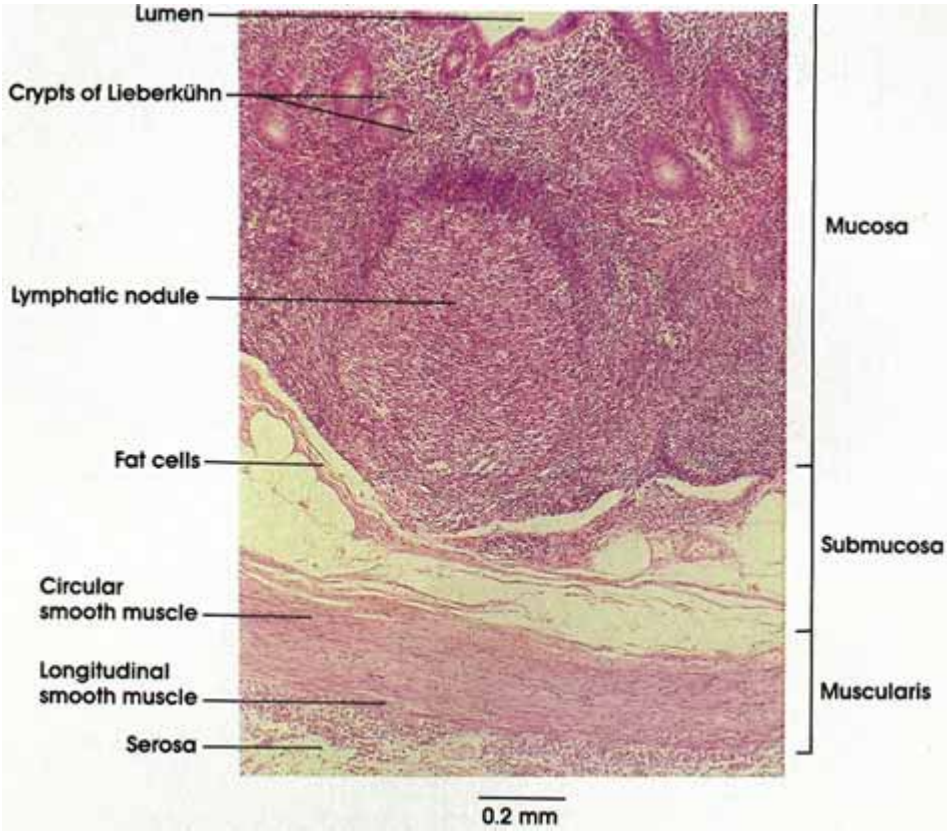
Peer Review Status: Externally Peer Reviewed

VERMIFORM APPENDIX



Human, 10% formalin, H. & E., 107 x.

The vermiform (worm-like) appendix extends from the cecum at the proximal end of the colon. The appendix has a structure similar to the colon except for the unusual longitudinal smooth muscle layer (taeniae coli, tapeworm of colon) of the latter, which terminates at the appendix and aids in its location when it is unusually placed.

The glands of the appendix are simple tubes, but they may fork. The glandular epithelium is rich in mucous cells and unicellular endocrine glands or enteroendocrine cells (EC). These cells are thought to secrete serotonin and substance P, which increase intestinal activity. The terms *argyrophil*, *argentaffin*, and *enterochromaffin* have been applied to these cells, which are rapidly gaining increased recognition for their importance to the function of the gastrointestinal system. See the introductory material at the beginning of this section for a listing of these cells. The surface epithelium is columnar with few mucous cells. Lymphatic nodules are abundant and intrusive and contain lymphatic nodules with germinal centers. See Plate 166, Lymphatic System. Both the nodules and massive lymphocytic infiltration are consipicuous histologic features that aid in the identification of this organ.

The lamina propria also characteristically contains fat cells.

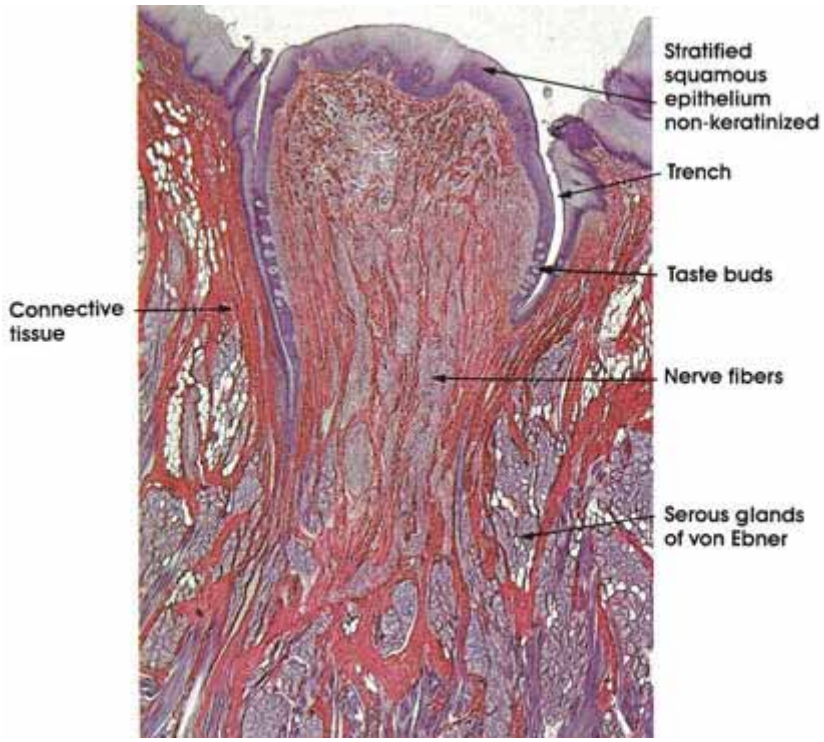
The lumen of the organ is frequently filled with intestinal debris.

The biological significance of the appendix is unknown.

Plate 10.179 Tongue: Vallate papilla

Ronald A. Bergman, Ph.D., Adel K. Afifi, M.D., Paul M. Heidger, Jr., Ph.D.
Peer Review Status: Externally Peer Reviewed

TONGUE
Vallate papilla



Human, Zenker's fluid, phosphotungstic acid hematoxylin stain, 26 x.

Vallate papillae line the V-shaped boundary between the anterior two thirds and posterior one third of the tongue. They are shaped like an inverted cone.

Stratified squamous epithelium: Covers the tongue surface and dips into the trenches between papillae.

Trench: A moat or groove that surrounds each vallate papilla.

Tastebuds: The organs of taste. Oval structures located in the lateral wall of vallate papillae and less frequently in the outer wall of the trench.

Nerve fibers: Myelinated nerve fibers, 1 to 6 μm in diameter, branch profusely within the papillae, lose their myelin, penetrate the basement membrane and form a plexus around the receptor cells of taste buds.

Serous glands of von Ebner: Limited to the posterior part of the tongue in the neighborhood of the vallate papillae. Ducts open into the circumvallate groove surrounding the vallate papillae.

Connective tissue: Forms the core of the papillae and supports the underlying glands. This connective tissue is rich in collagenous and elastic fibers.

von Ebner, 1842-1925, was a Viennese histologist.