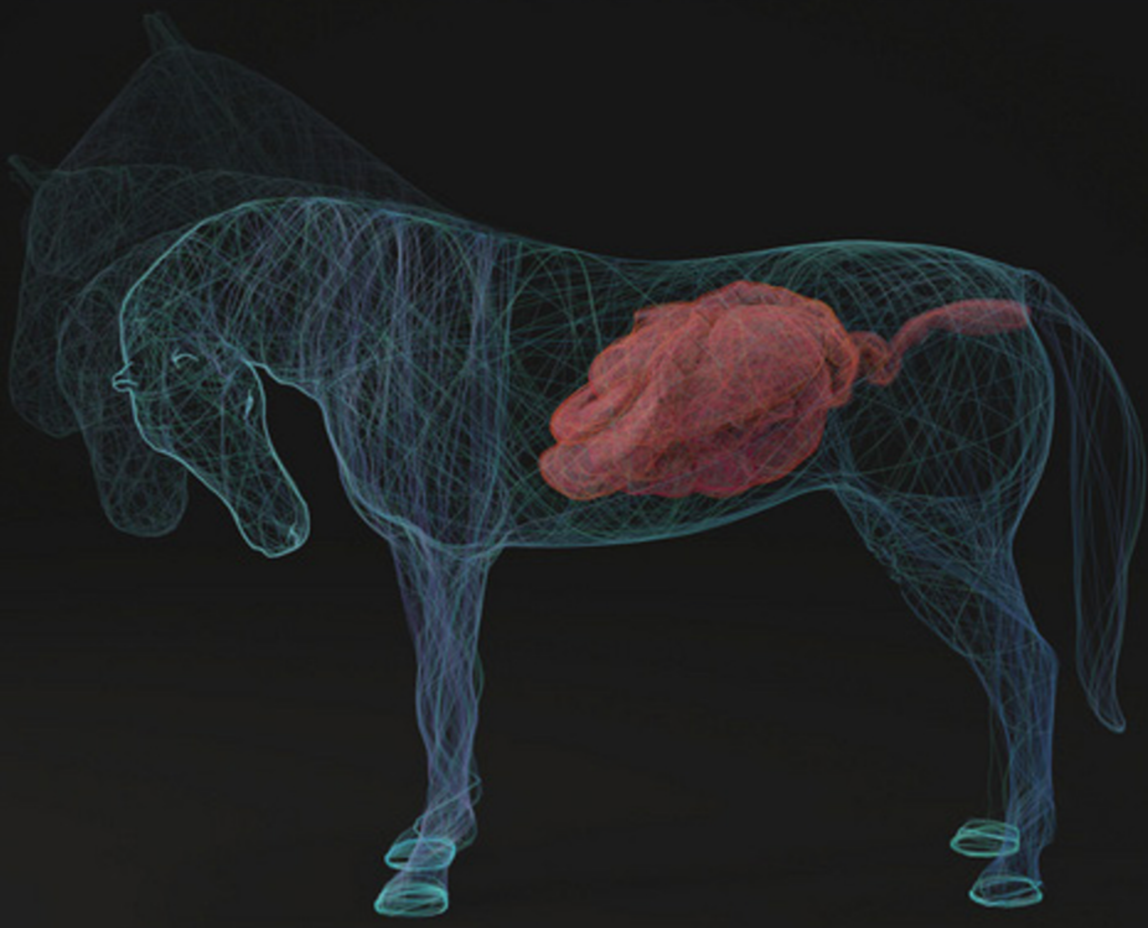
Third Edition

THE EQUINE ACUTE ABDOMEN

Edited by
Anthony T. Blikslager, Nathaniel A. White II, James N. Moore, and Tim S. Mair



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Preface

Colic is a clinical syndrome that has frustrated horse owners and veterinarians for centuries, and that remains the same today. In fact, colic continues to be at or near the top of the list of causes of death in horses. Advances made over the past three decades in recognition of colic as well as medical, anesthetic, and surgical techniques have significantly improved the prognosis for any horse presented with colic. For example, horses with even the most devastating forms of colic, such as large colon volvulus, can have an excellent prognosis for survival if they are treated early in the disease process.

This edition of *The Equine Acute Abdomen* details further advances in early recognition of colic, including recognition of pain using subtle behavioral signs, evaluation of biomarkers indicative of ensuing severe disease, advances in imaging the abdomen, and approaches to determining the prognosis. An area of equine practice that has changed the most since the previous edition of this book is critical care, with many hospitals now employing criticalists. Consequently, several chapters in this edition detail important advances in areas such as fluid therapy, nutrition, and the appropriate use of antimicrobial, anti-inflammatory, and prokinetic agents. There is also a comprehensive new section on colic in foals.

This edition of *The Equine Acute Abdomen* explores discoveries in exciting new areas related to colic, such as the role of intestinal stem cells and the microbiome. We expect that advances in these and other areas will likely have a vital role in our future understanding of the pathogenesis and consequences of colic. This edition additionally includes up-to-date information on the epidemiology, pathophysiology, and treatment of specific diseases that cause colic, as well as important topics that often receive less attention, such as colic in the donkey, grass sickness, and biosecurity.

Given the breadth of information covered in this edition, we hope that the reader will be better prepared to intervene when horses are presented with colic. It also is our hope that this edition will inform veterinarians about the latest advancements in critical care, introduce them to some of the current trends in equine colic research, and help them improve their ability to pre-empt or ameliorate colic.

Dedication

Dedicated to the horses we've learned from throughout our careers, including the ones we've treated on the clinic floor, worked with in the research laboratory, and partnered with to teach veterinary students.

About the Companion Website

This book is accompanied by a companion website:

www.wiley.com/go/blikslager/abdomen

The website includes:

- Animations
- Figures from the book as PowerPoint slides, to download

Part I

Normal Anatomy and Physiology

1

Gross and Microscopic Anatomy of the Equine Gastrointestinal Tract

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Introduction

Gaining a working knowledge of the equine gastrointestinal tract and associated intra-abdominal organs can be challenging, especially for inexperienced individuals. Experienced veterinarians who examine and treat horses with conditions characterized by acute abdominal pain (colic) know that the key to the diagnosis often lies in recognizing changes in anatomic structures or relationships among different organs. With this in mind, the focus of this chapter is the gross and microscopic structure of the horse's alimentary tract (Figure 1.1A, B, C, and D), starting with the esophagus. Because some conditions characterized by colic involve other organs within the abdomen, we have reviewed the relevant structural aspects of the liver, spleen, and pancreas. In compiling this information, our goal is to provide veterinary students and veterinarians with the foundational materials needed to understand clinical conditions that result in colic.

Esophagus

Gross Anatomic Features

The esophagus is the long muscular tube that connects the pharynx to the stomach. It is regionally subdivided into cervical, thoracic, and abdominal parts. Individual and breed variations exist, but in general the esophagus is positioned on the dorsal aspect of the trachea at the level of the 1st cervical vertebra, inclines to the left lateral surface of the trachea at the level of the 4th cervical vertebra, and is positioned ventrolateral to the trachea from the level of the 6th cervical vertebra up to and during passage through the thoracic inlet. The thoracic portion of the esophagus travels within the mediastinum and is positioned dorsal to the trachea to the level of the tracheal bifurcation. The esophagus passes dorsal to the base of the heart and continues caudally until it penetrates the diaphragm at the esophageal hiatus, accompanied by the dorsal and ventral vagal trunks. The abdominal portion of the esophagus is short and travels over the dorsal border of the liver, creating an esophageal impression, before joining the cardia of the stomach at an acute angle.

The esophagus is more superficial and therefore more accessible for surgery in the mid- to caudal-third of the left side of the neck ventromedial to the jugular groove. Deep cervical fascia ensheathes the esophagus as it passes along the neck and also forms the left carotid sheath enclosing the left common carotid artery, the left vagosympathetic trunk, and the left internal jugular vein (when present). These structures, along with the neighboring left recurrent laryngeal nerve and the left tracheal lymphatic trunk (embedded within the deep cervical fascia that ensheathes the trachea), are to be avoided during surgical approaches to the esophagus.

Microscopic Features

The esophagus is designed to facilitate the delivery of ingesta to the stomach. Longitudinally oriented folds occur along the length of the mucosa of the esophagus to allow for expansion of its lumen during the passage of a food bolus. The mucosa of the esophagus is considerably mobile upon the underlying submucosa. The tunica mucosa is composed of three layers, or laminae (Figure 1.2). The lamina epithelialis is nonkeratinized stratified squamous epithelium (Figure 1.3); mild to moderate keratinization of the epithelium may occur, depending on the nature of the swallowed material.

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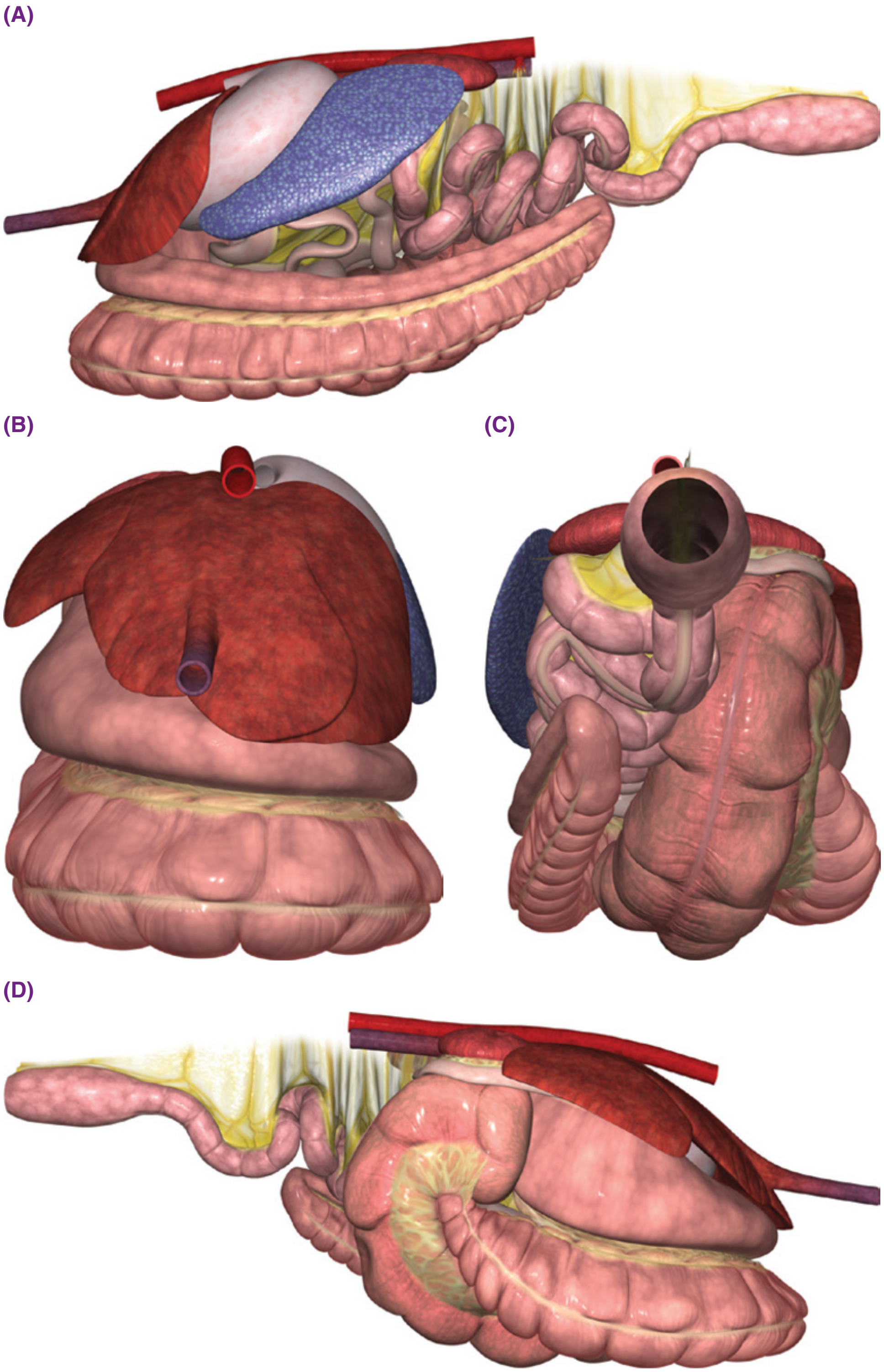


Figure 1.1 **(A)** The abdominal organs from the left side of the horse. **(B)** A view from the cranial-most aspect of the abdomen. **(C)** The abdominal organs visible from the caudal-most aspect. **(D)** The abdominal organs visible from the horse's right side. Source: Courtesy of The Glass Horse, Science In 3D.

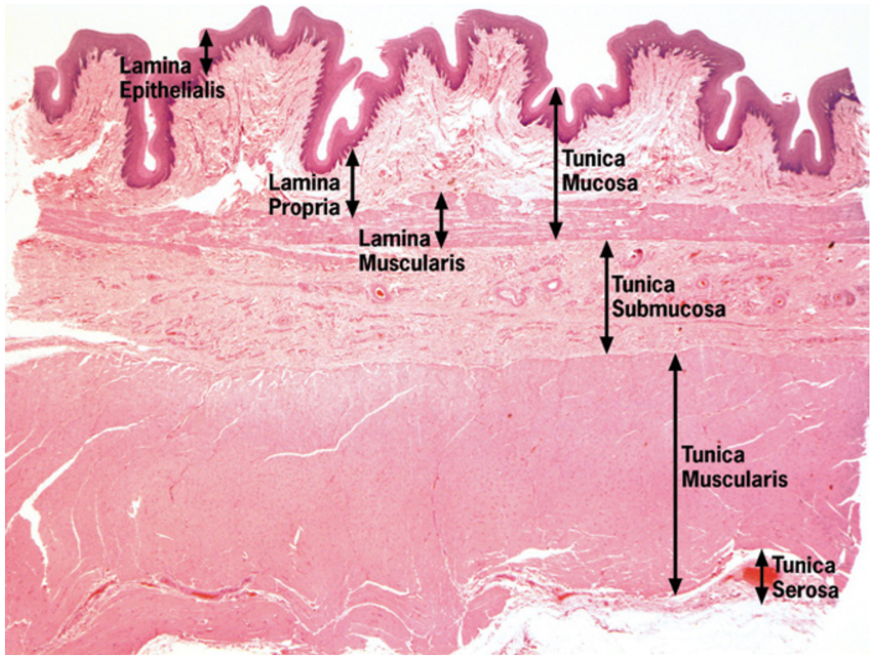


Figure 1.2 Full-thickness section of the thoracic esophagus. H&E stain.

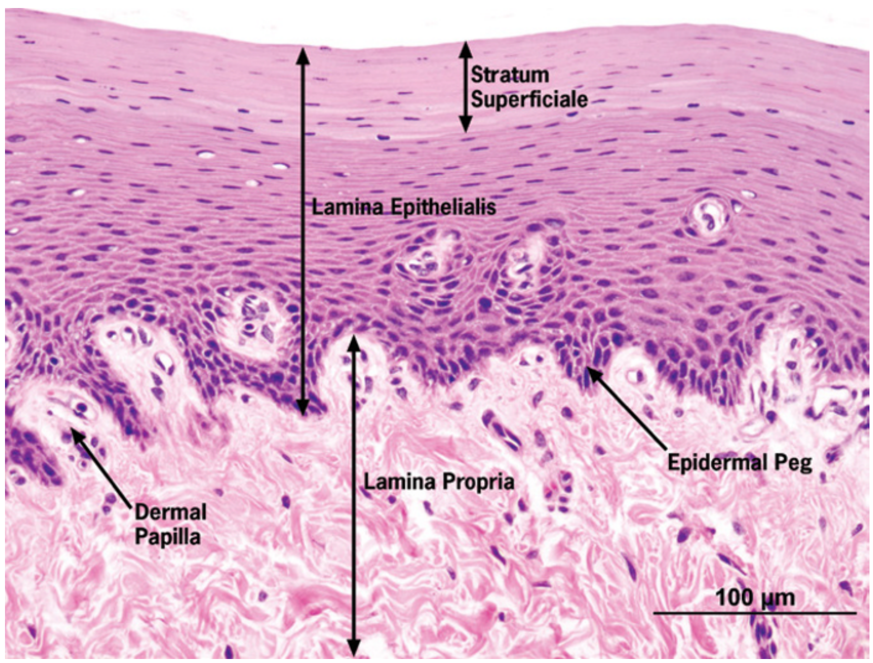


Figure 1.3 The lamina epithelialis of the esophagus. The epithelium is nonkeratinized with retention of nuclei throughout the most superficial layer (the stratum superficiale). The lamina propria is dense irregular connective tissue. The lamina propria and lamina epithelialis interdigitate via finger-like projections of the epidermis (epidermal pegs) and dermis (dermal papillae). H&E stain.

The lamina propria varies from loose to dense irregular connective tissue. The lamina muscularis mucosa consists of isolated bundles of longitudinally oriented smooth muscle in the cranial esophagus. The muscle bundles increase in density and coalesce into a distinct layer towards the caudal esophagus. Because the lamina muscularis mucosa serves as a demarcation between the mucosa and the submucosa, it is difficult to distinguish these layers where the muscularis is sparse or absent. The tunica submucosa is dense irregular connective tissue that contains prominent vasculature and the submucosal nerve plexus. Simple branching tubuloalveolar mucus-secreting submucosal glands are present at the pharyngoesophageal junction (Figure 1.4). The tunica muscularis is skeletal muscle in the cranial two-thirds of the esophagus and transitions into smooth muscle in the caudal third of the esophagus. There are two muscle layers in the tunica muscularis; however, the layers are not always distinguishable due to spiraling and interlacing of the muscle bundles. The cervical region of the esophagus

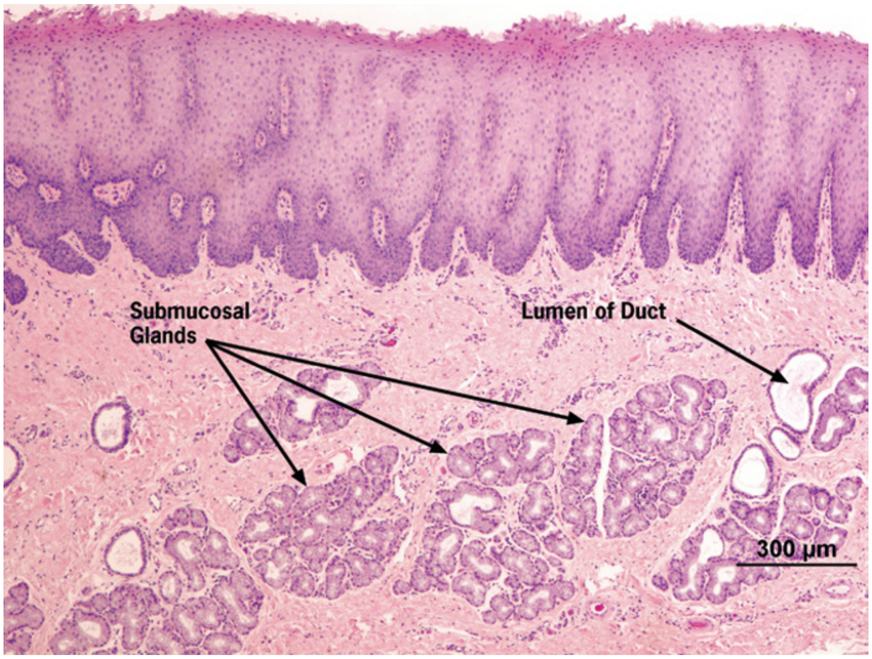


Figure 1.4 Esophageal submucosal glands. The mucous secretory products of the submucosal glands are ducted into the esophageal lumen. The larger clear spaces are sections of ducts. H&E stain.

has a tunica adventitia of dense irregular connective tissue that blends with the surrounding tissues. The thoracic and abdominal regions of the esophagus have a tunica serosa, which is mediastinal pleura and visceral peritoneum, respectively.

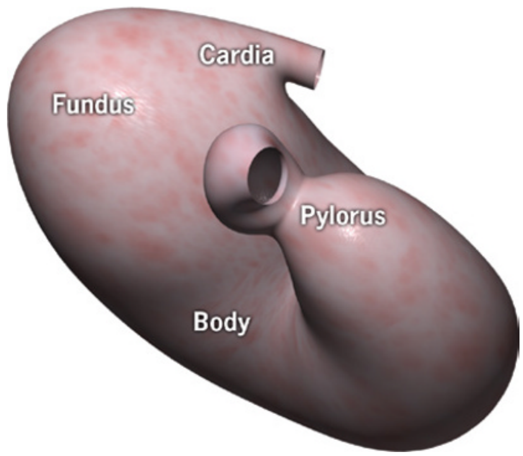


Figure 1.5 A view of the horse's stomach from the right side of the abdomen, permitting identification of the cardia, fundus, body, and pylorus. Source: Courtesy of The Glass Horse, Science In 3D.

Esophagus–Stomach Junction

The true gastroesophageal junction in the equine is microscopically similar to the caudal esophagus with the addition of a thickening in the inner circular layer of the tunica muscularis that functions as a sphincter between the two organs. The combination of the muscular cardiac sphincter and the oblique angle at which the distal end of the esophagus joins the cardia of the stomach makes it exceptionally difficult for horses to vomit.

Stomach

Gross Anatomic Features

The stomach is enclosed within the ribcage between the 9th and 15th ribs and is positioned in the left half of the abdomen, caudal to the diaphragm and liver and cranial to the spleen. It has four compartments, the cardia, fundus (saccus cecus), body, and pyloric regions (Figure 1.5). The cardia is the most cranial region and is firmly fixed to the diaphragm near the dorsal surface of the 11th rib. The fundus is dorsal to the cardia and is large and lined by a nonglandular mucosa. The body is the largest portion of the stomach and spans between the nonglandular region ventral to the cardia to the acute angle of the lesser curvature (the angular incisure). The pyloric region spans between the angular incisure to the duodenum and is subdivided into the pyloric antrum, canal, and the strong muscular sphincter, the pylorus. The pylorus is the only portion of the stomach located to the right of the median plane. The cardiac and pyloric regions are in close proximity due to the acute angle of the concave cranial surface of the stomach, the lesser curvature. The long convex greater curvature, extending between the cardia and the pylorus, defines the caudal surface of the organ. The parietal surface of the stomach lies against the diaphragm and the left lobe of the liver and the visceral surface faces the intestines.

The stomach is attached to the abdominal wall and surrounding organs by dorsal and ventral mesogastria. The portions of the dorsal mesogastrium involving the stomach include the gastrophrenic and gastrosplenic ligaments and the greater omentum. The region of the greater curvature near the cardia is attached to the crura of the diaphragm by the gastrophrenic ligament. The gastrosplenic ligament connects the spleen to the left part of the greater curvature of the stomach. The greater omentum (epiploon) is a peritoneal fold that originates from the dorsal abdominal wall and attaches along the greater curvature of the stomach. This fold extends caudally, forming a flattened pouch referred to as the omental bursa. The omental bursa is accessed via a narrow slit, the epiploic (omental) foramen. The boundaries of the epiploic foramen are the caudate lobe of the liver dorsocranially, the caudal vena cava dorsally, the portal vein ventrally, and the right lobe of the pancreas caudoventrally. The lesser omentum is the largest portion of the ventral mesogastrium. It connects the lesser curvature of the stomach to the visceral surface of the liver (the hepatogastric ligament) and its free right edge connects the duodenum to the liver (hepatoduodenal ligament).

Microscopic Features

The equine stomach has both nonglandular and glandular regions. Surface area is increased in the stomach by rugae grossly and by gastric glands microscopically.

The nonglandular region of the stomach is microscopically similar to the caudal esophagus with a few exceptions. The lamina muscularis of the tunica mucosa in the stomach is organized into two distinct layers. The tunica muscularis is thicker in the stomach because of an additional layer of smooth muscle.

The junction of the nonglandular and glandular regions of the stomach forms a folded border, or margo plicatus (Figure 1.6). Microscopically, the margo plicatus is identified as an abrupt transition within the lamina epithelialis from a nonkeratinized stratified squamous epithelium to a simple columnar epithelium.

The glandular region of the stomach is further divided into cardiac gland, proper gastric gland, and pyloric gland regions. Microscopically, the distinction between these three regions may not be sharply demarcated, depending on where the tissue sample is taken and on the individual horse sampled. Mixing of the glandular regions may occur, some of which can be seen grossly. For example, small islands of proper gastric glands may be present in the pyloric gland region of the fresh, unfixed organ. The demarcation between proper gastric glands and pyloric glands can be seen and felt grossly because the proper gastric glands are taller than the pyloric glands and because they are colored differently in the fresh specimen.

The lamina epithelialis of the tunica mucosa of the glandular stomach is a simple columnar epithelium (Figure 1.7). This epithelium lines the entire surface of the glandular region of the stomach (Figure 1.8), including the gastric pits, and provides a protective function by secreting mucus. The lamina epithelialis also includes the epithelium lining the individual gastric glands, which invaginate into the lamina propria. The epithelium lining the gastric glands varies in cell type, depending on the

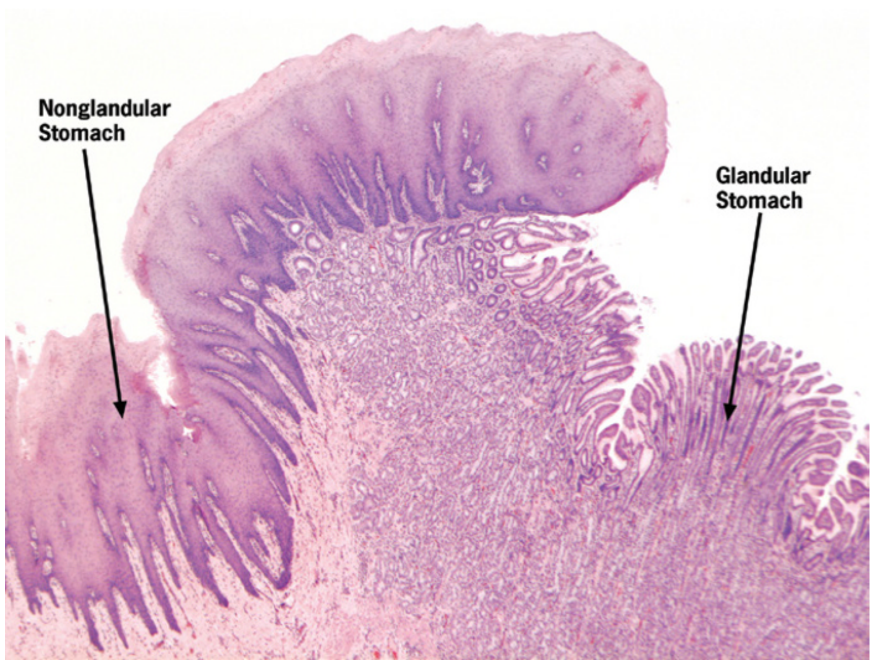


Figure 1.6 The junction of nonglandular and glandular regions of the equine stomach. The nonglandular region of the equine stomach slightly overlaps the glandular region of the stomach where the two adjoin, forming a folded border, or margo plicatus. H&E stain.

Figure 1.7 Simple columnar epithelium of the glandular portion of the equine stomach. This epithelium lines the surface of the glandular stomach and secretes a mucous product that is protective against the harsh acidic-fluid environment of the glandular stomach. H&E stain.

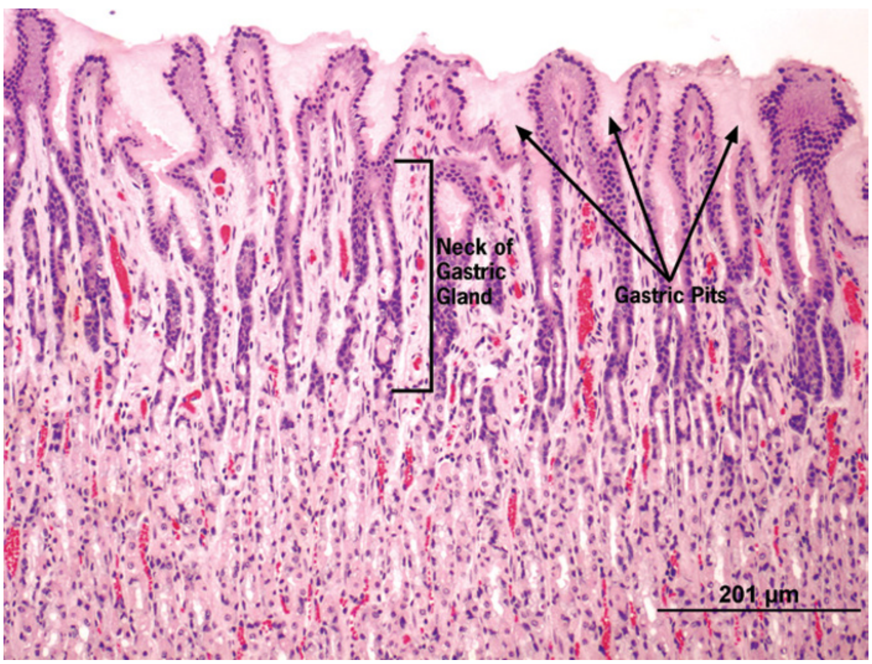


Figure 1.8 The gastric pits, necks, and upper portion of the proper gastric glands. The gastric pits in this image are filled with protective mucous, which is secreted by the simple columnar epithelium lining the surface and pits. Deep to the gastric pits are narrowings in the glands referred to as the necks. The necks of the gastric glands are where the stem cells are located. The secretory product of the surface mucous cells differs from the secretory product of the neck mucous cells in both composition and staining characteristics. H&E stain.

glandular region. Mitotic activity occurs in the neck region of all the gastric glands; daughter cells migrate and replenish both the surface epithelium and the epithelium lining the glands. The lamina propria is loose to dense irregular connective tissue, and in all regions is highly cellular, containing many lymphocytes, macrophages, plasma cells, and eosinophils. The lamina muscularis mucosa is an interwoven layer of smooth muscle bundles positioned perpendicular to one another. Many smooth muscle fibers extend adluminally from the lamina muscularis into the lamina propria. The tunica submucosa is typical, containing dense irregular connective tissue, prominent vasculature, and the submucosal nerve plexus. The tunica muscularis is composed of smooth muscle bundles arranged in oblique, circular, and longitudinal layers. The tunica serosa is visceral peritoneum.

The cardiac gland region is narrow and borders a portion of the margo plicatus. Cardiac glands are simple coiled tubular glands with some branching in the fundus of the glands. The length of the cardiac glands varies, particularly where the glands are juxtaposed against the

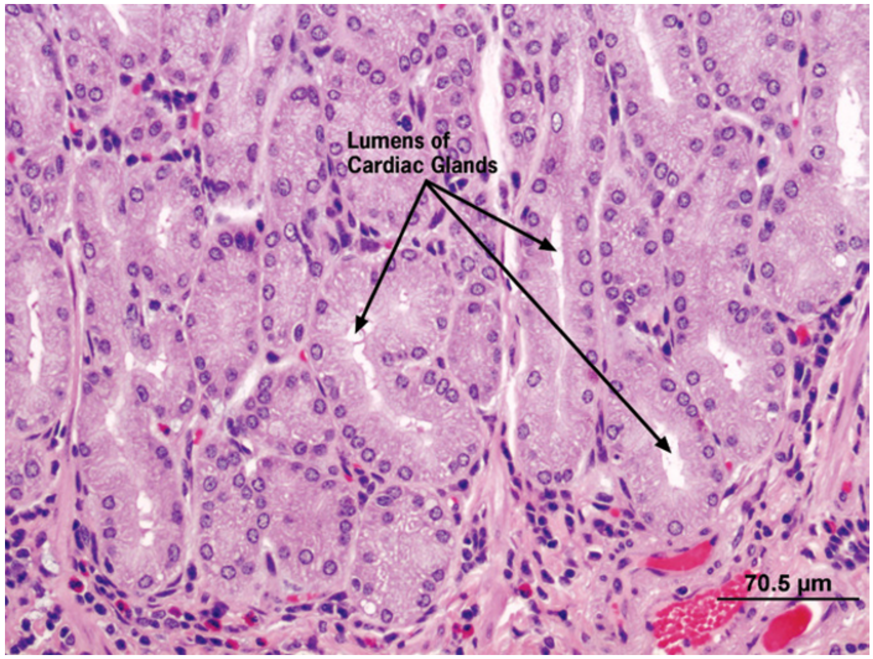


Figure 1.9 The deep portion of the cardiac glands from the equine glandular stomach. This image illustrates the body and base (fundus) of the cardiac glands. Cardiac glands are coiled tubular glands, therefore the glands will appear to be in many different planes when sectioned, and it will be difficult to trace the lumen of any one gland. The epithelium lining the glands secretes mucin, and the glandular secretory product is mucous. The vacuolation of the epithelial cytoplasm is due to mucin granules. Note the basally positioned nuclei of the glandular epithelium. H&E stain.

margo plicatus. The glands are shortest immediately adjacent to the margo plicatus; otherwise, the glands are similar to the proper gastric glands in depth. The cardiac glands are primarily mucus secreting (Figure 1.9). Chief cells and parietal cells are increasingly present within the cardiac glands as they transition into proper gastric glands. Enteroendocrine cells are present in the cardiac glands, but require special stains to be identified using light microscopy.

The proper gastric gland region occupies approximately two-thirds of the body of the equine stomach. Proper gastric glands are long simple tubular glands that are straight but have some coiling and branching at the fundus of the glands. Proper gastric glands are divided into an isthmus (the funnel-shaped opening of the gastric pit into the neck), a short neck, a long body, and a fundus, or base. The gastric pits overlying the proper gastric glands tend to be shallower than the pits overlying the cardiac glands and pyloric glands, but this varies throughout the glandular stomach. The cells of the proper gastric glands include mucous neck cells, parietal cells, chief cells, and enteroendocrine cells (Figure 1.10). In general, parietal cells predominantly populate the neck and upper to mid-portions of the body of the glands, whereas chief cells predominantly populate the lower portions of the body and the fundus of the glands. Mucus-secreting cells are also present in the proper gastric glands in the regions where the proper gastric glands are transitioning with the cardiac glands or the pyloric glands.

The pyloric gland region occupies the remaining one-third of the glandular stomach near the pylorus. Some of the pyloric glands border the margo plicatus. Pyloric glands are simple coiled tubular glands with some branching in the fundus of the glands. The pyloric glands are primarily mucus secreting (Figure 1.11), but may have scattered populations of parietal and chief cells, particularly near the junction of the pyloric glands with the proper gastric glands. Pyloric glands also have enteroendocrine cells.

The stomach joins the cranial part of the duodenum at the gastroduodenal junction.

Small Intestine

Gross Anatomic Features

The small intestine has three parts, the duodenum, jejunum, and ileum (Figure 1.12); these are suspended from the dorsal body wall by connecting mesentery, the mesoduodenum, mesojejunum, and mesoileum, respectively. The mesojejunoileum (collectively referred to as "the mesentery") attaches to the dorsal body wall ventral to the first lumbar vertebra. The celiac and cranial mesenteric arteries enter the mesentery at this site, and the stalk-like mass is referred to as "the root of the mesentery," which can be palpated via rectal examination.

The duodenum is approximately 1 m in length and is attached to the dorsal body wall by a short mesentery, the mesoduodenum. The duodenum is regionally subdivided into cranial, descending, and ascending parts. The cranial part is defined by a bulbous double curvature, the duodenal sigmoid flexure, which lies ventral to

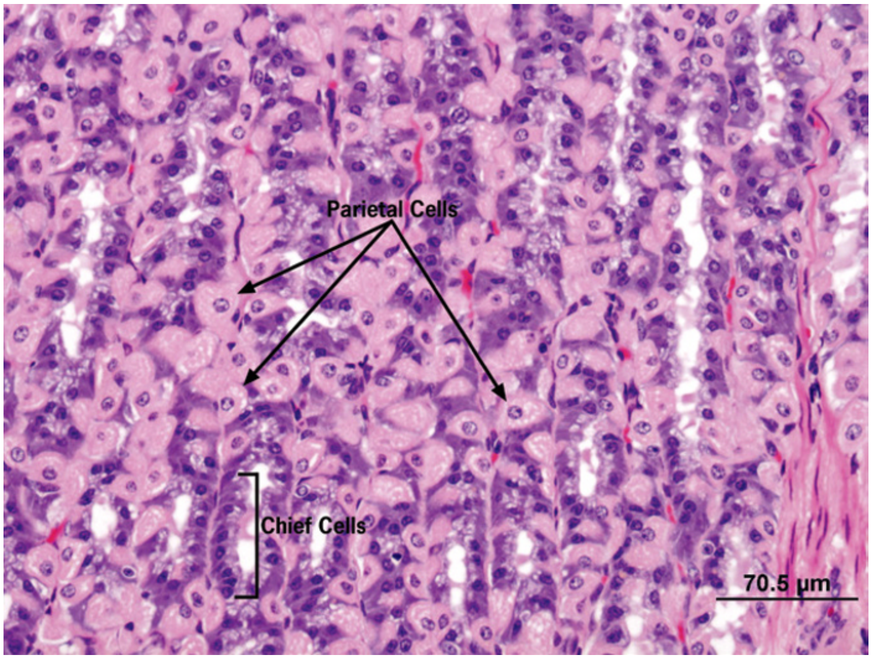


Figure 1.10 A portion of the proper gastric glands from the equine glandular stomach. This image illustrates the middle portion of the body of the proper gastric glands. Many eosinophilic parietal cells are visible; however, there are also many basophilic staining chief cells. The large parietal cells have a moth-eaten appearance due to the extensive canalicular system of the cells. The parietal cells produce and transport hydrogen and chloride ions into the cell canaliculi, where the ions combine to form hydrochloric acid. The chief cells produce proenzymes, particularly pepsinogen. H&E stain.

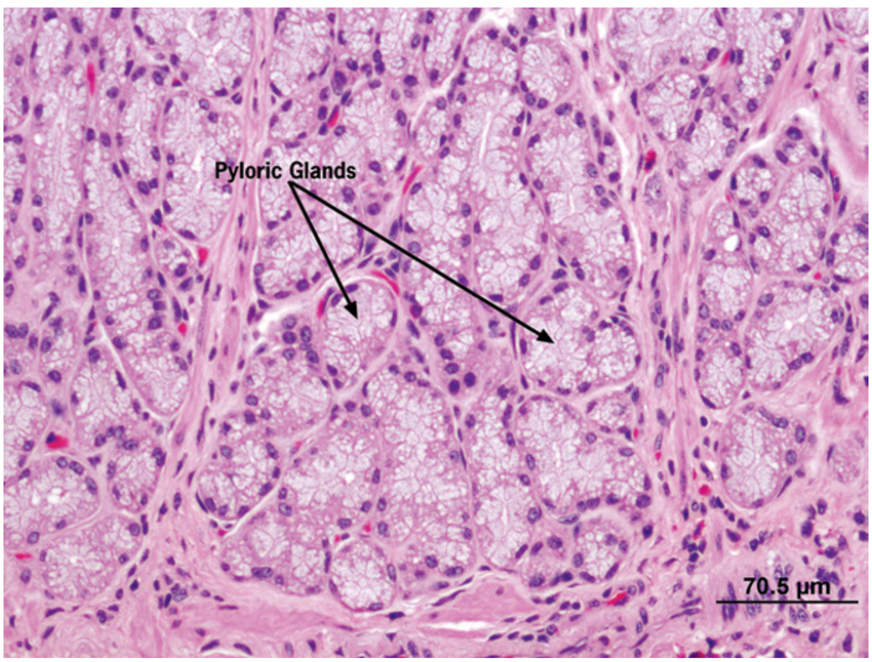


Figure 1.11 The deep portion of the pyloric glands from the equine glandular stomach. This image illustrates the body and base (fundus) of the pyloric glands. Pyloric glands are very similar to cardiac glands in that they both are coiled tubular glands that secrete mucous. H&E stain.

the liver in the region of the hepatic portal vein. The major and minor duodenal papillae are located opposite each other in the second bend of the flexure and the body of the pancreas fits snugly within the second concavity of this flexure. A sharp bend, the cranial duodenal flexure, marks the beginning of the descending part, which passes caudally and is located dorsally on the right side of the abdomen. At its caudal flexure (sometimes referred to as the short transverse part of the duodenum) at the caudal pole of the right kidney, the duodenum turns medially and passes from right to left around the base of the cecum, caudal to the root of the mesentery. The short ascending duodenum then passes cranially on the left of the mesentery to transition into the jejunum ventral and medial to the left kidney. The duodenojejunal junction and flexure are attached to the transverse colon by the duodenocolic fold.

At the duodenojejunal junction, the mesentery of the jejunum begins increasing in length. There are approximately 25 m of jejunum in the adult horse and because of the long mesentery; the coils of jejunum have considerable mobility. The majority of the jejunal coils reside in the left dorsal abdomen where they freely mix with those of the descending colon. The mobility of the jejunum within the abdomen increases the odds of untoward events such as incarceration within the epiploic foramen, inguinal canal, or rents in the mesentery and volvulus via twisting around the root of the mesentery.

The short terminal portion of the small intestine is the ileum, which is approximately 50 cm in length. The ileum has a thick muscular wall that delivers ingesta through the dorsomedial wall of the cecum via the ileal papilla, a protrusion of the ileum into the lumen of the cecum. The ileocecal fold attaches the ileum to the dorsal band of the cecum.

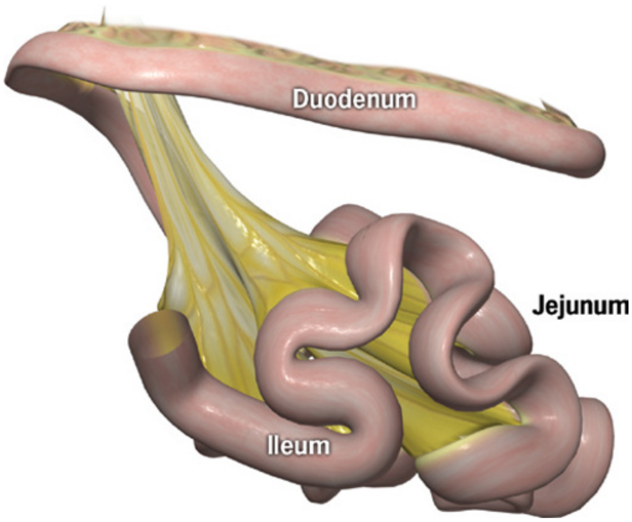


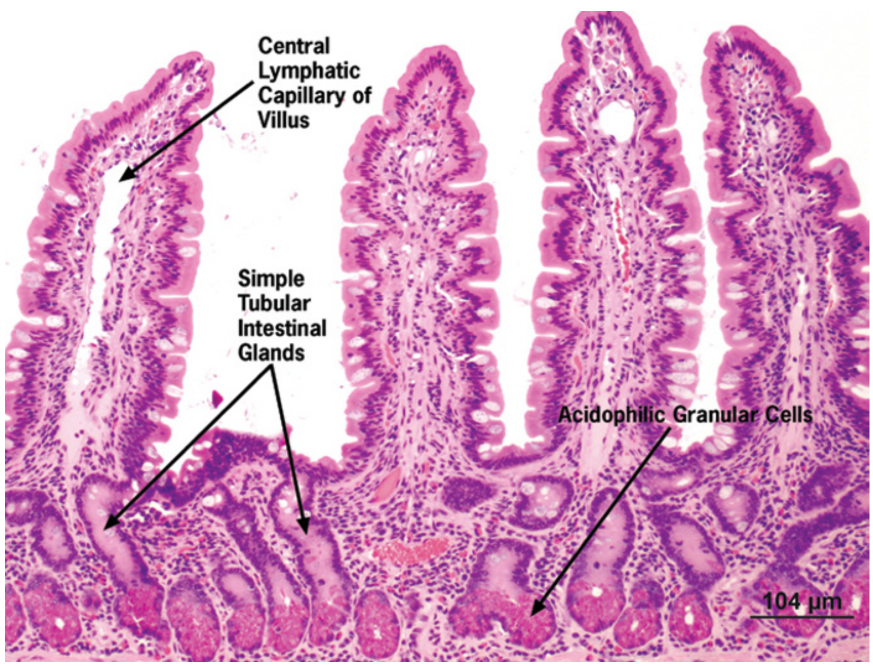
Figure 1.12 The duodenum, jejunum, and ileum, as viewed from the right side of the horse. Note the short mesoduodenum and long jejunal mesentery. Source: Courtesy of The Glass Horse, Science In 3D.

Microscopic Features

In the small intestine, the surface area is grossly increased by the sheer length of the organ and by plicae circulares (circular folds). Surface area is increased microscopically by villi and by microvilli. The microvilli are referred to as the striated border. Microscopically, the three divisions of the small intestine are similar. In the tunica mucosa, the lamina epithelialis lining the villi is made up of simple columnar cells that are interspersed with unicellular mucous glands, or goblet cells. The simple columnar cells are absorptive, and are referred to as enterocytes. The simple columnar epithelium also lines the intestinal glands (crypts of Lieberkühn).

The small intestinal glands are simple tubular glands that may coil and have some branching in the fundic region. The intestinal glands invaginate into the lamina propria. Cell division takes place in the fundic region of the intestinal glands; undifferentiated cells mature into goblet cells and enterocytes as they migrate toward the villi. In horses, another cell type, the acidophilic granular cell (Paneth cell) is also derived from the stem cells in the fundic region of the intestinal glands (Figure 1.13). Acidophilic granular cells occur in all divisions of the small intestine and are thought to play a role in mucosal immunity. Enteroendocrine cells are also present in the small intestinal glands. The lamina propria has variable cellularity, including but not limited to plasma cells,

Figure 1.13 The villi and intestinal glands of the equine jejunum. The small intestinal glands are simple tubular glands that empty into the intestinal lumen at the base of the villi. The bright eosinophilic-staining cells in the fundic region of these glands are the acidophilic granular (Paneth) cells. Lymphatic capillaries (central lacteals) are located within the lamina propria of the villi. H&E stain.



lymphocytes, macrophages, and granulocytes, particularly eosinophils. The lamina propria within the villi has both blood capillaries and lymph capillaries (lacteals). The lamina muscularis mucosa is present and gives off smooth muscle fibers that extend adluminally into the villi. Contraction of these fibers allows for shortening of the villi and is thought to aid in emptying the capillaries, which become engorged during digestion.

In general, the villi in the duodenum are blunt and wide whereas in the jejunum they are long and slender and in the ileum they are club-shaped. In the tunica submucosa, submucosal glands extend throughout the duodenum and into the jejunum (Figure 1.14). The submucosal glands are simple branching tubuloacinar glands that empty into the fundus of the intestinal glands (Figure 1.15). The glands predominantly contain mucous adenomeres with some serous adenomeres occurring occasionally. Gut-associated lymphoid tissue (GALT) occurs throughout the equine small intestine (Figure 1.16). GALT includes both nodular lymphoid tissue (primarily B cells) and diffuse lymphoid tissue (primarily T cells), which often occur together in aggregates

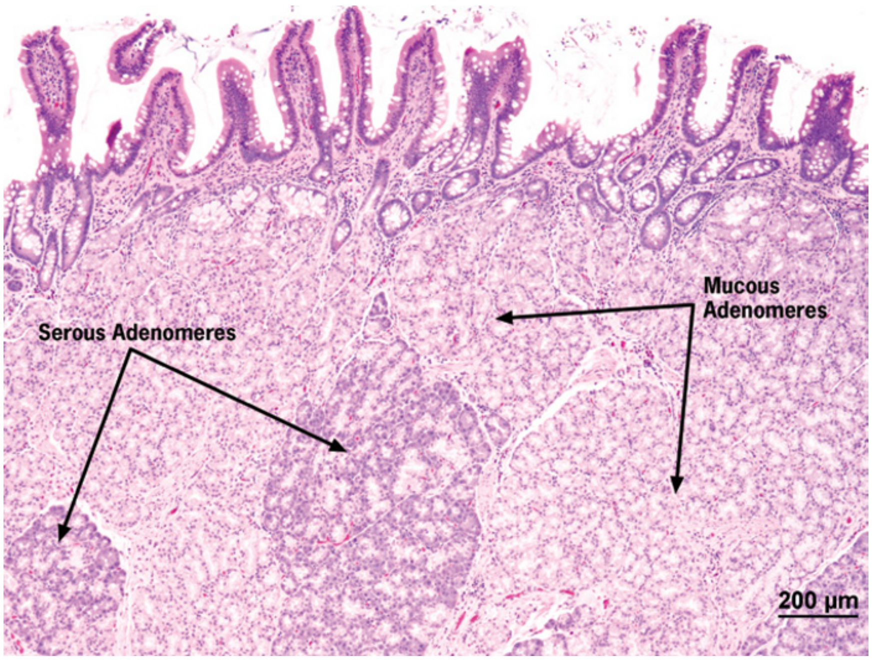


Figure 1.14 The submucosal glands of the equine jejunum. The submucosal glands are primarily composed of mucous adenomeres (light staining regions); however, serous adenomeres (darker staining regions) do occur. H&E stain.

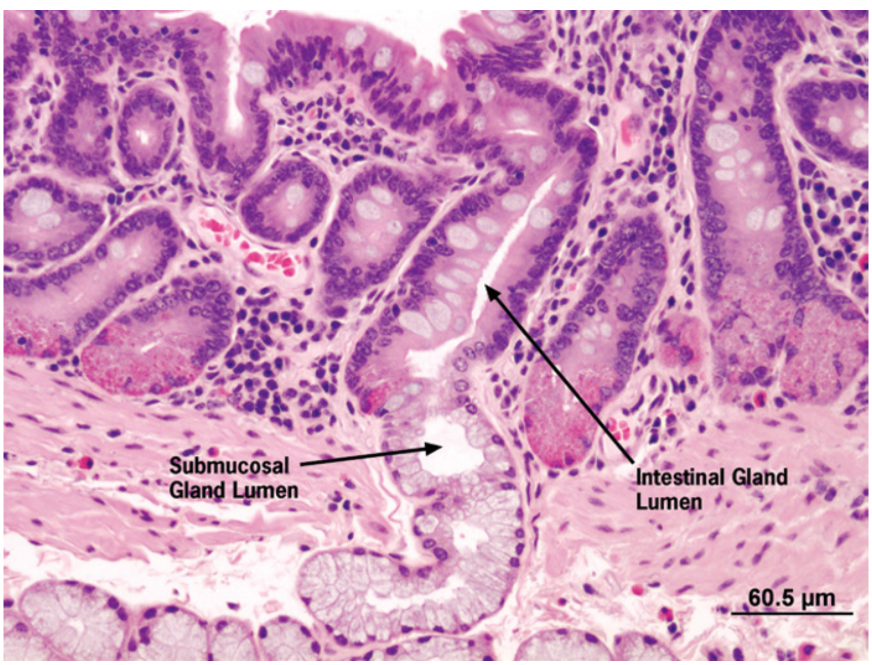


Figure 1.15 The junction of the submucosal and intestinal glands. The submucosal glands are not ducted directly to the intestinal lumen, but empty into the fundic region of the intestinal glands. H&E stain.

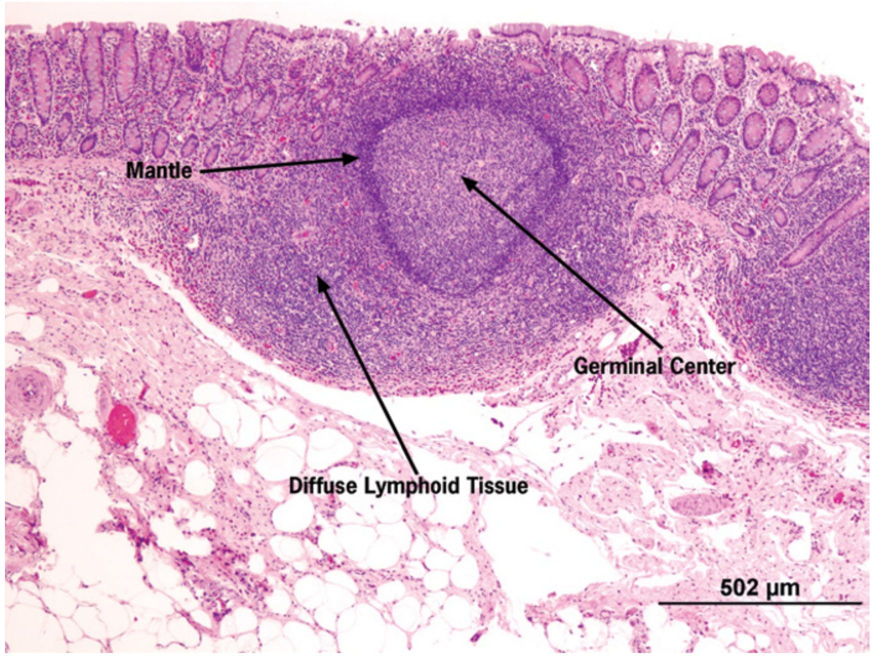


Figure 1.16 Gut-associated lymphoid tissue (GALT). GALT may be found throughout the tubular digestive tract. GALT is composed of nodular (primarily B cells) and diffuse (primarily T cells) lymphoid tissue. The nodular lymphoid tissue in this image of the ventral colon is undergoing proliferation in response to antigenic stimulation, forming a lighter staining central germinal center surrounded by a darker staining mantle of nonproliferative, nonreactive B cells. Surrounding the nodule is diffuse lymphoid tissue. H&E stain.

(Peyer's patches). Lymphoid aggregates are grossly visible as thickened regions in the intestinal wall; the mucosa overlying these aggregates has a pitted surface. Microscopically, the aggregates are located in the tunica submucosa and extend adluminally into the tunica mucosa. The lamina muscularis is often disrupted by the lymphocytic infiltration. The lamina epithelialis overlying the pits is lacking in goblet cells and contains specialized epithelial cells known as microfold cells ("M" cells) that play a role in the immune process of monitoring intestinal antigens (Dellmann and Eurell, 1998).

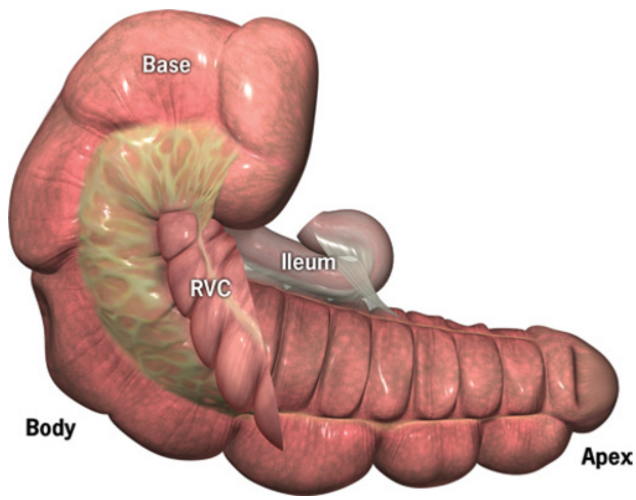


Figure 1.17 The cecum, terminal ileum, and proximal portion of the right ventral colon (RVC) as viewed from the right side of the horse. The ileocecal fold is evident where it attaches the antimesenteric border of the ileum to the cecum, as are the base, body, and apex of the cecum. Source: Courtesy of The Glass Horse, Science In 3D.

Large Intestine

Gross Anatomic Features

The large intestine includes the cecum, colon, rectum, and anal canal.

The cecum is a large comma-shaped fermentation vat that can accommodate 30 L or more of ingesta. The cecum is 1 m or more in length and is subdivided into a base, body, and apex (Figure 1.17). The base is wide and curves dorsally from beneath the caudal ribs to the right paralumbar fossa. Developmentally, the portion of the base cranial and ventral to the ileal papilla is part of the ascending colon, but this is not conventionally recognized. The body curves cranioventrally and has lesser and greater curvatures. The blind, pointed apex is located within the concavity of the sternal flexure of the ventral colon. The cecum is attached dorsally to the ventral surface of the right kidney, the pancreas, and the dorsal abdominal wall at the root of the mesentery.

The cecum has sacculations (haustra ceci) and four longitudinal bands (teniae ceci). The cecal arteries, veins, and lymphatic vessels pass through the mesentery overlying the medial and lateral cecal bands. The dorsal band of the cecum serves as the point of attachment for the ileocecal fold. The ventral cecal band is the most easily palpated band per rectum, running from the base toward the apex of the cecum; this band is almost entirely exposed, being concealed only where the cecum is attached to the dorsal body wall. A strong triangular fold of tissue, the cecocolic fold, attaches the lateral band of the cecum to the right ventral colon.

The ascending colon (large colon) is long and capacious, accommodating 80 or more liters of ingesta, and is folded into two horseshoe-shaped lengths of intestine, one dorsally and the other ventrally positioned, with the toes of the shoes pointed cranially. The ascending colon originates on the right side of the abdomen along the lesser curvature of the base of the cecum at the cecocolic ostium, located near the costochondral junctions of the last two ribs. It also terminates on the right side of the abdomen at the junction of the right dorsal colon with the transverse colon (Figure 1.18A, B, and C). With the exception of its origin and termination, the majority of the ascending colon is potentially freely mobile within the abdominal cavity, making the ascending colon prone to displacement and volvulus.

After its origin at the cecocolic ostium, the right ventral colon curves cranioventrally along the ventral abdomen until it reaches the sternum, where it is deflected to the left of the midline at the sternal flexure. From the sternal flexure, the left ventral colon continues caudally along the ventral abdominal floor. In the vicinity of the pelvic inlet, the left ventral colon makes a dorsally directed hairpin turn (the pelvic flexure) to become the left dorsal colon. When it contains ingesta, the pelvic flexure can be palpated during the rectal examination. The left dorsal colon continues cranially, dorsal to the left ventral colon, until it reaches the diaphragm (the dorsal diaphragmatic flexure) where it is deflected to the right of the midline. The right dorsal colon continues caudally, dorsal to the right ventral colon. At the base of the cecum, the right dorsal colon is deflected medially to continue as the transverse colon. The terminal portion of the right dorsal colon is dilated (ampulla coli).

The right and left ventral colons have an average diameter of approximately 25 cm. The most pronounced changes in the diameter occur at the pelvic flexure, where the diameter decreases to approximately 8 cm, and at the junction between the ampulla coli and the transverse colon, where the diameter changes from approximately 50 cm in the right dorsal colon to approximately 8 cm in the transverse colon. These large-to-small diameter changes are frequent sites of impaction.

There are four longitudinal bands on the right and left ventral colons (two in the mesocolon, two free), one on

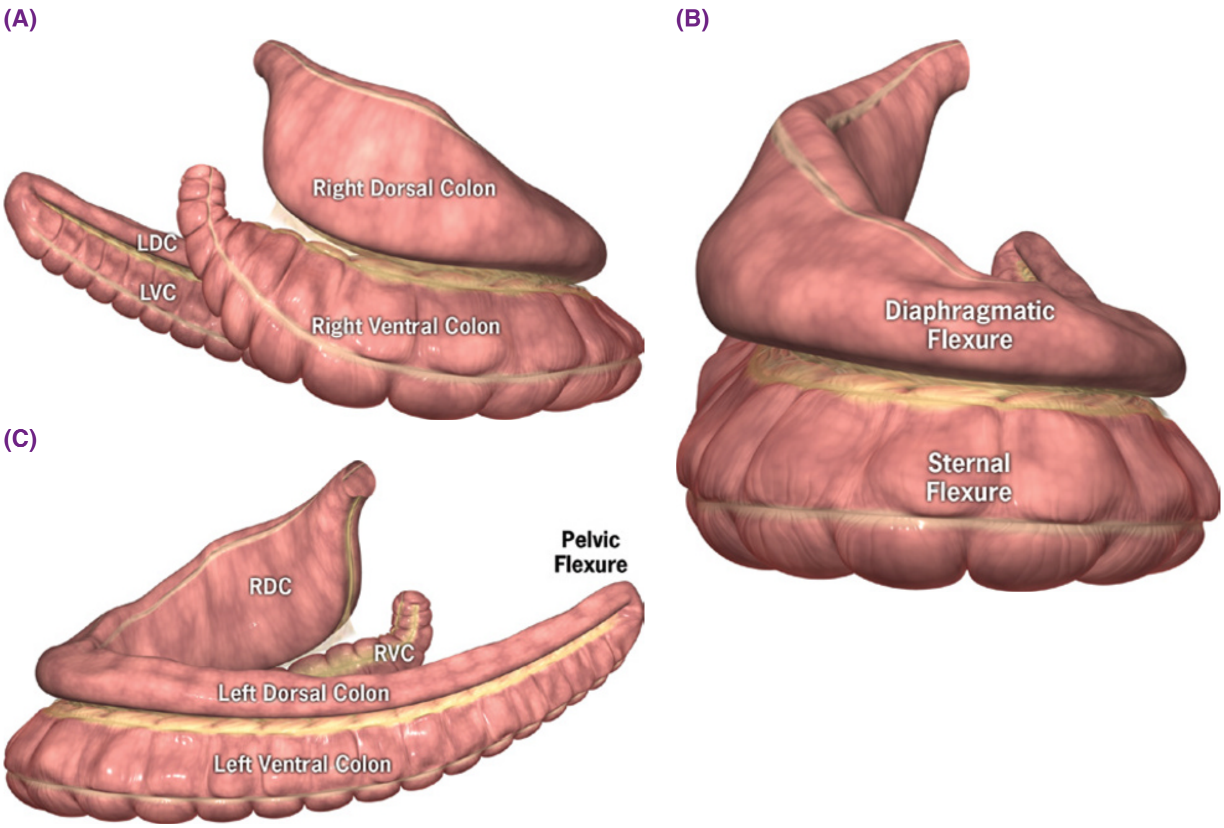


Figure 1.18 **(A)** The large colon, as viewed from the right side of the horse. The left ventral (LVC) and left dorsal (LDC) colons are evident towards the caudal aspect of the horse's abdomen. **(B)** The large colon from the cranial-most aspect of the abdomen, depicting the sternal flexure in the ventral colon and the diaphragmatic flexure in the dorsal colon. **(C)** The large colon, as viewed from the left side of the horse. The right ventral (RVC) and right dorsal (RDC) colons are identified. Source: Courtesy of The Glass Horse, Science In 3D.