

Veterinary Bioscience 1: Digestive system

Lecture 22 – Intestines of herbivores and omnivores: Comparative anatomy

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Key words

Digestion; duodenum; pancreas; pancreatic ducts; bile duct; jejunum; ileum; ileocaecal orifice; caecum; ascending colon; taeniae; haustra; pelvic flexure; transverse colon; descending colon; rectum.

Intended Learning Outcomes

At the end of this lecture you should be able to:

- describe the comparative gross anatomy of the small and large intestine and pancreas of the horse, ruminants, pig and bird.
- describe the course and position in the body of the small and large intestines.
- relate some of these differences to the ways in which different species utilise different diets.

SMALL INTESTINE

Horse



The small intestine is approximately 22–25m in total length.

The **duodenum** is the first 1–1.5m. The cranial portion of the duodenum forms an **s-shaped curve**. The convexity of the first curve is directed dorsally and the second ventrally. The **head of the pancreas is attached to the concavity of the second curve**.

The horse has **2 pancreatic ducts** opening into the duodenum. At a point ~12–15cm from the pylorus, the **pancreatic duct and the bile duct** enter in a pouch in the wall of the duodenum – the **hepatopancreatic ampulla** (also referred to as the **major duodenal papilla**). It is situated on the convex margin of the second part of the s-shaped curve. A second **accessory pancreatic duct** opens on the smaller **minor duodenal papilla** in the opposite wall of the duodenum.

The equine **pancreas** is **reddish cream** colour in life but readily decomposes and darkens after death. The shape is **irregularly triangular**, with its **base directed towards the right** and the apex fits into the second concavity of the duodenal flexure. It lies in a transverse plane, near the vertebral column, ventral to the aorta and caudal vena cava, and is placed between the liver and stomach cranially and the dorsal sac of the caecum and the right dorsal colon caudally. **The caudal border** contains a deep **notch (incisura pancreatis)** where the **root of the mesentery** and **cranial mesenteric artery** are in contact with the pancreas. The **portal vein** is also in contact with the notch and passes through the pancreas very obliquely. A thin bridge of gland tissue lies dorsal to the portal vein thus forming the **pancreatic (portal) ring (annulus pancreatis)**.

The **jejunum and ileum** lie in numerous coils, mingled with those of the small colon and mainly **occupy the left dorsal region of the abdomen** due to the presence of the caecum and large colon occupying the other parts of the abdomen. The **terminal part of the ileum** passes to the medial face of the caecum and **opens into the caecum** at the **ileocecal orifice**. At this orifice the mucous membrane projects slightly into the cavity of the caecum, forming the **ileal papilla (ileocecal valve)** – quite vascular and composed of smooth muscle.

The **great mesentery** in the horse reaches about 50 cm in length. This is sufficient to allow coils of small intestine to reach the abdominal floor, the epiploic foramen, the pelvic cavity or even descend through the inguinal canal into the scrotum.

Near the junction of the ileum with the caecum, the free edge of the mesentery passes to the caecum and forms the **ileocecal fold**.

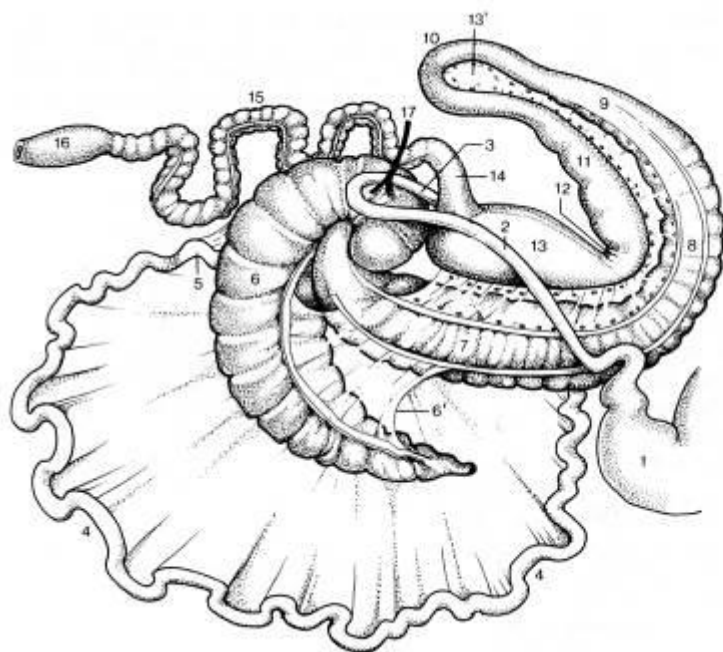


Figure 21-11. The intestinal tract seen from the right, schematic. The caudal flexure of the duodenum and the cranial mesenteric artery (17) have been displaced to the right of the animal to lie over the base of the cecum.

- 1, Stomach; 2, 3, descending and ascending duodenum; 4, jejunum; 5, ileum; 6, cecum; 6', cecocolic fold; 7, right ventral colon; 8, ventral diaphragmatic flexure; 9, left ventral colon; 10, pelvic flexure; 11, left dorsal colon; 12, dorsal diaphragmatic flexure; 13, right dorsal colon; 13', ascending mesocolon; 14, transverse colon; 15, descending (small) colon; 16, rectum; 17, cranial mesenteric artery.

Dyce et al 2002

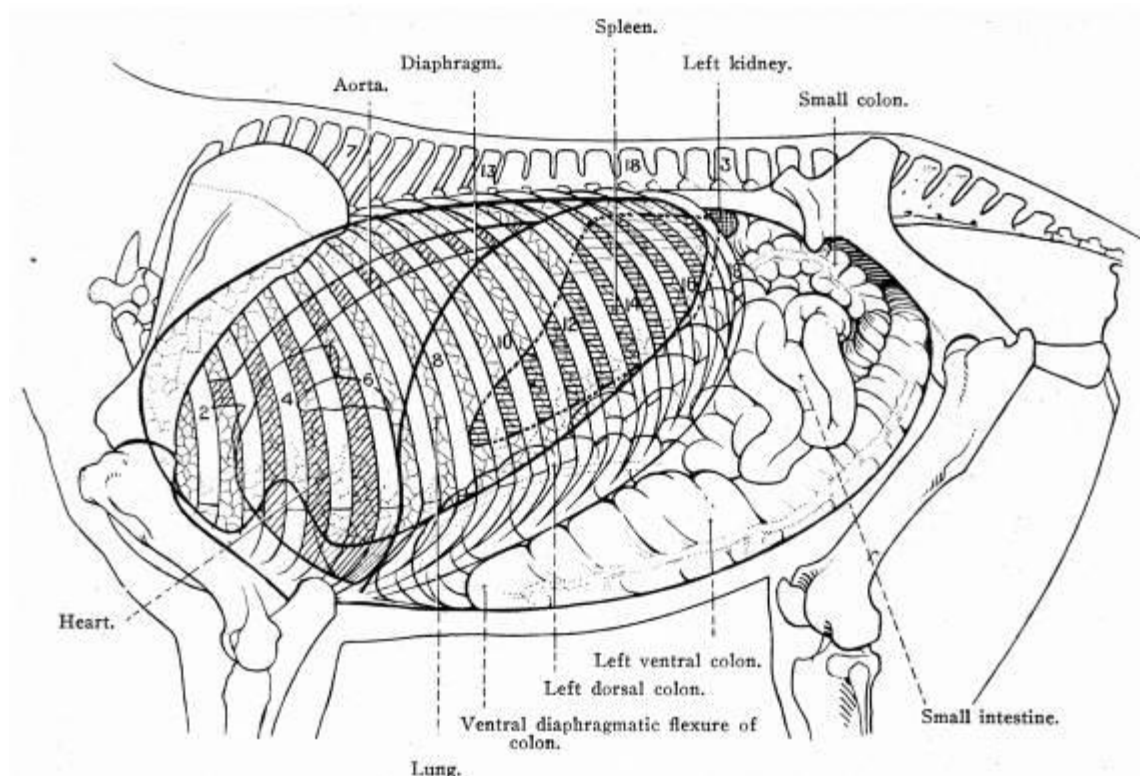


FIG. 41.—Diagram illustrating the topography of the thoracic and abdominal viscera as seen from the left.

Bradley 1923

Cow



The small intestine has an average length of 40 m.

Duodenum

Is about 1 m in length.

At its origin at the pylorus it forms a **sigmoid flexure**.

The **major duodenal papilla** is situated about **60 cm caudal to the pylorus**.

Only the **common bile duct opens into the major duodenal papilla**.

A **single pancreatic duct** (accessory duct) enters the descending duodenum on the **minor duodenal papilla** about **25-30cm past the entry of the bile duct**.

The **pancreas** is located **almost entirely to the right of the median plane**. It is **quadrilateral** in shape and consists of **two lobes that join in a body** located cranial to the portal vein, where the gland is adherent to the liver. Opposite the body is a **deep notch (incisura pancreatis)** – through which the **cranial mesenteric artery and portal vein pass**. The **smaller left lobe** is enclosed in the dorsal attachment of the greater omentum at the root of the mesentery. It extends across the abdomen, insinuated between the liver, diaphragm and great vessels dorsally and the intestinal mass and dorsal ruminal sac ventrally. **The larger right lobe** is enclosed in and follows the mesentery of the descending part of the duodenum, ventral to the right kidney and against the flank.

Jejunum and ileum

The jejunum is tightly coiled and lies largely on the **right side of the abdominal cavity** in the **supra-omental recess**. In adult ruminants the greater omentum usually conceals all the intestines except the descending duodenum.

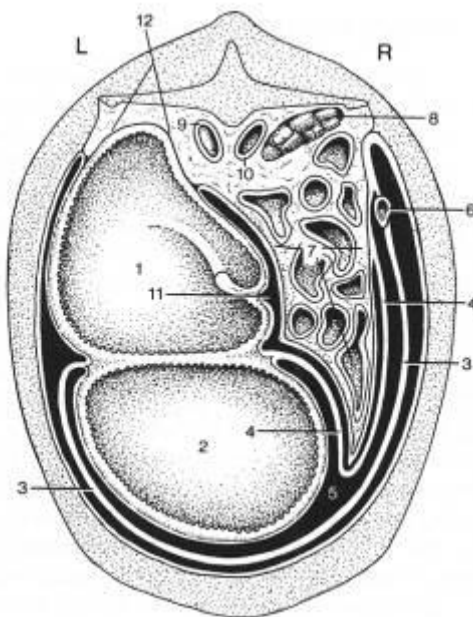


Figure 28-21. Schematic transverse section of the abdominal cavity to show the disposition of the greater omentum.

1, Dorsal sac of rumen; 2, ventral sac of rumen; 3, superficial wall of greater omentum; 4, deep wall of greater omentum; 5, omental bursa; 6, descending duodenum; 7, intestinal mass; 8, right kidney; 9, aorta; 10, caudal vena cava; 11, supraomental recess; 12, retroperitoneal attachment of rumen.

Dyce et al 2002

Sheep



The total length of the small intestine is approximately 25 m.

The **duodenum** is approximately the first 0.8 m.

The **pancreas** in the sheep and goat is similar in form and position to the cow. **BUT:** A **single duct** – the **pancreatic duct** – representing the ventral primordium, **opens** into the duodenum **on the major duodenal papilla in conjunction with the bile duct**, usually by means of a common trunk.



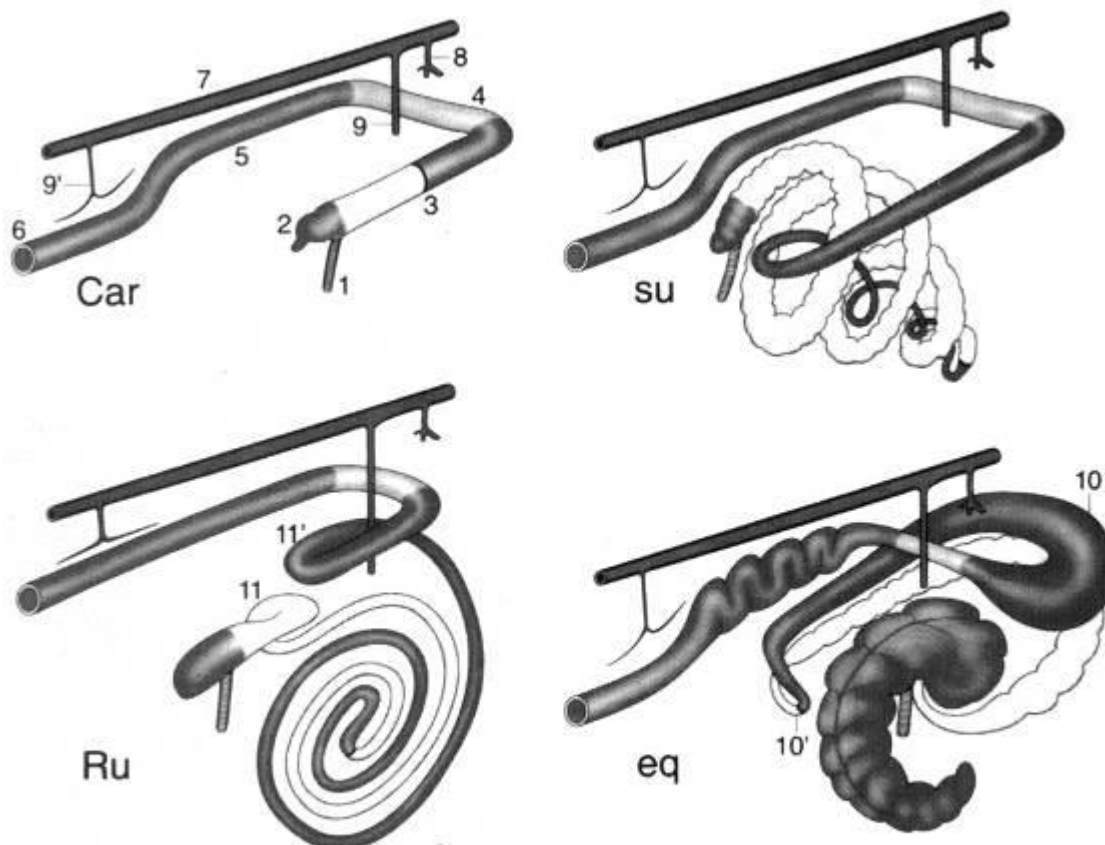
The small intestine is 15-20 m in length.

The **duodenum** is approximately the first 0.6 m of the small intestine. The **common bile duct opens at the major duodenal papilla** about 2.5-5 cm from the pylorus. The **dorsal pancreatic duct opens at the minor duodenal papilla** about 10-12 cm from the major duodenal papilla (**single pancreatic duct**).

The **pancreas** extends across the dorsal wall of the abdominal cavity caudal to the stomach. It is **somewhat triangular (or tri-radiate) in shape**. About **2/3 of the pancreas lies to the left of the median plane** – this **left lobe** is related to the fundus of the stomach, the spleen and the cranial pole of the left kidney. The **right lobe** follows the descending duodenum and contacts the liver cranially. It may reach the cranial pole of the right kidney caudally. The **middle portion is related to the portal vein**.

The **jejunum** is tightly coiled and lies in the dorsal region of the abdominal cavity, extending from the stomach to the pelvis and to the right of the colon and caecum. Many coils lie against the **right flank** and the caudal part of the abdominal floor.

LARGE INTESTINE



Dyce et al 2002

Figure 3-44. Schematic drawing of the large intestine of the domestic mammals: carnivores (Car), the pig (su), ruminants (Ru), and the horse (eq). Cranial is to the upper right.

1, ileum; 2, cecum; 3, ascending colon; 4, transverse colon; 5, descending colon; 6, rectum and anus; 7, aorta; 8, celiac artery; 9, 9', cranial and caudal mesenteric arteries; 10, 10', dorsal diaphragmatic and pelvic flexures of ascending colon; 11, 11', proximal and distal loops of ascending colon.

Horse



The large intestine is about 7.5–8m in length – divided into the **large (great) colon** and **small colon**

In comparison with the small intestine:

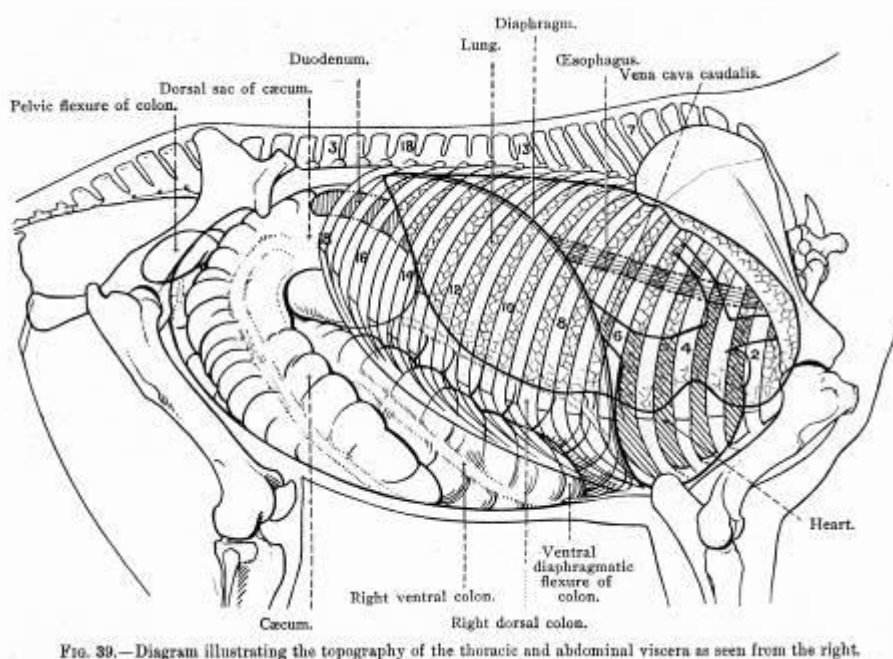
- It is **very much greater in calibre**

- It is **sacculated** for the most part - *haustra*

- It possesses **external longitudinal bands** - *taenia*

- It has a more fixed position in the abdomen

The horse has a **very extensive large intestine, especially the caecum and the ascending colon**. Similar to the rumen of ruminants, they serve **as chambers for bacterial fermentation** of cellulose. Because of its large size, the **ascending colon, together with the transverse colon**, are called the **large (great) colon**, whereas the **descending colon** is called the **small colon**.



Bradley 1923

FIG. 39.—Diagram illustrating the topography of the thoracic and abdominal viscera as seen from the right.

Caecum

The equine caecum has a **base, a body and an apex**. It is very large with an average length of 1.25 m and a capacity of 25–30 litres. It is **comma-shaped** and is situated chiefly to the right of the median plane, extending from the right iliac and sublumbar regions to the abdominal floor caudal to the xiphoid cartilages. The right or parietal surface of the caecum is related chiefly to the right abdominal wall, duodenum and liver. The left or visceral surface lies against the left colon, the root of the mesentery and the small intestine.

The **base of the caecum (or dorsal sac)** is the **most capacious, dorsal and caudal part of the caecum**.

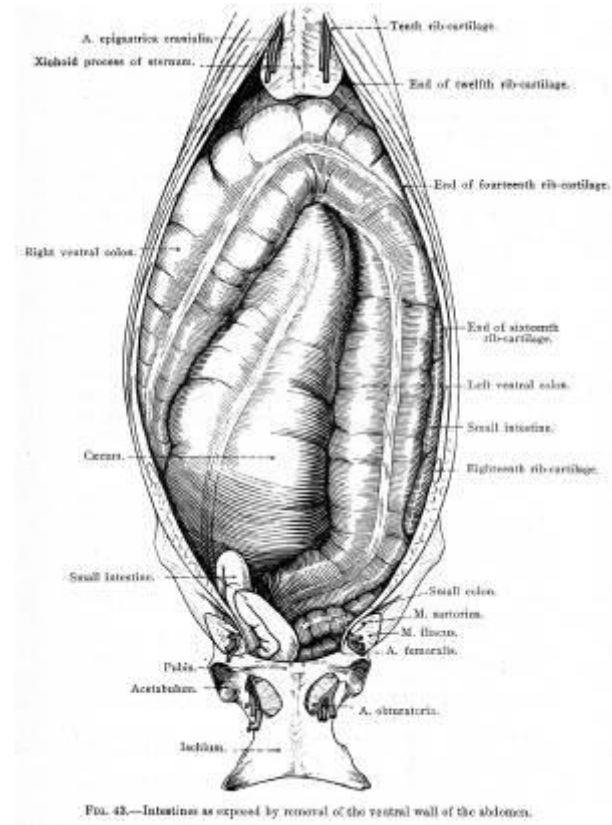
Usually found in the **right dorsal flank** from a line through the tuber coxae to about the middle of the 14/15th rib. The **greater curvature is dorsal** and the **lesser curvature is ventral and medial**. The **ileocaecal orifice** and the **cecocolic orifice** are found **on the lesser curvature of the base about 5-7.5 cm apart**. The **caecocolic junction** is to the right of and **nearer the pelvic brim** than is the ileocaecal junction. **Both junctions are surrounded by a ring of muscular fibres**. In the lumen the mucous membrane around the ileo-caecal opening is slightly raised into a circular fold - **ileal papilla**.

The **body of caecum** extends **ventrally and cranially** from the base. As it descends **within the abdomen**, it is displaced medially **and when it reaches** the ventral wall of the abdomen it lies between the ventral parts of the ascending colon. The **apex of the caecum** lies on the abdominal floor, about a hand length **caudal to the xiphoid cartilage** and may even extend to just left of the midline.

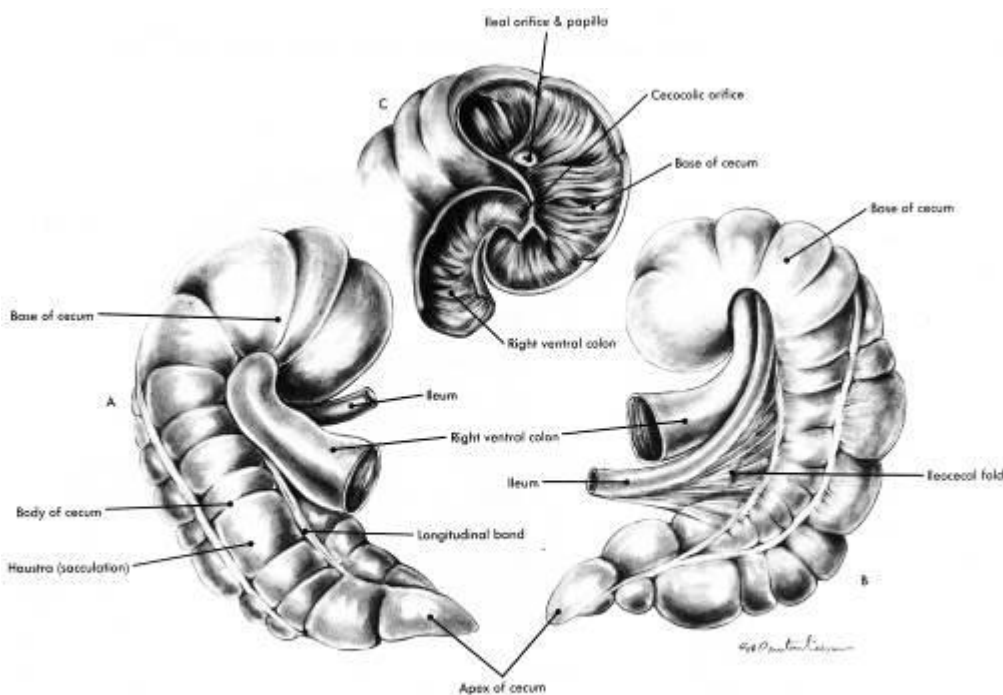
External features: The caecum has **four longitudinal bands – taenia** – found on the dorsal, ventral, right and left surfaces. These bands of **smooth muscle and elastic tissue** cause **four rows of sacculations – haustra** – which correspond to **four rows of saccular cells/pockets (cellulae caeci)** in the **lumen**. These serve to delay the passage of ingesta.

Attachments: The **base** is **attached dorsally** by connective tissue and peritoneum on the ventral surface of the pancreas and right kidney and an area of the abdominal wall caudal to these. Is also **attached medially** to the transverse colon and ventrally to the origin of the great colon (right ventral colon) via the **cecocolic fold**. The **body** is **attached dorsolaterally** to the first part of the colon by the **caecocolic fold**. The **apex** is free and thus may vary in position.

Function: Microbial fermentation – produces gas that is discharged at intervals into the right ventral colon.



Bradley 1923



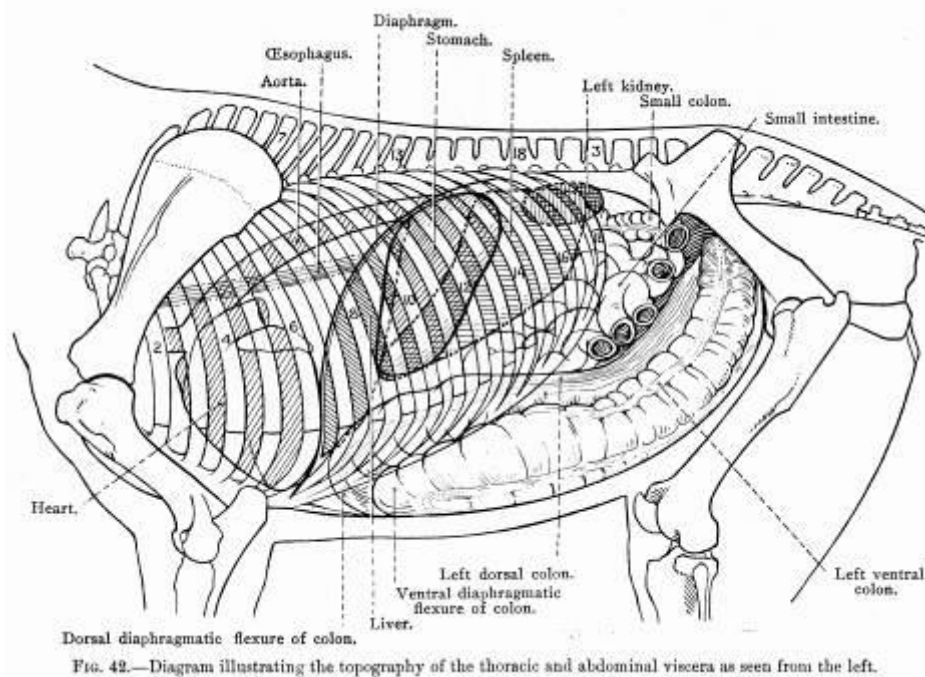
A, Cecum (right aspect). B, Ileum and cecum (left aspect). C, The communications of the cecum.

Fig. 3-13

Constantinescu 1991

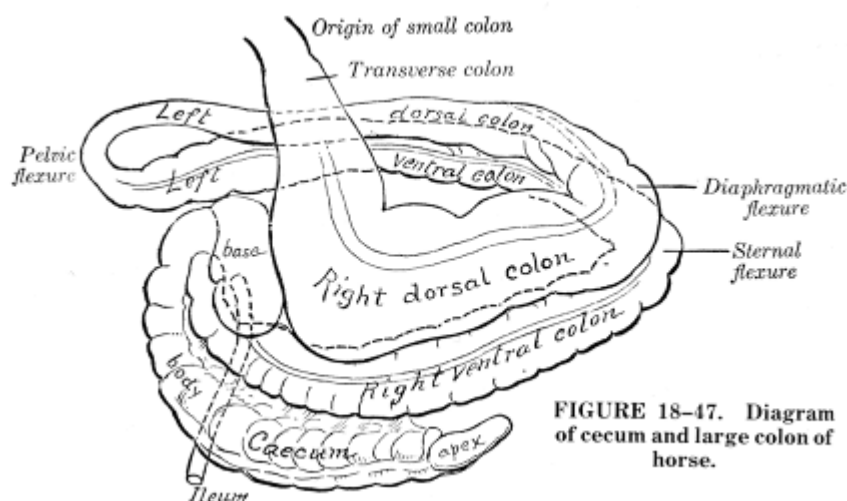
Large (Great) Colon – Ascending and Transverse Colon

Very large, ~ 3–4 m in length and capacity greater than 60 litres.



Bradley 1923

Arranged in a **double horseshoe-shaped loop**. The sequence runs: right ventral colon → sternal flexure → left ventral colon → pelvic flexure → left dorsal colon → diaphragmatic flexure → right dorsal colon



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Ventral colon

Right ventral colon

Narrow as it **emerges from the cecocolic junction in the upper right flank**. Expands quickly to a wide tube that **runs ventrally and cranially on the right abdominal floor**. The **right (and left) ventral colons** carry **4 rows of taeniae** and **4 rows of haustra**.

Sternal flexure

Left ventral colon

Runs **towards the pelvis on the left abdominal floor**.

Pelvic flexure

Sharp and narrow flexure. Joins the ventral colon to the dorsal colon. Marks the boundary between two functional units of the colon. 3 of the 4 taeniae disappear, so the haustra disappear. The single remaining taenia is found along the lesser curvature of the flexure and may be palpated per rectum.

Note – At this point the decrease in fluidity of the ingesta, the sudden alteration in course, and the reduction in calibre, all explain why **impaction is common at this level**. The position of the flexure varies with the fullness of the rectum, bladder and uterus, but it is usually easily palpated per rectum, at or just in front of the pelvic brim. Often it is palpated to right of the median plane.

Dorsal colon

Left dorsal colon

Is **narrow and smooth walled as it emerges from the pelvic flexure**. It gradually widens, the **taenia increase from 1 to 3 and the haustra return**. It **runs cranially above the left ventral colon** and below the coils of small intestine and descending colon to reach the liver.

Diaphragmatic flexure

Right dorsal colon

Is the **shortest and widest part of the ascending colon, carrying 3 taenia**. It is **strongly fixed in position** – adherent to the abdominal roof, the caecal base and the root of the mesentery. It **runs caudodorsally below the liver to the level of the cranial extension of the base of the caecum** where it is **deflected medially** and opens into the narrow **transverse colon**.

Transverse colon

Is **very short** and **passes from right to left** cranial to **the root of the mesentery**, having a direct retroperitoneal attachment to the abdominal roof. It **carries 2 taenia**, rapidly narrowing to the much smaller calibre of the descending colon into which it opens at about the level of the left kidney.

Note – The right ventral and dorsal colons are closely applied to each other by a common peritoneal sheet. The left ventral and dorsal colons are less closely associated as the peritoneal layer between the two gradually widens from the diaphragmatic to the pelvic flexure. **Except at its origin and termination, the ascending colon is free within the abdomen**, but its great bulk usually ensures it does not change much in position. However, **rotation of these parts about their common axis can lead to a twist – volvulus – a severe abdominal catastrophe**.

Small Colon – Descending Colon

Approximately 3.5 m in length, carrying **2 taenia and 2 rows of haustra**, it lies mainly within the **dorsal, caudal and left part of the abdomen**, largely **dorsal to the small intestine**. It is **long, narrow and thrown into coils supported by a long mesentery (mesocolon)**, centred around the **caudal mesenteric artery**. The small colon **opens into the rectum at the pelvic brim**. The rectum at its termination has a flask shaped dilation – **ampulla recti**.

Impaction Colic*

Impaction of ingesta usually occurs at:

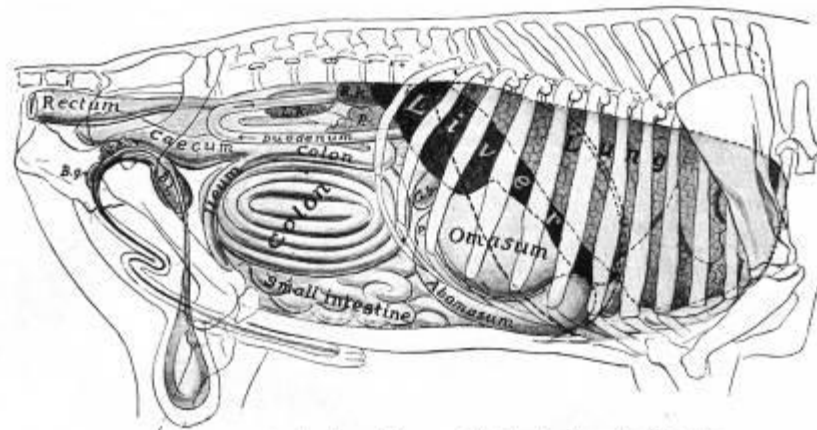
- The base of the caecum
- The pelvic flexure
- The terminal end of the right dorsal colon
- The small colon

*Colic – term usually used to refer to a syndrome of abdominal pain (not a specific clinical diagnosis).



The **large intestine** for most of its length is of **similar calibre to the small intestine**.

It has **no taenia or haustra**. With the exception of the free end of the caecum, the large intestine **lies in the supra-omental recess along with the small intestine**.



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FIGURE 29-53. Projection of viscera of bull on body wall; right side.

B.g., bulbourethral gland; BL, urinary bladder; G.b., gallbladder; L.K., left kidney; P (Above duodenum), pancreas; P (below G.b.), pylorus; R.K., right kidney; V.s., vesicular gland. Costal attachment and median line of diaphragm are indicated by dotted lines.

Caecum

Simple and relatively small, about 75cm in length with a capacity of about 8 litres (about 1.5 litres in the sheep). At the junction of the ileum with the large intestine, the caecum is continuous cranially with the colon and **extends caudodorsally in the right flank**, usually ending with its apex lying to the right of the pelvic inlet. It is **separated from the right flank by the greater omentum**. There are no taenia or haustra. The **caecocolic orifice** opens into the colon.

Colon (about 10 m in length)

Ascending colon

The great increase in length of the colon of ruminants, compared to carnivores, is due to elongation of the ascending colon. A spiral loop forms in the embryo, but is flattened into a **sagittal disc in the adult**, which lies between the layers of the mesentery, but is always on the left side of the blood vessels.

Proximal loop begins as the **direct continuation of the caecum**.

Runs cranial to ~ the level of the **ventral aspect of the last 2 ribs** before **doubling back** on itself. It is **separated from the abdominal wall in the right paralumbar fossa by the duodenum and the greater omentum**. Ventral to the caudal flexure of the duodenum, the **proximal loop turns medially around the caudo-dorsal border of the mesentery** and **runs cranially on the left side of the mesentery**. Then continues ventrally as the first part of the spiral loop.

Spiral loop is composed of:

Centripetal coils – usually 2 full turns in the cow.

Central flexure is at the centre of the spiral loop.

Centrifugal coils – usually 2 full turns, the last continuing into the distal loop.

Distal loop extends dorsally and caudally on the proximal loop and turns around the caudal border from the left to the right of the mesentery and runs cranially on the right side, medial to the proximal loop and continues into the transverse colon.

Transverse colon

Is **very short**. Passes from right to left around the cranial surface of the cranial mesenteric artery and is **continued by the descending colon**.

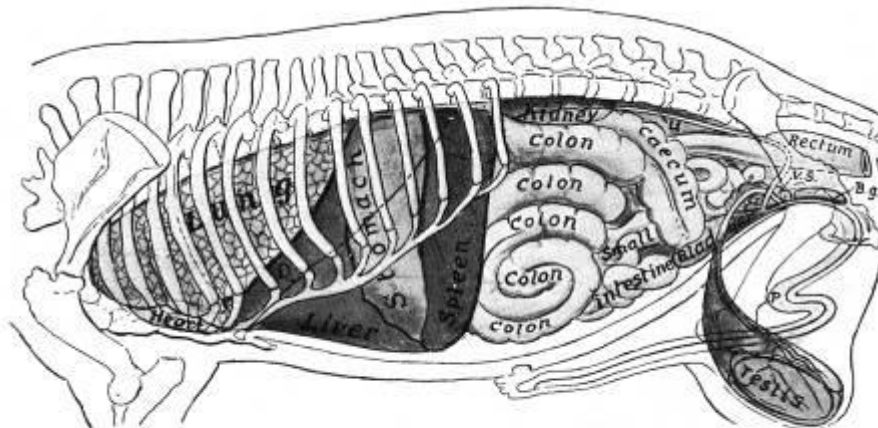
Descending colon

Runs caudally dorsal to the ascending duodenum. **Inclines to the right** under the right kidney, **forming a slight S-shaped flexure near the pelvic inlet and joins the rectum**. There is no ampulla in the rectum.

Pig



The large intestine is about 4–4.5 m in length and is mostly **much wider than the small intestine**. It is connected by a mesentery with the dorsal abdominal wall between the kidneys.



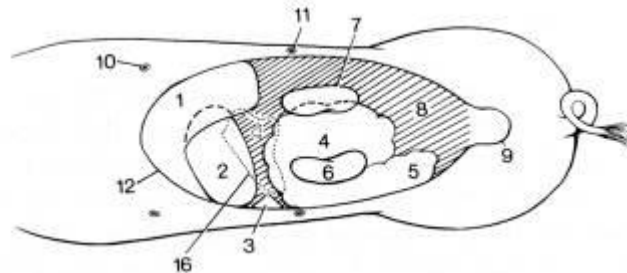
Getty 1975

FIGURE 40-26. Projection of viscera of pig on body wall; left side.

B.g., Bulbourethral gland; D, costal line of diaphragm; P, penis; U, ureter; V.S., vesicular gland.

Figure 36-3. A, Dorsal projection of the abdominal cavity showing the approximate position of the major abdominal organs, schematic.

1, Liver; 2, stomach; 3, spleen; 4, mass of ascending colon; 5, cecum; 6, left kidney; 7, right kidney; 8, space for small intestine; 9, pelvic cavity; 10, position of fifth rib; 11, position of last rib; 12, position of diaphragm; 16, pancreas;



Modified from Dyce et al 2002

Caecum

Large, cylindrical and approximately 20-30 cm long, **containing 3 taenia and 3 rows of haustra**. **Located against the dorsal and cranial part of the left flank** and extends ventrally, caudally and medially, caudal to the coiled part of the colon. Its ventral blind end – the **apex** – **usually lies on the floor of the abdomen**, near the median plane. The **dorsal end is directly continuous with the colon**.

Colon

Is initially as large as the caecum but **gradually decreases in calibre**. It **lies chiefly to the left of the median plane, caudal to the stomach**.

The ascending colon – Greatly elongated in the pig and is coiled to form a cone shaped mass.

Base of the cone is **dorsal** and is attached to the roof of the abdominal cavity near the left kidney and the pancreas.

Apex of the cone is ventral and reaches the floor of the abdomen.

The **centripetal turns** are located **on the outside of the cone**

They **form a conical clockwise (viewed dorsally) spiral of 2–3 coils**.

This portion **has 2 taenia and 2 rows of haustra**.

The **centrifugal turns** are concealed **in the centre of the cone**

The coils return to the base in tight counterclockwise turns.

The **calibre** of this **portion markedly reduces** in size.

This narrow part has **no taenia or haustra**.

The **final turns** continues as the **transverse colon**.



The **duodenum** passes caudally from the right surface of the gizzard and most of the U-shaped duodenal loop lies on the abdominal floor and follows the caudal curvature of the gizzard. The **pancreas** lies largely between the loop and **empties into the distal end of the duodenum** (ascending duodenum) via **3 pancreatic ducts** along with 1 or 2 hepatic ducts. The **umbilical and supraduodenal loops** of the small intestine are equivalent to the **jejunum and ileum** of mammals and constitute the longest portion of the alimentary tract. The jejunum and ileum can be difficult to demarcate from each other, with the **vitelline diverticulum (Meckel's diverticulum)** often used to define the junction.

The **large intestine** usually comprises **two caeca** and the colon. The caeca are relatively long and large in the chicken and owl, small in the pigeon and passerine birds and absent in the psittacines. When present, the caeca arise at the ileocolic junction and pursue retrograde courses beside the ileum to which they are attached by ileocecal folds. They pass cranially at first, then double back, allowing the blind ends to lie near the cloaca. Bacterial breakdown of cellulose occurs in the caeca. The **colon** is short and only slightly wider than the small intestine and terminates at the cloaca.

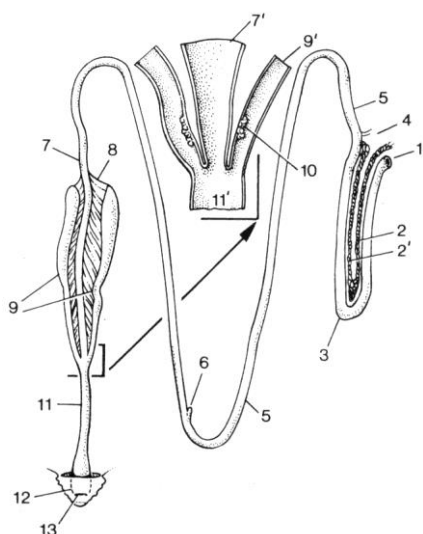


Figure 39-13. Isolated intestinal tract with detail of ileocolic junction.

1, Pylorus; 2, 2', dorsal and ventral lobes of pancreas; 3, duodenal loop; 4, bile and pancreatic ducts entering duodenum; 5, jejunum; 6, vitelline diverticulum; 7, ileum; 7', ileum opened; 8, ileocecal fold; 9, caeca; 9', cecum opened; 10, cecal tonsil; 11, colon; 11', colon opened; 12, cloaca; 13, vent.

Dyce et al 2002

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Points to think about

- The gross anatomy of the equine caecum and its position in the abdominal cavity.
- The components of the large (great) colon of the horse and its general course in the abdomen, from its origin at the caecum until its termination in the small colon.
- The general position of the caecum and great colon of the horse in relation to the abdominal wall. Think about which components of these structures are usually palpable via the rectum.
- The general position of the small intestine and small colon in the equine abdomen. Think about how you would differentiate between these two parts of the intestine.
- Comparison between the opening of the bile and pancreatic duct systems in the duodenum of the dog, horse, cow, sheep and pig.
- The meaning of the terms taenia and haustra as they relate to the digestive system and in what domestic species they are found.
- The components of the colon of the cow and their general anatomy.
- The gross anatomy of the ascending colon of the pig.

