

Veterinary Bioscience 1: Digestive system

Lecture 6 – The compound stomach of the ruminants

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Key words

Compound stomach; reticulum; rumen; omasum; abomasum; digestion

Intended Learning Outcomes

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

- describe the anatomy of the ruminant stomach
- demonstrate an understanding of its position in the body and relationships to other organs.
- integrate the structural features of the different components of the compound stomach with their function.
- note any species differences.

THE COMPOUND STOMACH

Function is to act as a **fermentation chamber** where fodder (composed of complex carbohydrates) is broken down into useable metabolites by symbiotic micro-organisms.

The relative **sizes of the four compartments vary with age**, in correlation with the nature of the food ingested.

Occupies almost three quarters of the abdominal cavity - fills almost the **entire left half of the abdominal cavity** in the adult animal, extending from diaphragm to pelvic inlet and extends considerably over the median plane into the right half.

It has **four compartments** which are grouped into:

The **fore-stomach (or proventriculus)** which is **non glandular** -
Rumen
Reticulum
Omasum

The **Abomasum** which is **glandular**

At birth, the **abomasum** is the **largest compartment**; In the **adult**, the **rumen** is the **largest**

The **reticulum**:

Is the **smallest** compartment in **cattle**
Lies on the left side cranial to the rumen

The **omasum**:

Is the **smallest** compartment in **sheep**
Lies on the right side of the rumen and reticulum

The **abomasum**:

Is somewhat **elongated and lies on the abdominal floor**

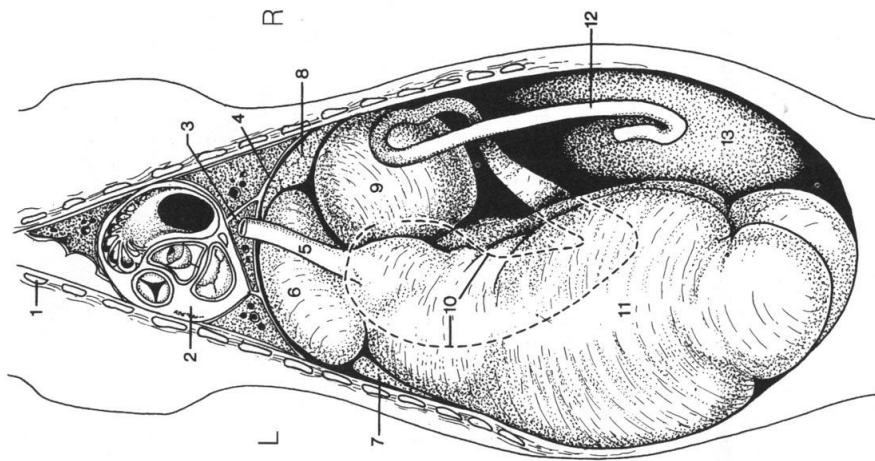


Figure 28-14. Dorsal section of the thorax, and dorsal view of the stomach and intestinal mass to illustrate the topography of the bovine thoracic and abdominal organs.

1, First rib; 2, heart sectioned at the level of the valves; 3, accessory lobe of right lung; 4, diaphragm; 5, esophagus; 6, reticulum; 7, spleen; 8, liver; 9, omasum; 10, outline of abomasum; 11, dorsal sac of rumen; 12, descending duodenum; 13, intestinal mass.

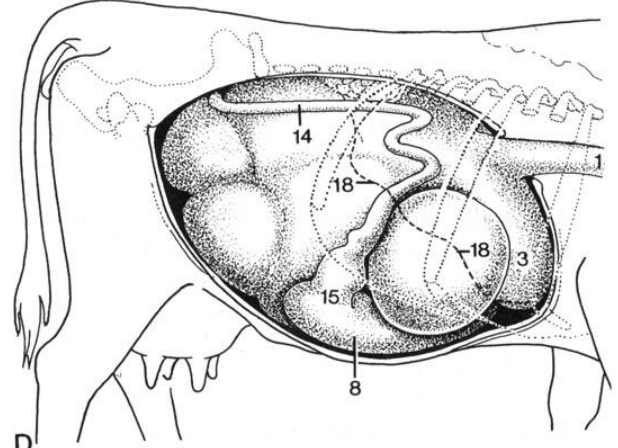
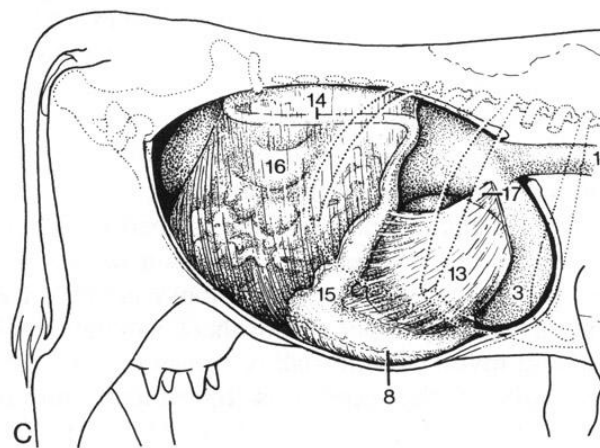
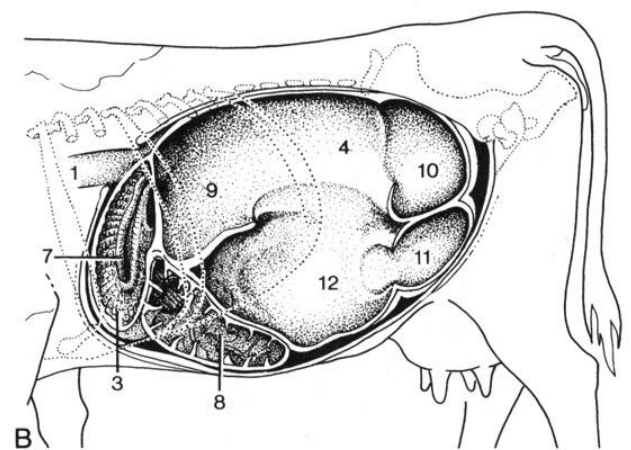
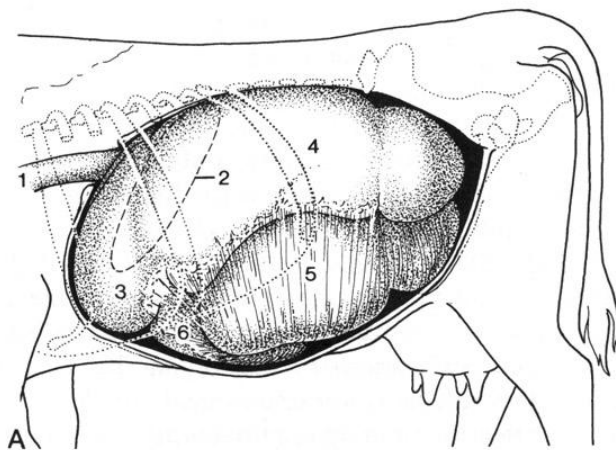


Figure 28-4. Topography of the abdominal viscera. *A*, Relationship of abdominal viscera to the left abdominal wall. *B*, The interior of the stomach seen from the left. *C*, Relationship of abdominal viscera to the right abdominal wall; the liver has been removed. *D*, Position of the parts of the stomach seen from the right.

1, Esophagus; 2, outline of spleen; 3, reticulum; 4, dorsal sac of rumen; 5, ventral sac of rumen, covered by superficial wall of greater omentum; 6, fundus of abomasum, covered by superficial wall of greater omentum; 7, reticular groove; 8, body of abomasum; 9, atrium ruminis; 10, caudodorsal blind sac; 11, caudoventral blind sac; 12, ventral sac of rumen (opened); 13, omasum, covered by lesser omentum; 14, descending duodenum; 15, pyloric part of abomasum; 16, greater omentum covering the intestinal mass; 17, lesser omentum cut away from the liver; 18, position of caudoventral border of liver.

RETICULUM - Alternative term: the honeycomb.

Lies on the **left side, opposite the 6th to 8th ribs**; it is the **most cranial compartment**. It contributes ~ **5% of total stomach capacity in Ox** (~ 7-8% in sheep). The reticulum reaches from the cardia to the **most forward part of the diaphragm** and occupies the full height of this shallower part of the abdomen.

It also passes across the midline, especially **ventrally**, where it **lies above the xiphoid process** of the sternum. External pressure applied in this position will elicit a pain response in cases of reticulitis (inflammation of the reticulum).

External features:

- Is somewhat pear-shaped, but is flattened craniocaudally.
- **Diaphragmatic surface** is convex and lies **against the diaphragm and liver**.
- **Visceral surface** is flattened and lies **against the atrium of the rumen**.
- Dorsally it ends by joining the wall of the rumen.
- **Ventrally** the **fundus** of the reticulum forms a rounded cul-de-sac that is **in contact** with the sternal part of the **diaphragm**, the **liver**, the **omasum** and the **abomasum**.

Internal features:

- **Three openings** -
 - Cardia** - is the **slit like** opening of the oesophagus positioned at the junction of the rumen and reticulum and **opens into both chambers**.
 - Ruminoreticular orifice** - wide opening between the rumen and reticulum which communicate over the **U-shaped ruminoreticular fold**.
 - Reticulo-omasal orifice** - round exit into the omasum at the **lower end of the reticular groove**.
- **Reticular groove** -
 - On the **medial wall** - extends from **the cardia to the reticulo-omasal orifice**.
 - The **mucosal surface** lining the floor of the groove is **smooth and pale**.
- **Primary folds** (reticular folds) -
 - Reticular **mucosa** is **harsh** and usually **stained a greenish brown** and has a distinctive pattern of ridges about 1cm high - **primary folds** - which form **honeycomb-like** structures (four-, five-, and six-sided **reticular 'cells'**). This honeycomb pattern becomes less regular toward the junction with the rumen and gradually merges with the ruminal surface.
 - There are shorter **secondary folds** within the cells.
 - Low **papillae** are present **on these primary and secondary folds** and on the cell floors.

Structure of the wall

contains the usual 4 layers of –

- Mucosa,
- Submucosa,
- Muscularis externa and
- Serosa

(Banks 1986)

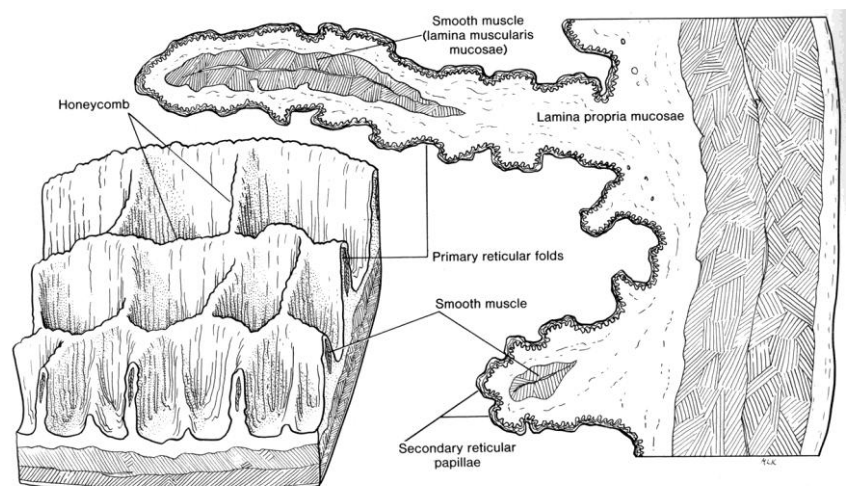


Figure 21.43. A three-dimensional and cross-sectional diagram of the wall of a reticulum. An isolated mass of smooth muscle is located in the tip of the reticular fold.

Functions:

- Serves as a sieve for coarse material
- Absorbs fatty acids, water, salts, etc.
- Passes coarse material back to the rumen and fine material to the omasum by **very forceful contractions**.
- Heavy materials such as ingested nail or wire lodge in the reticulum - will give rise to **traumatic reticulitis** ('hardware disease') and can lead to fatal pericarditis.

The RUMEN

(Alternative term: paunch)

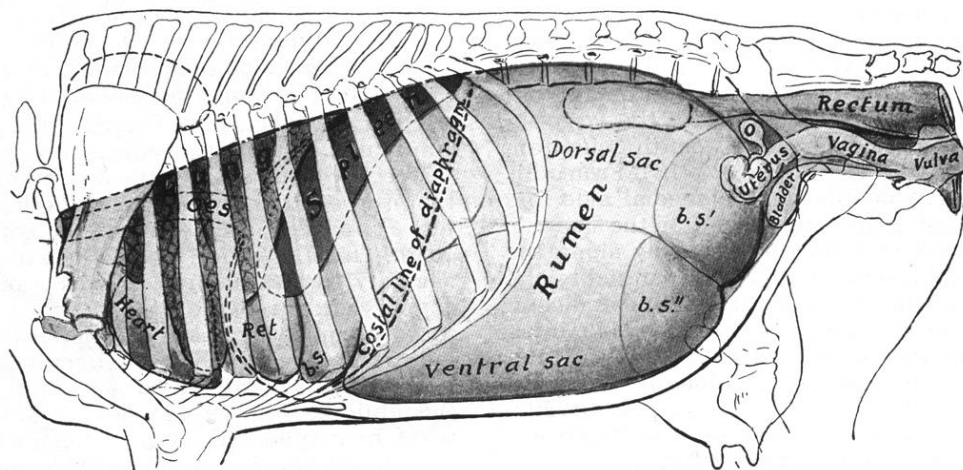


FIGURE 29-54. Projection of viscera of cow on body wall; left side.

b.s., Atrium of rumen; b.s.', b.s'', blind sacs of rumen; O, ovary; Oes, esophagus; Ret., reticulum. The left kidney, concealed by the dorsal sac of the rumen, is indicated by dotted lines. The median line of the diaphragm is dotted.

Getty 1975

Fills the **left half of the abdominal cavity** extending from the **8th rib to the pelvic inlet**.

From the **abdominal roof to the floor** and from the **left body wall across the midline, especially caudally and ventrally** - Contributes **~80% of total stomach capacity**.

The dorsal sac of the rumen may be palpated per rectum. Direct **contact of the dorsal sac with the upper part of the left flank** facilitates auscultation and palpation and easy access for decompression in cases of "bloat".

External features: compressed laterally and has:

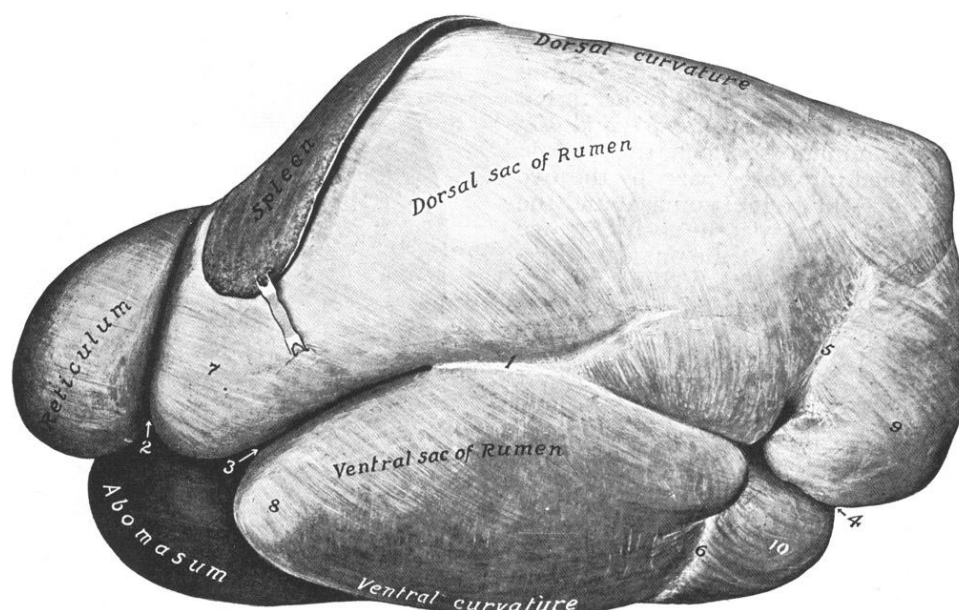
- **Dorsal curvature** - is firmly attached to the sublumbar muscles on the left by peritoneum and connective tissue as far caudal as the 4th lumbar vertebrae.
- **Ventral curvature** - lies on the floor of the abdomen with the superficial wall of the omental bursae between.

Has two surfaces: **Parietal or left surface:**

- Is convex
- **Is related to the diaphragm, the left wall of the abdomen and the spleen**

The superficial wall of the **greater omentum** intrudes between the ventral sac of the rumen and the abdominal wall

Getty 1975



Getty 1975

FIGURE 29-33. Stomach and spleen of ox; left side.

1, Left longitudinal groove of rumen; 2, ruminoreticular groove (not so distinct dorsally as indicated here); 3, cranial groove of rumen; 4, caudal groove of rumen; 5, 6, left dorsal and ventral coronary grooves; 7, atrium of rumen; 8, cranial end of ventral sac; 9, caudodorsal blind sac; 10, caudoventral blind sac.

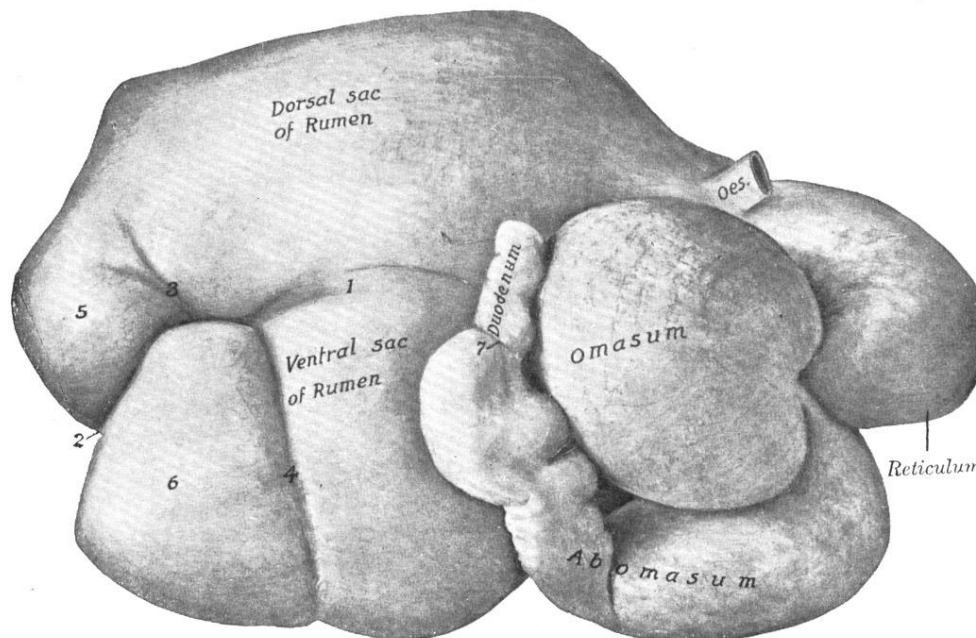


FIGURE 29-34. Stomach of ox; right side.

Oes, esophagus; 1, insula between right longitudinal groove below, and accessory groove above; 2, caudal groove of rumen; 3, 4, right dorsal and ventral coronary grooves; 5, 6, caudodorsal and caudoventral blind sacs; 7, pylorus. The positions of the reticulum, omasum, and abomasum have been altered by removal of the stomach from the abdominal cavity and inflation.

Visceral or right surface:

Related chiefly to the **omasum, and abomasum, intestines and liver.**

Has many grooves which demarcate it into **several sacs**:

- **Dorsal sac**
- **Ventral sac**
- **Caudodorsal blind sac**
- **Caudoventral blind sac**
- **Cranial sac**
- And the **insula ruminis** - an elliptical area which is not a proper sac

External Grooves:

- **Cranial groove** - transverse groove that divides the cranial end of the rumen into the cranial sac (**ruminal atrium**) and the cranial end of the ventral sac
- **Rumino-reticular groove** - is the line of separation between the ruminal atrium and the reticulum. It is deep ventrally but dorsally the wall of the reticulum and the rumen are continuous and form the dome-like **ventricular atrium** on which the oesophagus terminates.
- **Right and Left longitudinal grooves** - extend from the cranial to caudal grooves and indicate the division of the rumen into dorsal and ventral sacs.
- **Right and Left accessory grooves** -
- The right accessory groove forms a convex curve dorsal to the right longitudinal groove but is joined to it at both ends. The elliptical area on the surface of the rumen that it encloses is referred to as the **insula ruminis**.
- The left accessory groove arises from the middle of the left longitudinal groove and extends caudodorsally and fades out.
- **Right and Left dorsal coronary grooves** - demarcates the caudodorsal blind sac from the dorsal sac
- **Right and Left ventral coronary grooves**
- **Caudal groove** - deep transverse groove that divides the rumen into the caudodorsal and caudoventral blind sacs

Internal features:

Pillars - internally the grooves correspond to bands of smooth muscle known as pillars. These pillars bear the same name as the grooves:

- **Cranial pillar** - marks off the cranial extremity (ruminal atrium) from the rest of the dorsal sac. Right and left ends extend caudally as the longitudinal pillars
- **Rumino-reticular fold** - U-shaped fold that bounds the rumino-reticular orifice at the cranial end of the ruminal cavity
- **Ruminal pillars** - left and right - encircle the rumen dividing it into dorsal and ventral major sacs
- **Accessory pillars** - right curves around the insula ruminis
- **Coronary pillars** - mark off the caudal blind sacs
- **Caudal pillar** - separates the caudodorsal and caudoventral blind sacs

NB: No dorsal demarcation between the rumen and the reticulum - region is termed the **ventricular atrium**- area where the oesophagus enters the stomach

NB: **Ruminal atrium** is that part of the rumen caudal to the rumino-reticular fold.

Rumino-reticular orifice - the opening into the reticulum.

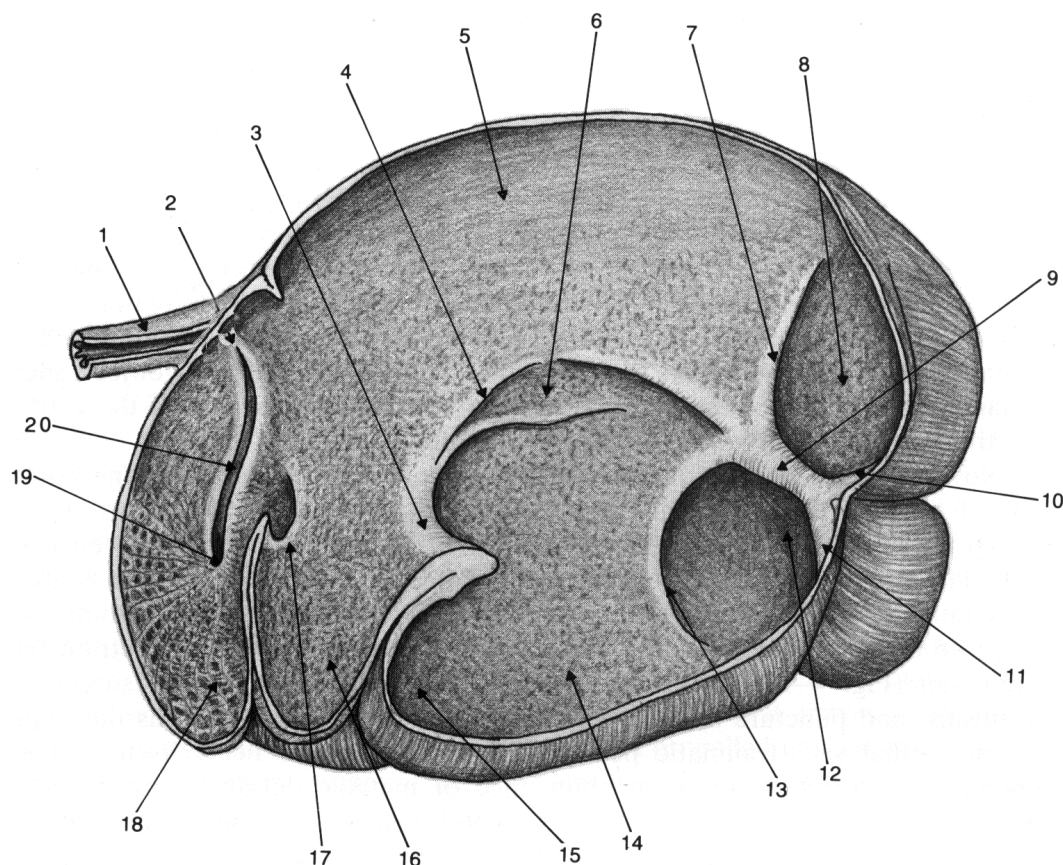


FIGURE 4-14. Internal features of ruminoreticulum of adult ox, left lateral view.

- | | |
|--|--|
| 1. Esophagus | 10. Left dorsal coronary pillar of rumen |
| 2. Cardiac opening | 11. Left ventral coronary pillar of rumen |
| 3. Cranial pillar of rumen | 12. Caudodorsal blind sac of rumen |
| 4. Right longitudinal pillar of rumen | 13. Right ventral coronary pillar of rumen |
| 5. Dorsal sac of rumen | 14. Ventral sac of rumen |
| 6. Insula ruminis (area of right ruminal wall between dorsal and ventral branches of right longitudinal pillar of rumen) | 15. Recess of rumen |
| 7. Right dorsal coronary pillar of rumen | 16. Cranial sac of rumen |
| 8. Caudodorsal blind sac of rumen | 17. Ruminoreticular fold |
| 9. Caudal pillar of rumen | 18. Reticulum |
| | 19. Reticulo-omasal opening |
| | 20. Reticular groove |

After Smallwood 1992

Rumen Papillae

– The rumen surface is covered with prominent projections known as papillae which vary in height according to age, diet and location.

Papillae:

Are **long** and numerous in the **ventral** and **dorsal caudal blind sacs**.

Fewer and less prominent in the **ventral sac**.

Are **short or absent** on the roof of the **dorsal sac** - due to the presence of gas bubbles resulting from fermentation.

NB: Volatile fatty acids stimulate development of papillae.

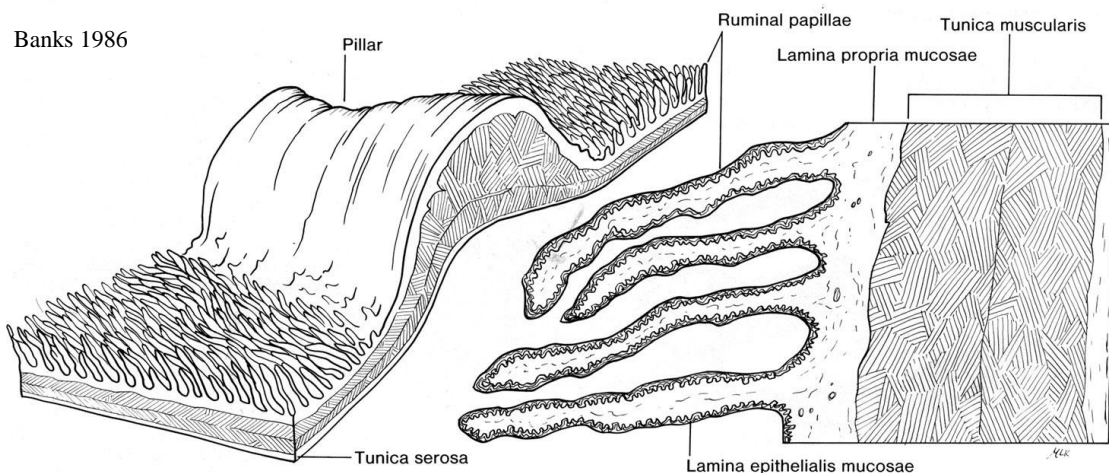


Figure 21.40. A three-dimensional and cross-sectional drawing of the wall of a rumen. The core of connective tissue is all that is contained within the papillae.

Functions of the rumen:

- Ruminal contractions mix the ingesta and furthers the process of microbial fermentation releasing volatile fatty acids and gases.
- The absorption of volatile fatty acids, sodium, water, etc.
- Papillae increase the surface area for absorption and assist mixing of ingesta.
- Papillae also serve as heating rods for speeding up the fermentation process.
- Rumination and eructation.

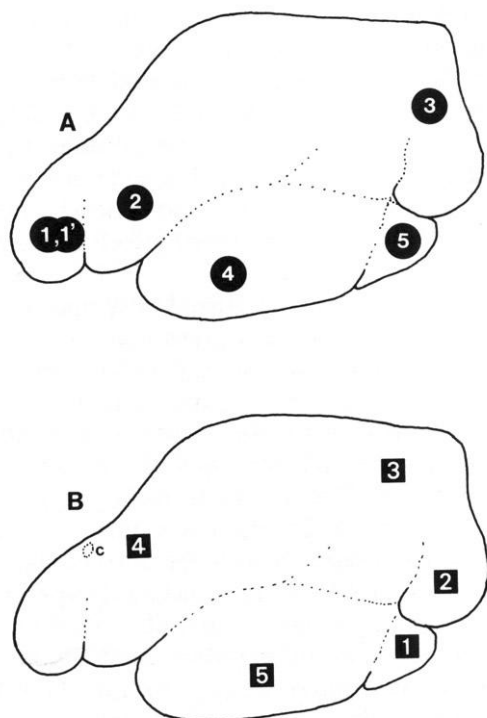


Figure 6-17. The "A" and "B" sequences. The pattern of the most important sequential, regional contractions of the wall of the reticulo-rumen are shown. A: Steps 1 to 5 show the typical sequence of contractions ("A" sequence), responsible for mixing the contents of the rumen. Note that this begins with a double (or biphasic) contraction of the reticulum (1 and 1'). The contraction is next evident in the anterior dorsal sac (2) of the rumen, the caudal region (3), the main ventral rumen (4), and finally in the caudoventral sac (5). B: The eructation—or "B"—sequence starts in the caudoventral blind sac (1), sweeps forward across the dorsum (2 and 3) to reach the vicinity (4) of the cardia (c), then is completed with contraction of the main ventral rumen (5).

Currie 1988

The OMASUM

(Alternative terms: the book or the butcher's bible).

Contributes ~ **7 – 8% of total stomach capacity** in the ox. It lies mainly on the **right of the midline** extending from the **7th to the 11th rib**. It is positioned with the rumen and reticulum on its left and the liver and body wall on its right. This is the **smallest compartment in the sheep and the goat**.

External features:

- Is spherical to ellipsoidal in shape, but is somewhat compressed laterally.
- Has **greater and lesser curvatures**:
 - Greater curvature faces dextrocaudally.
 - Lesser curvature faces levocranially.
- Lower pole of the omasum has an extensive attachment to the fundic region of the abomasum around the omaso-abomasal orifice.
- Much of the **right surface** of the omasum is **covered** by, and is partly **connected to**, the **lesser omentum**.

Internal features:

- **Two openings** -
 - Reticulo-omasal orifice** is at the **upper end** of the **omasal canal**.
 - Omaso-abomasal orifice** at the **lower end** of the **omasal canal** is large and oval and partly obscured by the prolapse of the abomasal folds.
- **Omasal groove** -
 - Runs between the two openings and is in fact the **floor of the omasal canal**.
 - Mucosa in this region is smooth except for a few low longitudinal ridges.
- **Omasal laminae** -
 - Many **parallel folds** of **four different sizes** that fill the omasum.
 - Arise from the sides and greater curvature and project towards the lesser curvature - site of the omasal canal.
- **Interlaminar recesses** - spaces between the folds.
- **Omasal canal** - central area not occupied by folds.
- **Papillae** – The mucosa forms numerous projections or papillae that cover the surface of the laminae. Most are small and somewhat flattened but there are a few large conical projections.

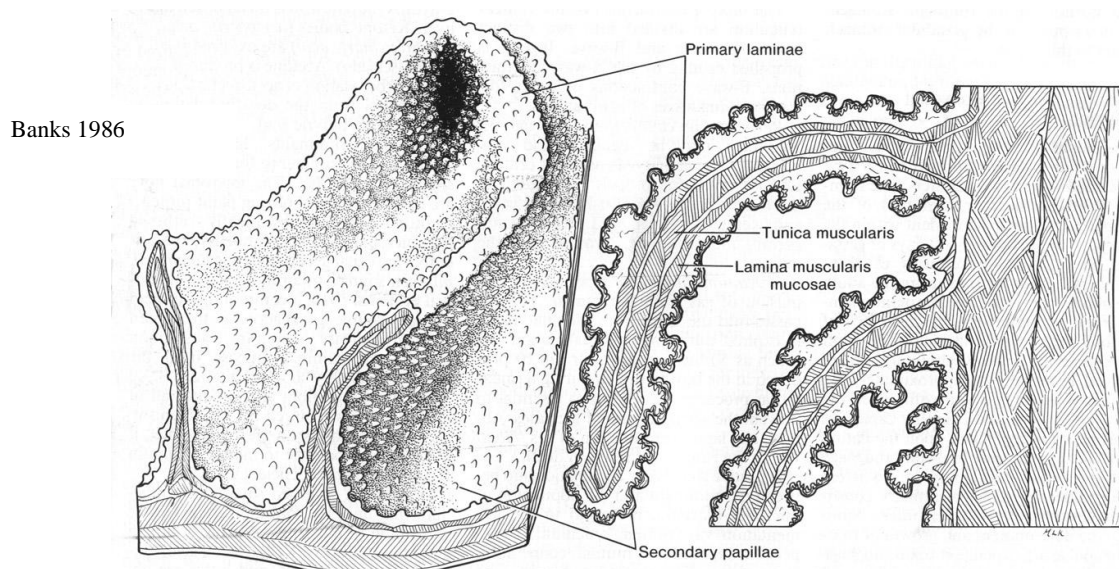


Figure 21.45. A three-dimensional and cross-sectional drawing of the wall of an omasum. Note that the core of the laminae contains elements of the lamina muscularis mucosae and tunica muscularis.

Functions:

- Absorbs fatty acids, water, salts.
- Serves as a two-stage pump for transfer of ingesta from the reticulum to the abomasum.
- It is a sieve for quality control separation.

The ABOMASUM

(Alternative term: 'true stomach').

This is a somewhat elongated sac which chiefly **lies on the abdominal floor** - partly between the ventral sac of the rumen and the reticulum. The caudal end is flexed around the lower pole of the omasum. Contributes ~ 7-8 % of total stomach capacity in ox.

Position and relations of the abomasum depend upon:

Age; Pregnancy; The fullness of the different parts of the compound stomach; Intrinsic abomasal activity; and the contractions of the rumen and reticulum to which the abomasum is attached.

But there is a limit to normal variation beyond which deviations produce digestive disturbance:

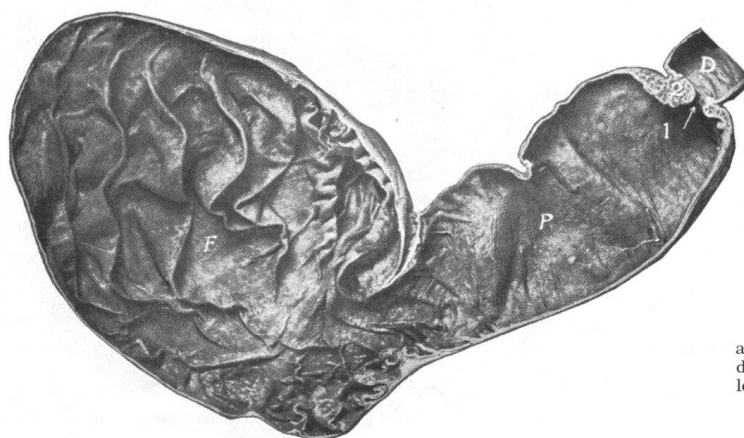
Abomasal displacement - left or right - is a well recognised disorder, especially in dairy cows.

External features: Are basically similar to the simple stomach (see lecture 9).

- The **larger cranial pole:**
Forms a pear-shaped sac equated with the **fundus and body** of the simple stomach
Connected by muscle bundles **to the reticulum, ruminal atrium and the ventral sac of the rumen.**
- The **narrower caudal pole:**
Forms **the pyloric region.** This passes transversely to the right; Terminates at the pylorus just caudal to the lower part of the omasum

Internal features:

- **Two openings -**
Omaso-abomasal orifice
Pylorus - opens into the duodenum (upper small intestine)
- **Spiral folds –**
The **dark mucosa** of the abomasum is thrown up into many spiral folds that arise around the entrance and course over the walls of the fundus and body, decreasing as they approach the flexure; they serve to increase the mucosal surface area. In the region of the omasal-abomasal orifice these folds help to form a **mucosa "plug"** that limits reflux of ingesta into the omasum.
- **Torus -**
The **lighter mucosa** of pylorus bears a few low rugae but is marked by a **large swelling that projects from the lesser curvature to narrow the pyloric passage.** The vascular structure of the torus suggests it is capable of engorgement, but its functional significance is unknown.



Getty 1975

FIGURE 29-46. Interior of abomasum of ox.

F, Body of the abomasum with abomasal folds; P, pyloric part; D, duodenum; 1, pylorus; 2, torus pyloricus.

Structure of the wall

- Mucosa - is smooth pink and glandular; a **thick muscularis mucosa is present**
- Submucosa
- Muscularis externa - smooth muscle thicker inner (circular) and a thin outer (longitudinal) layer.
- Serosa is absent from the surface only along the origin of the omentum

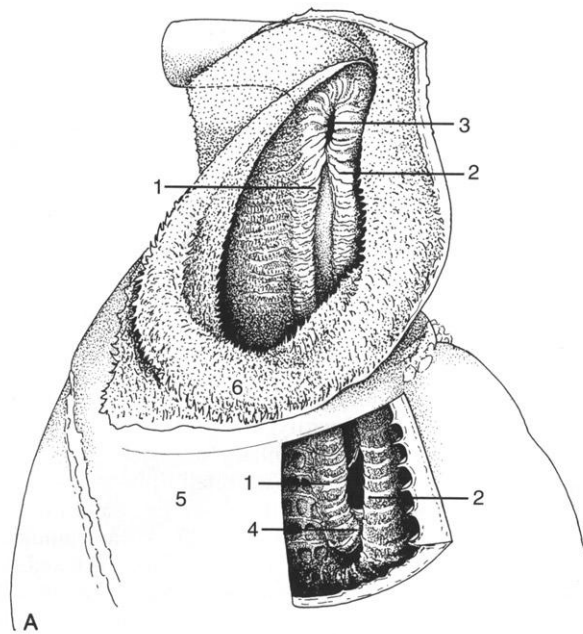
Functions:

Is **rich in glands** that produce digestive enzymes and HCl for digestion and mucus for protection.

GASTRIC GROOVE

(Alternative name: oesophageal groove).

Function: Serves as a conduit for **conveying milk from the oesophagus into the abomasum** without having to go through the rumen



Dyce et al 2002

Figure 28-15. Opening of esophagus into stomach with the course of the (slightly untwisted) reticular groove (A),

1, Left (cranial) lip of reticular groove; 2, right lip of reticular groove; 3, cardiac orifice; 4, reticulo-omasal orifice; 5, wall of reticulum; 6, ruminoreticular fold;

Consists of **three segments** -

- **Reticular groove** -
 - From the **cardia to the reticulo-omasal orifice**
 - Bounded by two **prominent muscular folds**
 - Passes ventrally on the medial wall of the atrium and reticulum**
 - It is open along its left side facing the cavity of the reticulum and rumen
 - Muscular folds **roll into a tube when a young animal drinks milk**
- **Omasal groove** -
 - From **reticulo-omasal orifice to omaso-abomasal orifice** on floor of omasum
 - Muscular folds are not very prominent
 - It is open along its right side facing the cavity of the omasum
- **Abomasal groove** -
 - Not a proper groove, just **an area without gastric folds**
 - It extends along the lesser curvature of the abomasum

Blood and nerve supply to the compound stomach

Blood Supply - branches of the **celiac artery**; veins are satellites to the arteries eventually draining into the portal vein.

Nerve supply - branches from the dorsal and ventral trunks of the vagus nerve.

Comparative aspects: Small ruminants - sheep and goat

- **Reticulum**
Is **relatively larger** (7-8% of total stomach capacity).
Contact with the ventral abdominal floor is subject to much variation.
- **Ventral Sac of Rumen**
Is relatively **larger**.
Extends **more to the right of the midline**.
- **Caudodorsal Blind Sac of Rumen**
Extends more caudally than the dorsal blind sac.
- **Omasum**
Is the **smallest** compartment (~5% of total stomach capacity)
- **Abomasum**
Is relatively larger.
Due to smaller size of the omasum is usually in direct contact with the liver.

Getty 1975

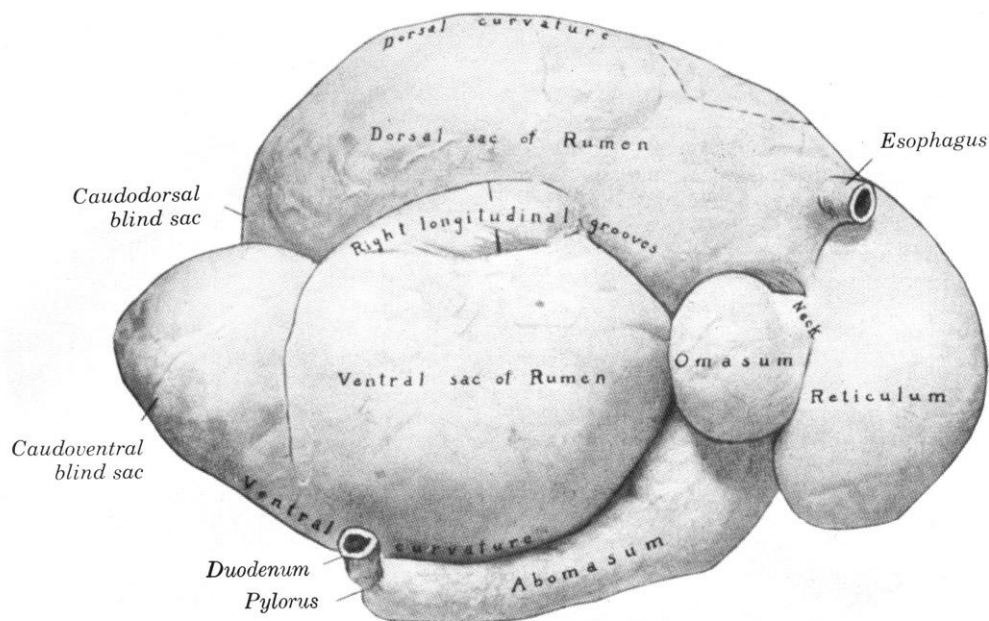


FIGURE 29-35. Stomach of sheep; right side.

From a photograph of a specimen fixed *in situ*. Dotted line indicates position of spleen.

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Points to think about:

- The position of the rumen in the body of the adult and its relationship to other structures.
- The components of the gastric groove and their gross anatomy. The function of the gastric groove.
- The external and internal features of the reticulum.
- The position of the reticulum in the adult cow and how this is related to the potential for development of disease of the pericardium.
- The external and internal features of the rumen.
- The relationship of the gross anatomy of the rumen to its function.
- The internal features of the omasum and its function.
- The position of the abomasum in the adult non-pregnant cow.
- Comparisons between the compound stomach of the cow and the sheep.

