RAMA UNIVERSITY

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FACULTY OF AGRICULTURAL SCIENCES AND ALLIED INDUSTRIES

Digestive System of Cattle

Mouth and Teeth

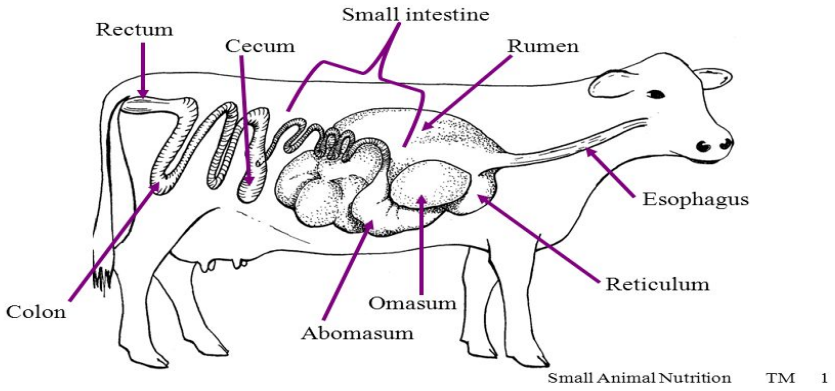
Cattle belong to a class of animals known as ruminants. Ruminants are cloven hooved animals that have four compartments to their stomach and chew their cud. In addition, ruminants have an unusual configuration of teeth. Their small and large intestine are designed to handle large volumes of material. Cattle evolved to exist on large amounts of fiber. They do not do well on all grain or high fat diets.

The mouths of cattle are very different from most nonruminant animals. Cattle have 32 teeth. They have 6 incisors and 2 canines in the front on the bot tom. The canines are not pointed but look like incisors. There are no incisors on the top; instead cattle have a **dental pad**. Cattle have 6 premolars and 6 molars on both top and bottom jaws for a total of 24 molars. In addition, there is a large gap between the incisors and molars. This configuration allows cattle to harvest and chew a large amount of fibrous feed.

Because their teeth are primarily for grinding, cattle use their tongues to grasp or gather grass and then pinch it off between their incisors and dental pad. Since they lack upper incisors, cattle cannot bite off grass very well, and they are inefficient at grazing closely. The inside of the cheeks and palate are rough which helps hold feed in while cattle chew with a side to side motion.

In addition to reducing the size of feed particles, the mouth aids in digestion by adding saliva to the feed. Cows will produce 20-35 gallons of saliva a day. The saliva helps moisten the feed. Saliva also contains sodium bicarbonate to keep the rumen at the proper neutral pH (6.5-7.2) for good microbial growth. Much of the water contained in saliva is recycled by the cow.

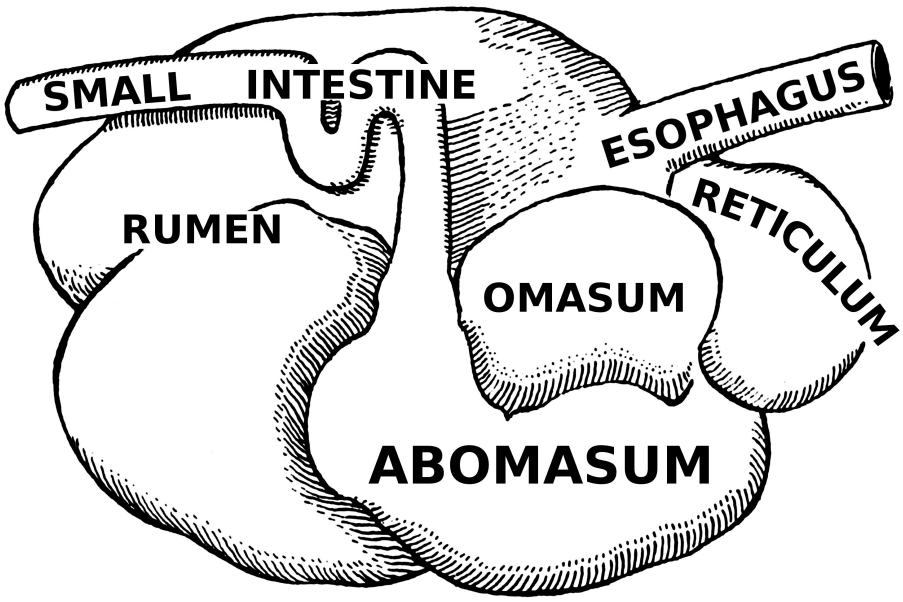
The Ruminant Digestive System



Stomach

The four compartments of the cattle stomach are the rumen, reticulum, omasum, and abomasum. The **rumen** is the largest compartment, and it contains billions of bacteria, protozoa, molds, and yeasts. These microorganisms live in a symbiotic manner with the cow, and they are the reason cattle can eat and digest large amounts of roughage. The rumen microorganisms are adaptable enough that cattle can digest a large variety of feeds from grass, hay, and corn to brewer's grains, corn stalks, silage, and even urea.

The bacteria and protozoa do most of the digestion of feeds for the cow. This is a tremendous factory. There are 25 to 50 billion bacteria and 200 to 500 thousand protozoa in every milliliter of rumen fluid (about 0.06 ounces). The microorganisms digest the plant fiber and produce volatile fatty acids. These fatty acids are absorbed directly through the rumen wall and supply 60 to 80 % of the energy needed by the cow. In addition to energy, the microorganisms produce protein including essential amino acids from the protein and nitrogen the cow ingests. Because the microbes can use nitrogen to make protein, cows can eat urea and other sources of non-protein nitrogen that would kill non-ruminants. The microbes also make vitamins B and C.



The **reticulum**, with its honeycomb like lining, is a compartment of the stomach that is involved with rumination. It also acts as a trap for foreign objects ingested by the cow. It is not unusual to find rocks, nails, and pieces of wire and metal in the reticulum of cattle. If wire or metal punctures the side of the reticulum, it can cause “hardware disease.” Hardware disease is actually an irritation or infection of the diaphragm, heart or lungs. It is hard to treat, but can be prevented by keeping metal trash out of pastures. Specially shaped magnets can be administered to cows to decrease the possibility that ingested metal will pierce the digestive tract. These magnets stay in the reticulum for the life of the animal.

When cattle ruminate, or chew their cud, they are regurgitating a bolus of incompletely chewed feed. In order for the microbes to digest fiber rapidly and efficiently it must be in small pieces, so cattle re-chew their food several times. Cows also eructate or belch giving off carbon dioxide and methane. When cows “lose their cud” or stop ruminating, it is an indication that they have a digestive upset, and their rumen is not functioning properly.

Bloat is another condition that occurs when cows can’t eructate. It is caused by a rapid change in feed or overeating grain (gaseous bloat) or grazing pure stands of clover or alfalfa (frothy bloat). Gaseous bloat is a result of improper digestion or fermentation of grain. It is treated by passing a tube into the rumen or using a trocar and cannula to make an external opening in the rumen to release the gas pressure. The procedure may have to be repeated. Frothy bloat is a result of surfactants in legumes causing gas to be trapped in a bubbly foam. Large amounts of mineral oil must be

forced into the rumen via a tube to break up the bubbles as a treatment for frothy bloat. Bloat must be treated quickly as the increased rumen size and pressure interferes with normal breathing.

The incidence of bloat in cattle grazing legumes can be reduced by maintaining at least 50% of the stand as grass. Also, cattle should not be turned out onto a pasture with a high percentage of legumes when cattle are hungry or the pasture is wet. Once cattle are adapted to legume/grass pastures, they can graze it even when wet. A final option is to use “bloat guard” blocks which contain poloxolene.

Although rumen microbes can digest a great variety of different feeds, they are very sensitive to drastic changes in feeds. Some groups of microbes are better at digesting fiber (forages), whereas others are better at digesting starch (grains). Changing rapidly from a forage-based diet to a grain-based diet causes millions of fiber-digesting microbes to die-off as they cannot digest the starch, and there are too few starch-digesting microbes to use the grain so the grain sours in the rumen. As a result, rumen pH decreases, the rumen stops working, and the animal becomes ill. In severe cases, cattle can develop acidosis and founder or die.

The **omasum** is also known as “the book” or many piles because of its many leaf-like folds. It functions as the gateway to the abomasum, filtering large particles back to the reticulorumen and allowing fine particles and fluid to be passed to the abomasum. Though the complete function of this compartment is unknown, it does aid in water resorption and recycling of buffers for the saliva. The omasum may also absorb some volatile fatty acids. The abomasum is also known as the “true stomach.” It functions much like the human stomach producing acid and some enzymes to start protein digestion. Animals that go off feed or have acidosis can develop a displaced abomasum or “twisted stomach.” The abomasum will actually float out of place and become torsioned stopping the flow of digesta. Surgery is the only cure for a displaced abomasum. Although displaced abomasum is more common in dairy cattle than beef cattle, producers should be aware of the possibility of this problem in cattle that have had severe digestive upsets.

Lower Digestive Tract

The rest of digestion is performed in the **small intestine** and large intestine much as it is in humans and other mammals. Digesta that leaves the rumen and enters the lower digestive tract includes some microbes and undigested fiber, as well as protein and some sugars produced by the microbes. By-pass protein, fat, and carbohydrates also enter the lower digestive tract. Bypass protein, fat, and carbohydrates are nutrients that

cannot be digested in the rumen but may be digested in the abomasum and small intestine.

Enzymes to digest proteins, sugars, and starch flow into the small intestine from the pancreas, while the gall bladder produces bile to help digest fats. The small intestine also produces some enzymes to aid in digestion, but its major function is absorption of digested nutrients. Except for the volatile fatty acids, most of the nutrients are absorbed in the small intestine including protein, starch, fats, minerals and vitamins.

Water is primarily absorbed in the **large intestine**. Undigested feed, some excess water, and some metabolic wastes leave the large intestine as fecal material. The consistency of manure is an indicator of animal health and is dependent on water, fiber, and protein content of the feed. For example, cattle on lush spring forage will have profuse watery, greenish colored manure, whereas animals on a hay diet will have firm manure that is dark in color. Animals should produce manure that is indicative of the diet they are receiving. If not, it may indicate a digestive upset or disease. Light colored manure, manure tinged with blood, and watery manure (when on a dry diet) are not normal situations. Manure should not smell putrid or rancid. Producers should recognize changes in manure that indicate problems.

The Digestive System of poultry

The digestive system consists of the alimentary canal along which the food passes after eating to where the residual wastes are eliminated from the body, together with the liver and the pancreas. The digestive system is responsible for the ingestion of food, its breakdown into its constituent nutrients and their absorption into the blood stream, and the elimination of wastes from this process.

The liver produces bile and is associated with the metabolism of nutrients together with a number of other functions. The main function of the pancreas is the production of digestive enzymes and special compounds called hormones.

The alimentary canal

The alimentary canal is a long tube-like organ that starts at the beak and ends with the vent or cloaca in the abdominal region. Generally the alimentary canal has layers of muscle that run lengthwise and around it and is lined with mucous membranes. Glands that produce important digestive juices are found in different locations of the canal. The nutrients from the food, after digestion, are absorbed through the wall of the alimentary canal into the circulatory system for transport to the liver or other parts of the body. The waste remaining is eliminated from the body via the cloaca or vent.

Mouth structure

Fowls don't have lips and cheeks, they instead have a beak which is an area of dense and horny skin lying over the mandible and incisive bones that serve as the bony foundation. There are no teeth. The so called egg tooth found on the end of the beak of newly hatched chickens is an aid to their escape from the egg at hatching and disappears after a day or two. The hard palate that forms the roof of the mouth, presents a long, narrow median (median – along the middle) slit that communicates with the nasal cavity. The hard palate has five transverse rows of backwardly pointing, hard, conical papillae. Numerous ducts of the salivary glands pierce the hard palate to release their secretions into the mouth cavity.

Salivary glands

A thick layer of stratified squamous epithelium covers the free surface. The salivary glands run the whole length of the hard palate, the groups of glands merging to form one mass of glandular tissue under the epithelium. Lymphoid tissue is found in most glands.

The salivary glands are:

1. Maxillary – in the roof of the mouth
2. Palatine – on either side of the nasal opening in the roof of the mouth
3. Apheno-pteryoid glands – in the roof of the pharynx on each side of the common opening for the eustachian tubes (the eustachian tubes connect the middle ear to the mouth and their function is to equalise the air pressure on each side of the tympanic membrane in the ear)
4. Anterior sub-mandible glands – in the angle formed by the union of the upper and lower beaks or mandibles
5. Posterior sub-mandibular glands
6. Lingual glands – in the tongue
7. Crico-arytenoid glands – around the glottis
8. A small gland in the angle of the mouth

Pharynx and tongue

The pharynx is continuous with, and follows, the mouth. The combined cavity of the mouth and the pharynx is often referred to as the oropharynx. The common opening for the two eustachian tubes is located in the middle of its dorsal wall (roof). The tongue is long and pointed and conforms to the shape of the beak in which it operates. The epithelium of the tongue is thick and horny, especially towards the tip. A transverse row of simple, large and horny papillae with their tips directed towards the rear of the mouth cavity are located on the posterior end. The hyoid bone provides the framework to support the tongue. The entoglossal bone extends longitudinally in the median plane. Small patches of lymphatic tissue are located throughout the corium. Mucous glands are located in the tongue with short ducts directed towards the rear. Some believe that there are taste buds located on the tongue, but this belief is not universally held. In any case, the sense of taste appears to be very weak if at all present.

The mouth has two major functions:

1. To pick up the food particles.
2. To direct the food into the oesophagus – as part of the bird's eating behaviour.

Oesophagus, crop and proventriculus

The oesophagus is wide and is capable of being significantly stretched. It connects the mouth region to the crop in close association with the trachea. The crop is a large dilation of the oesophagus located just prior to where the oesophagus enters the thoracic cavity. The crop provides the capacity to hold food for some time before further digestion commences. This capacity enables the bird to take its food as "meals" at time intervals but permits continuous digestion. Inside the thoracic cavity, the oesophagus enters or becomes the proventriculus which is a very glandular part of the digestive tract (often called the glandular stomach).

The wall of the oesophagus is composed of four layers of tissue, the innermost being mucous membrane. The mucous membrane is an important barrier to the entry of microbes and the mucous it produces is a lubricant that aids the passage of the food along the alimentary canal. The structure below the crop is similar to that above except there is less lymphoid tissue below the crop. The crop structure is similar to that of the oesophagus except there are no glands present in fowls. Ducks and geese have glands in the crop mucous membranes. In pigeons the surface cells of the crop slough off during brooding to form pigeon's milk which is used to feed the baby pigeons in the nest.

Proventriculus

The glandular stomach, or proventriculus, is relatively small and tubular. The wall is very thick and is composed of five layers:

1. Outer serous membrane
2. Muscle layer composed of three separate layers:
    - Two thin longitudinal layers
    - Thick circular layer
3. Layer of areolar tissue containing blood and lymph vessels
4. Thick layer composed mainly of glandular tissue
5. Mucous membrane

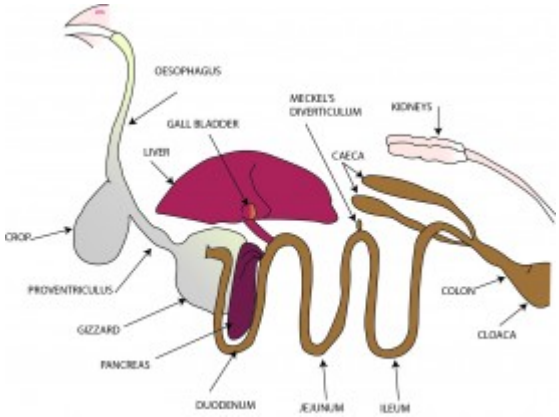
The glands form the greater part of the thickness of the organ. Simple single glands group to form lobules each of which converges into a common cavity near the surface. The cavities converge to form a common duct that leads to the surface through the apex of a small papilla (see figure below). These glands produce a number of juices or enzymes that are used in the digestion or breaking down of food into its constituent nutrients. The mucous membrane is raised into folds and between these folds are numerous simple tubular glands that produce hydrochloric acid as well as lymphoid tissue.

Gizzard

The muscular stomach or gizzard is located immediately after the proventriculus, partly between the lobes and partly behind the left lobe of the liver. It

has a flattened, rounded shape somewhat like a convex lens, with one side slightly larger than the other. Each surface is covered by a glistening layer of tendinous tissue which is thicker at the centre and becoming thinner towards the edges. Under this outer layer there are located very powerful masses of red muscle. The inner surface is lined with a creamy-coloured, thick, horny tissue raised in ridges. The gizzard almost always contains quantities of hard objects such as gravel or other grit that aids in the disintegration of food, which is the primary function of the gizzard.

The entrance from the proventriculus and the exit to the duodenum are close together and dorsal in location. The gizzard consists of a number of layers of tissues, some of which contain straight tubular glands. The innermost layer is a strong, flexible skin that is able to withstand the potentially damaging effects of the muscular action grinding the food often in the presence of stones or other insoluble material. The glands of the gizzard produce a liquid which is a keratinised material that passes to the surface of the horny lining where it hardens to replace tissue worn away by the grinding action of the organ.



The small intestine

The small intestine begins at the exit from the gizzard and ends at the junction of the small intestine, caeca and colon. It is relatively long and has a constant diameter. Of the three parts of the mammalian small intestine, the duodenum, jejunum and ileum, only the duodenum can be easily distinguished in the fowl. There is no clear demarcation between the jejunum and ileum and the small intestine appears as one long tube. Much of the digestion of the food and all of the absorption of the nutrients takes place in the small intestine and hence its structure is quite important. The structure is as follows:

1. Serosa – a serous membrane on the outside of the intestine.
2. A layer of longitudinal muscle – fibres run along the length of the intestine.
3. A layer of circular muscle – three times as thick as the longitudinal muscle. Located between the two muscle layers are:
    - Blood vessels
    - Lymph vessels
    - A network of nerve fibres
4. An ill-defined sub-mucosa – the areolar of the oesophagus.

5. Mucous membrane consisting of:
    - A thick muscularis mucosae of longitudinal and circular muscle
    - Corium – many glands, lymphoid tissue, muscle fibres and a variety of free cells
    - Epithelium or surface

The small intestine has a number of very important functions:

1. Produces a number of enzymes involved in the digestion process
2. Site of much of the digestion of the food
3. Site of much of the absorption of food

Villi

When a piece of the small intestine is immersed in water it takes on a very velvety appearance because of the presence of villi – long flattened, fingerlike projections that extend into the lumen (inside) of the intestine like flexible fingers. The villi are very actively involved in the absorption process. A single layer of columnar epithelium together with goblet cells covers the lining. The goblet cells secrete mucous. Permanent folds in the mucous membrane called the “valves of kerkring” are located at the proximal end (closest to the front) of the duodenum.

A lacteal (lymph vessels), capillaries, bundles of plain muscle fibres, nerves and other tissues and cells occupy the core of the villus. The villi have the function of providing a vastly increased surface area for the more efficient absorption of the nutrients. The efficiency of the absorption is influenced by the surface area available for the nutrients to move through i.e. the more villi the better the absorption. They also provide a means of concentrating the nutrients collection ability once they have moved through the intestine wall.

Duodenum

After the duodenum the small intestine forms a coil and is suspended from the dorsal wall of the abdominal wall by a thin membrane called the mesentery. This membrane carries the blood vessels associated with the intestine. The duodenum starts at the gizzard and forms an elongated loop that is approximately 20 centimetres long. The **pancreas** lies between the arms of the loop and is attached to, and actually holds together, each arm of the duodenum.

Lymphoid tissue in the duodenum is very plentiful and is usually located in the corium. The lymphoid tissue collects the lymph and the lymph vessels transport fluid, other than blood, that is found in the spaces between cells and tissues until it passes into the blood system. **Bile ducts** from the gall bladder that are attached to the liver and two to three pancreatic ducts enter the small intestine by a common papilla at the caudal end (closest to the rear) of the duodenum. The **pancreas** is a very important organ in the process of digesting food and it is attached to each side of the duodenal loop and lies between the two arms.

Jejunum and the ileum

The jejunum and the ileum, together about 120 cm long, commence at the caudal end of the duodenum where the bile and the pancreatic duct papilla are

located and terminates at the ileo-caecal-colic junction. This junction is where the small intestine, the two caeca and the colon all meet. This portion of the small intestine is similar in structure to the duodenum except that:

1. It is suspended in the mesentery
2. The villi are shorter
3. There is less lymphoid tissue

Meckel's Diverticulum is a constant feature about half way along the small intestine and appears as a small projection on the outer surface of the small intestine. This projection is where the yolk sac was attached during the development of the embryo.

Large intestine

The large intestine is very short and does not differ to any extent from the calibre of the small intestine. It runs in nearly a straight line below the vertebrae and ends at the cloaca. Sometimes this section is referred to as the colon and the rectum (the rectum being the terminal section). The **bursa of fabricius** is located immediately above the cloaca of young birds but disappears when the birds have reached approximately one year old.

Caeca

The two caeca or blind pouches are about 16-18 centimetres long in the adult. They extend along the line of the small intestine towards the liver and are closely attached to the small intestine along their length by the mesentery. Each caecum has three main parts:

1. A narrow base with thick walls arising at the ileo-colic-caecal junction
2. Middle part with thin walls
3. The wide blind apex with fairly thick walls

The structure of the caeca is as follows:

1. Serous membrane
2. Outer longitudinal muscle
3. Circular muscle
4. Inner longitudinal muscle forming the muscularis mucosae of the mucous membrane

Cloaca

The large intestine terminates in the front part of the cloaca. The cloaca is a tubular cavity opening to the exterior of the body and is common to the digestive and urogenital tract. The structure of the cloaca is very similar to that of the intestine except that the muscularis mucosa disappears near the vent. It divides into three chambers, each separated by a constriction not readily defined:

1. The copradaeum – a continuation of the colon-rectum
2. The urodaeum – middle part into which the ureters and genital ducts open
3. The proctodaeum – opens to the exterior of the vent. Birds less than one year old have a dorsal opening leading into the blind, rounded sac – the bursa of fabricius