Ruminant Digestive System

Ruminants: are **mammals** that are able to acquire nutrients from plant-based food by **fermenting** it in a specialized **stomach** prior to digestion, principally through microbial actions.

-Ruminating mammals include: cattle, goats, sheep, giraffes, deer and kangaroos.

The Ruminant's digestive tract consists of:

The mouth, esophagus, a complex four-compartment stomach, small intestine and large intestine **(figure 1)**.

The stomach includes the **rumen**, **reticulum or "honeycomb**," the **omasum** and the **abomasum or "true stomach"**.

The rumen: The rumen (on the left side of the animal) is the largest of four compartments and is divided into several sacs. It can hold 25 gallons or more of material, depending on the size of the cow. Because of its size, the rumen acts as storage or holding vat for feed. It is also a fermentation vat. A microbial population in the rumen digests or ferments feed eaten by the animal. Conditions within the rumen favor the growth of microbes **(mostly bacteria, as well as some protozoa, fungi and yeast)**. The rumen absorbs most of the volatile fatty acids produced from fermentation of feedstuffs by rumen microbes. Absorption of volatile fatty acids and some other products of digestion are enhanced by a good blood supply to the walls of the rumen. Tiny projections called **papillae** increase the surface area and the absorption capacity of the rumen.

The reticulum: The reticulum is a pouch-like structure in the forward area of the body cavity. The tissues are arranged in a network resembling a **honeycomb**. A small fold of tissue lies between the reticulum and the rumen, but the two are not actually separate compartments. Collectively they are called the **rumino-reticulum**.

Heavy or dense feed and metal objects eaten by the animal drop into this compartment. The reticulum lies close to the heart. Nails and other sharp objects may work into the tissue and cause "hardware disease." If not prevented by a magnet or corrected by surgery, infection may occur and the animal may die.

The omasum: This globe-shaped structure (also called the "**many plies**") contains leaves of tissue (like pages in a book). The omasum absorbs water and other substances from digestive contents. Feed material

(ingesta) between the leaves will be drier than that found in the other compartments.

The abomasum: This is the only compartment (also called the **true stomach**) with a glandular lining. Hydrochloric acid and digestive enzymes, needed for the breakdown of feeds, are secreted into the abomasum. The abomasum is comparable to the stomach of the non-ruminant.

The small intestine:

The small intestine measures about 20 times the length of the animal. It is composed of three sections: the duodenum, jejunum, and ileum. The small intestine receives the secretions of the pancreas and the gallbladder, which aid digestion. Most of the digestive process is completed here, and many nutrients are absorbed through the villi (small finger-like projections) into the blood and lymphatic systems.

Cecum:

The cecum is the large area located at the junction of the small and large intestine, where some previously undigested fiber may be broken down.

Large intestine:

This is the last segment of the tract through which undigested feedstuffs pass. Some bacterial digestion of undigested feed occurs, but absorption of water is the primary digestive activity occurring in the large intestine.

Function of the Digestive Tract:

1- Eructation (belching): Large quantities of gas, mostly carbon dioxide and methane, are produced in the rumen. Production amounts to 30 to 50 quarts per hour and must be removed; otherwise bloating occurs. Under normal conditions, distension from gas formation causes the animal to belch and eliminate the gas.

2-Rumination: The process of re-chewing the cud (**fermented ingesta**) to further break down plant matter and stimulate digestion**.**

A cow may spend as much as 35 to 40 percent of each day ruminating (cud chewing). The actual amount of time spent ruminating varies from very little (when grain or finely ground rations are fed) to several hours

(when long hay is fed). Mature cattle spend little time chewing when eating. During rest periods, feed boluses (cud) are regurgitated for

re-chewing to reduce particle size and for re-salivation. Feed is more readily digested by rumen microbes as particle size is reduced.

Motility of the rumen and reticulum:

The rumen is always contracting and moving. Healthy cows will have one to two rumen contractions per minute. The contractions mix the rumen contents, bring microbes in contact with new feedstuffs, reduce flotation of solids, and move materials out of the rumen. Lack of or a decrease in frequency of rumen movements is one way of diagnosing sick animals.

There are two types of rumen contractions:

1- **Primary contraction (reticulo-rumen contraction).**

Facilitate mixing of the dry dietary with buffered saliva and fermentative bacteria.

2- **Secondary contraction.**

Include both mixing and eructation of gas.

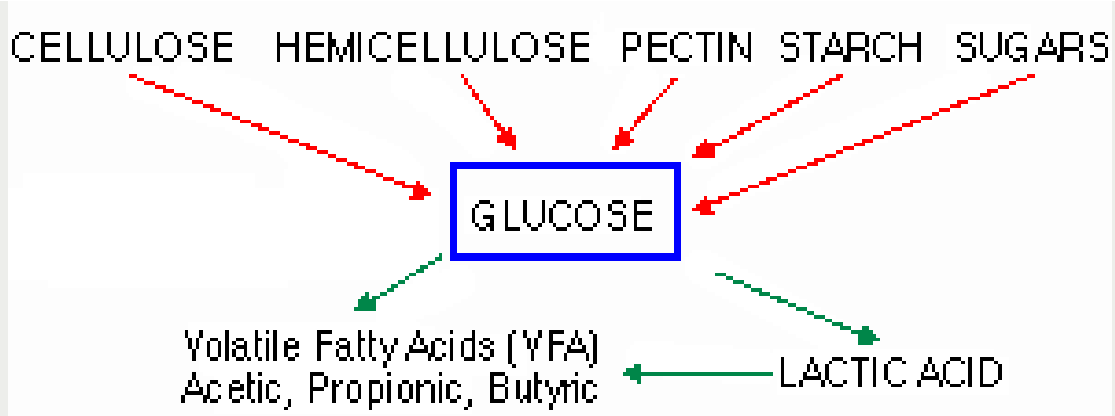
Saliva production:

As much as 50 to 80 quarts of saliva can be produced by salivary glands and added to the rumen each day. Saliva provides **liquid for the microbial population, recirculates nitrogen and minerals, and buffers the rumen.** Saliva is the major buffer for helping to maintain a rumen pH between **6.2 and 6.8** for optimum digestion of forages and feedstuffs.

Vomiting: Cattle rarely vomit. Occasionally certain feeds will induce vomiting. Some pasture plants, usually weeds, contain alkaloids that can cause this problem. Should this condition persist, a veterinarian should be consulted.

Digestion in ruminants:

Microbial digestion of feed carbohydrate in the rumen.



Digestion of energy feeds in the rumen.

Simple and complex carbohydrates (fiber) are digested by rumen microbes and converted into volatile fatty acids. The volatile fatty acids, which consist mainly of acetic, propionic, and butyric acids, are the primary energy source for ruminants. Approximately 30 to 50 percent of the cellulose and hemicellulose is digested in the rumen by the microbial population. Sixty percent or more of the starch is degraded, depending on **the amount fed and how fast ingested materials move through the rumen.** Most sugars are 100 percent digested within the rumen.

The volatile fatty acids are absorbed from the rumen into the blood stream and transported to body tissues, including the udder, where they are used as sources of energy for maintenance, growth, reproduction, and milk production. The cow derives 50 to 70 percent of its energy from the volatile fatty acids produced in the rumen.

Protein and non-protein nitrogen utilization in the rumen.

Some of the protein consumed by the cow escapes breakdown in the rumen. Protein undergoing fermentation is converted to ammonia, organic acids, amino acids, and other products. Approximately 40 to 75 percent of the natural protein in feed is broken down. **The extent of breakdown depends on many factors including:**

1-Solubility of the protein.

2-Resistance to breakdown.

3- Rate of feed passage through the rumen.

Many rumen micro-organisms require ammonia (breakdown product of protein) for growth and synthesis of microbial protein. Ammonia also may be provided from NPN sources such as urea, ammonium salts, nitrates, and other compounds. Rumen microbes convert the ammonia and organic acids into amino acids that are assembled into microbial protein. Excess ammonia is mostly absorbed from the rumen into the blood stream, but small amounts may pass into the lower digestive tract and be absorbed. Feed protein (that escapes breakdown in the rumen) and microbial protein pass to the abomasum and small intestine for digestion and absorption.

Vitamin synthesis. The rumen micro-organisms manufacture all of the B vitamins and vitamin K. Vitamin synthesis in the rumen is sufficient for growth and maintenance. Under most conditions, cattle with functioning rumens do not require supplemental B vitamins or vitamin K in the diet. Niacin (B3) and thiamine (B1) may be needed under stress conditions.

Fat digestion. Most of the digestion and absorption of fat occurs in the small intestine. Rumen micro-organisms change unsaturated fatty acids to saturated acids through the addition of hydrogen molecules. Thus, more saturated fat is absorbed by cows than by simple-stomach animals. **Feeding large quantities of unsaturated fatty acids can be toxic to rumen bacteria, depress fiber digestion, and lower rumen pH.**

Calf Digestive System:

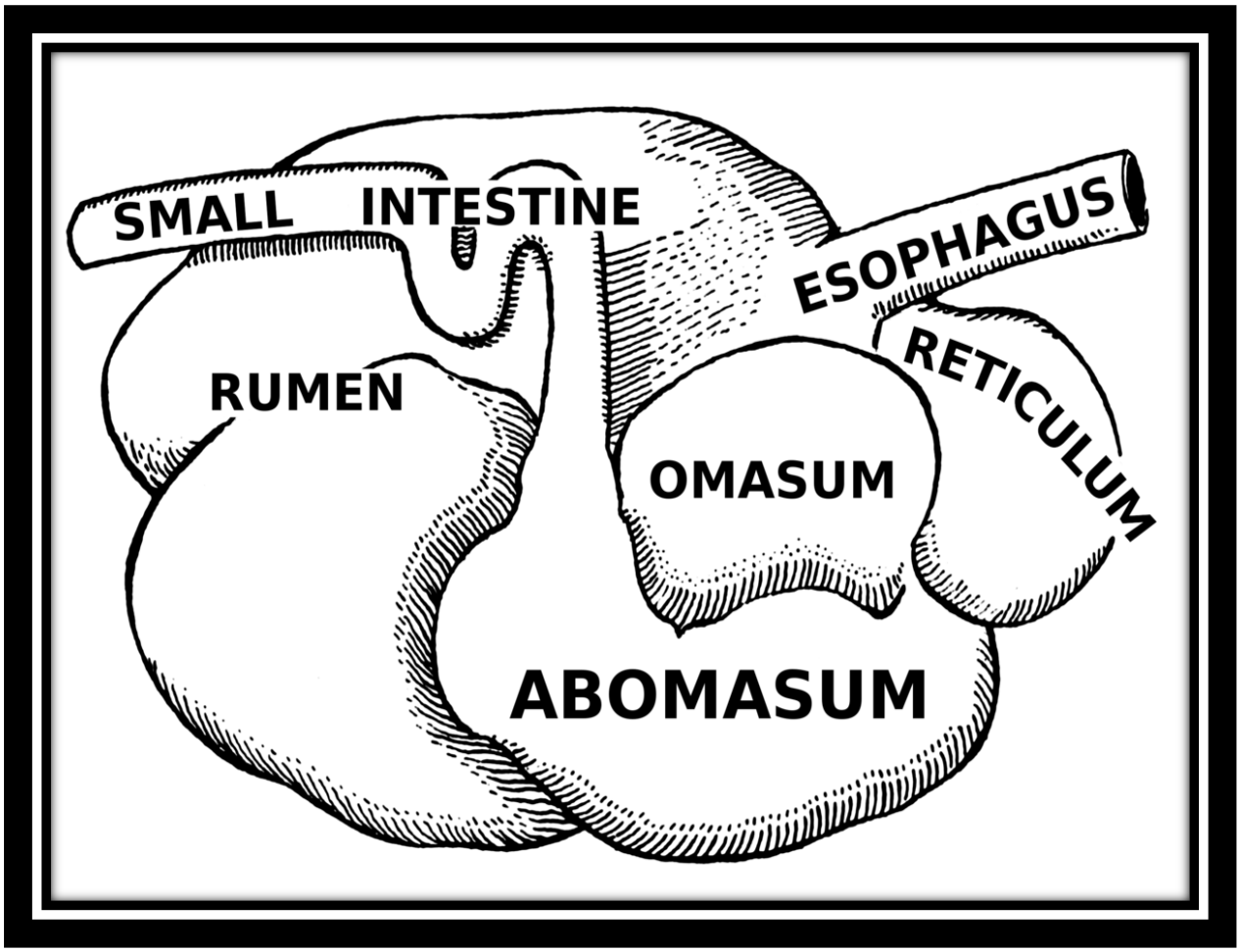
At birth and during the first few weeks of life, the rumen, reticulum, and omasum are undeveloped. In contrast to the mature cow, in the calf, the abomasum is the largest compartment of the stomach. At this stage of life, the rumen is nonfunctional and some feeds digested by the adult cannot be used by the calf. During nursing or feeding from a bucket, milk bypasses the rumen via the **esophageal groove** and passes directly into the abomasum. Reflex action closes the groove to form a tube-like structure which prevents milk or milk replacer from entering the rumen. When milk is consumed very rapidly, some may overflow into the rumen.

As long as the calf remains on milk, the rumen remains undeveloped. When calves begin consuming grain and forage, a microbial population

becomes established in the rumen and reticulum. End products of microbial fermentation are responsible for the development of the rumen. This occurs as early as 3 weeks of age with most feeding programs. Cud inoculation is not necessary to initiate rumen development. If grain feeding with or without forage is started during the first few weeks of life, the rumen will become larger and heavier with papillae development, and will begin functioning like the adult's when the calf is about 3 months of age.

End products of Ruminant Digestion:

1- VFAs(`Main energy source for cows)
2- CO2
3- CH4(Methane)
4- NH3(Ammonia)
5- Microbes


SMALL INTESTINE
ESOPHAGUS
RETICULUM
RUMEN
OMASUM
ABOMASUM

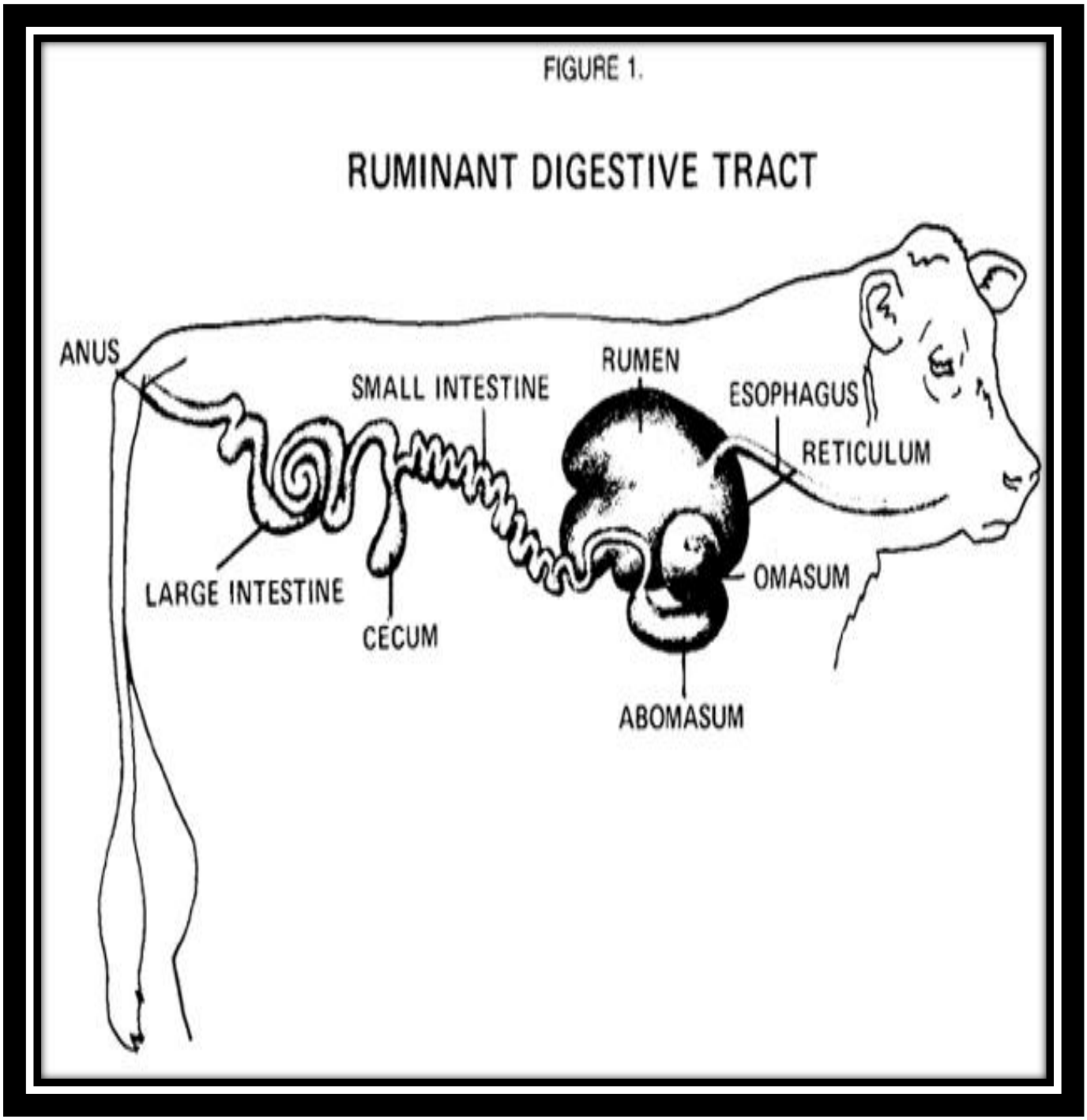


FIGURE 1.
RUMINANT DIGESTIVE TRACT
ANUS
SMALL INTESTINE
RUMEN
ESOPHAGUS
RETICULUM
LARGE INTESTINE
CECUM
OMASUM
ABOMASUM