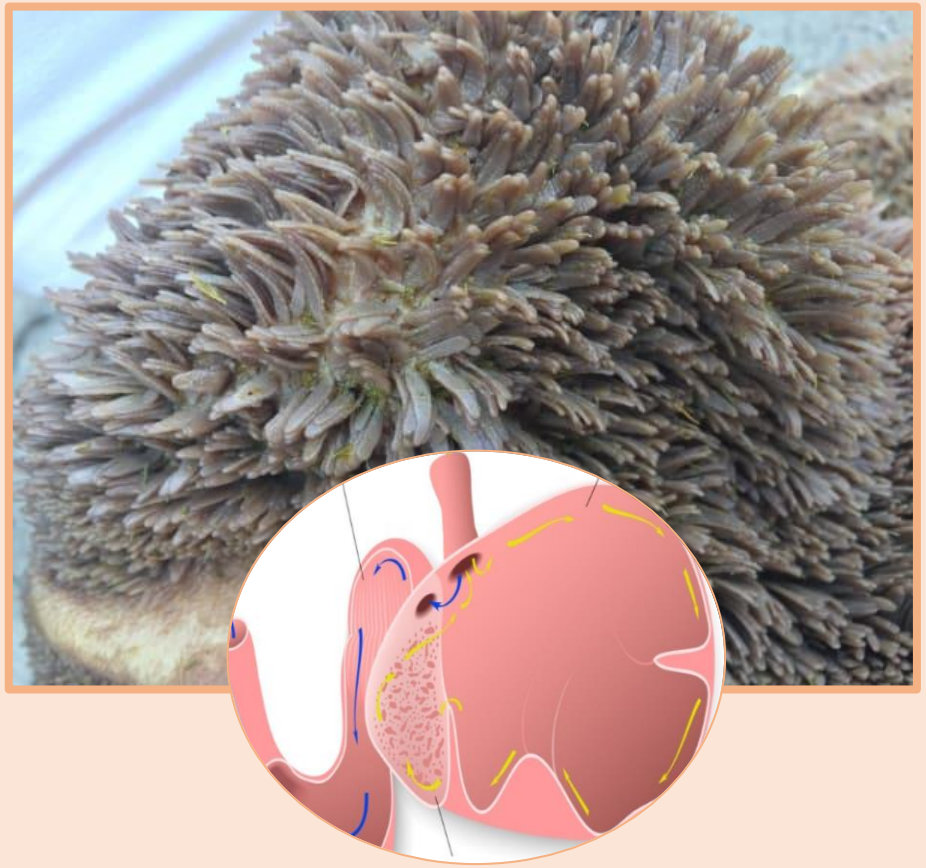
Theme 3: Animal Nutrition and Feeding

RUMEN FERMENTATION

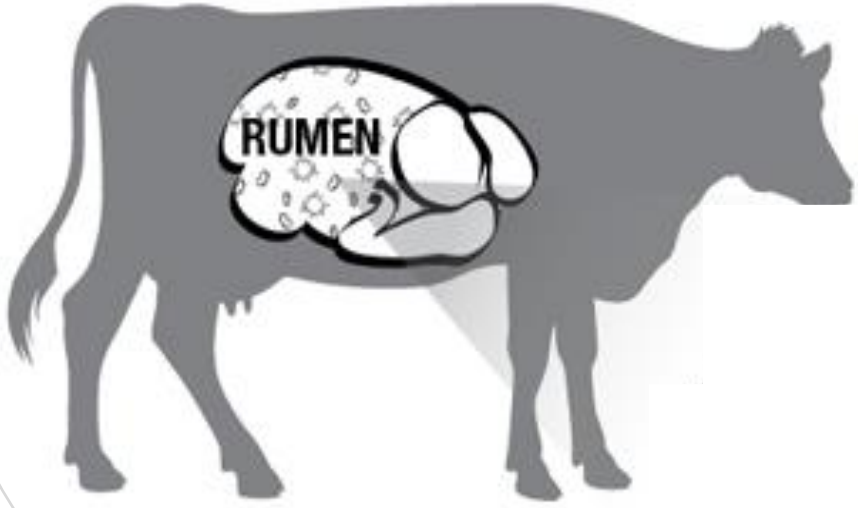
(Level 3)

Topic	Training & information Content
3.1	Estimating feeding value of fodder & feed on dairy farms
3.2	Sampling feeds & forages/analysis interpretation
3.3	Estimating Dry Matter intake for various breeds/age categories of dairy cattle in the tropics
3.4	Reviewing feed intake, rumen fill, Body Condition Scoring (BCS)
3.5	Life weight estimation of cows
3.6	Rumen fermentation
3.7	Mineral & vitamin requirement, guidelines
3.8	Manure scoring and evaluation
3.9	Guidelines for ration calculations for various breeds, heifers, lactation stage (Rumen8)
3.10	Use of Rumen8 software for ration calculation
3.11	Optimization of ration with Rumen8
3.12	Feeding management guidelines
3.13	Feeding management of dry cows/close-up
3.14	Feeding systems
3.15	Metabolic disorders
3.16	Scoring locomotion and hoof condition
3.17	Mycotoxin in dairy cattle nutrition
3.18	Heat stress in dairy cattle nutrition
3.19	Monitoring feeding management, using KPIs (based on Rumen8)



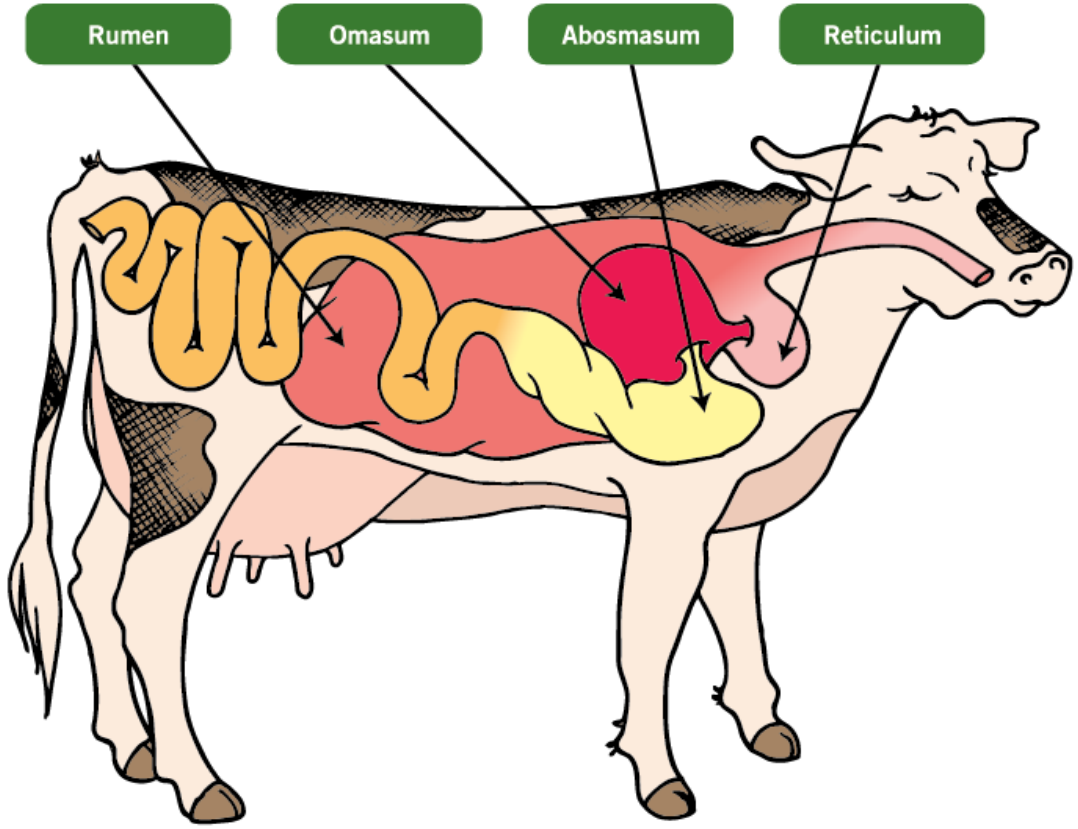
1. You will learn about (learning objectives):

- ❑ The rumen as one of the most important parts of the cow's digestive system.
- ❑ How the rumen functions and its ecosystem; rumen microorganisms.
- ❑ Fermentation processes in the rumen and factors affecting it.



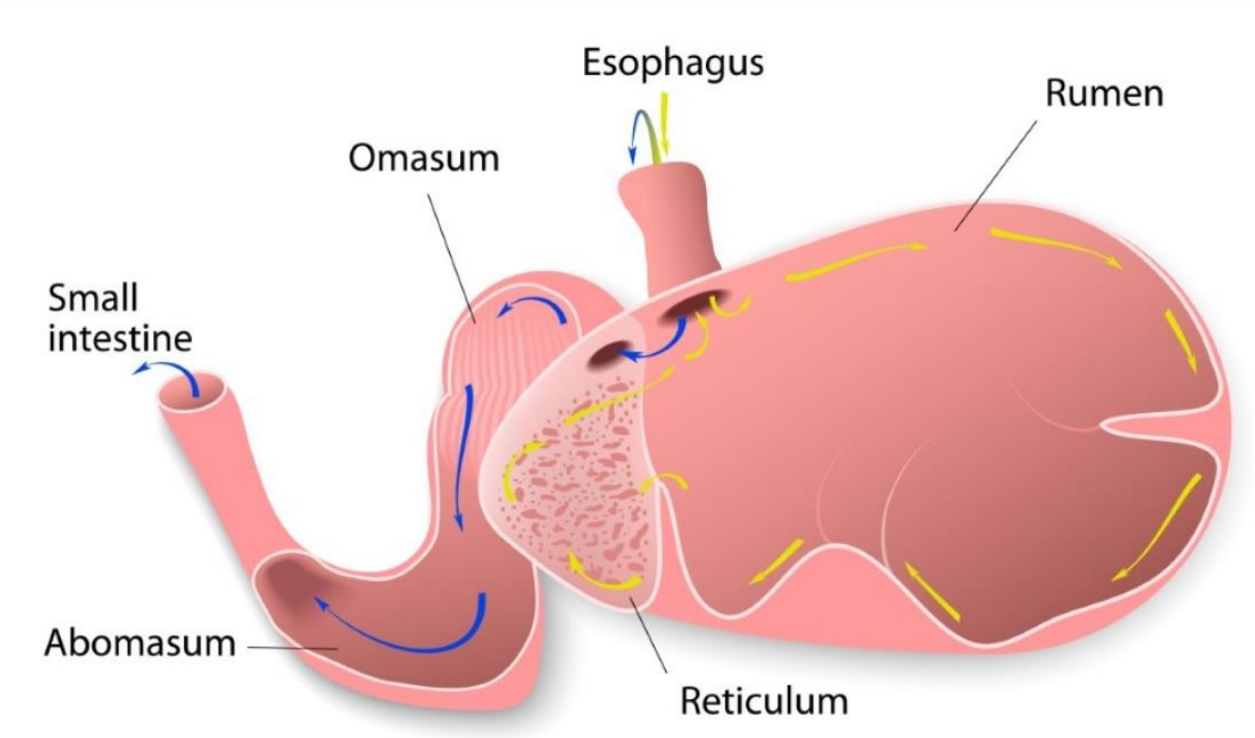
2. Introduction

- A cow’s digestive system is composed of the reticulum, omasum, abomasum, rumen and the intestines.
- The rumen is mainly where the major fermentation processes occur and starts.
- Rumen fermentation is a process that converts ingested feed into nutrients e.g. energy for the dairy cow.



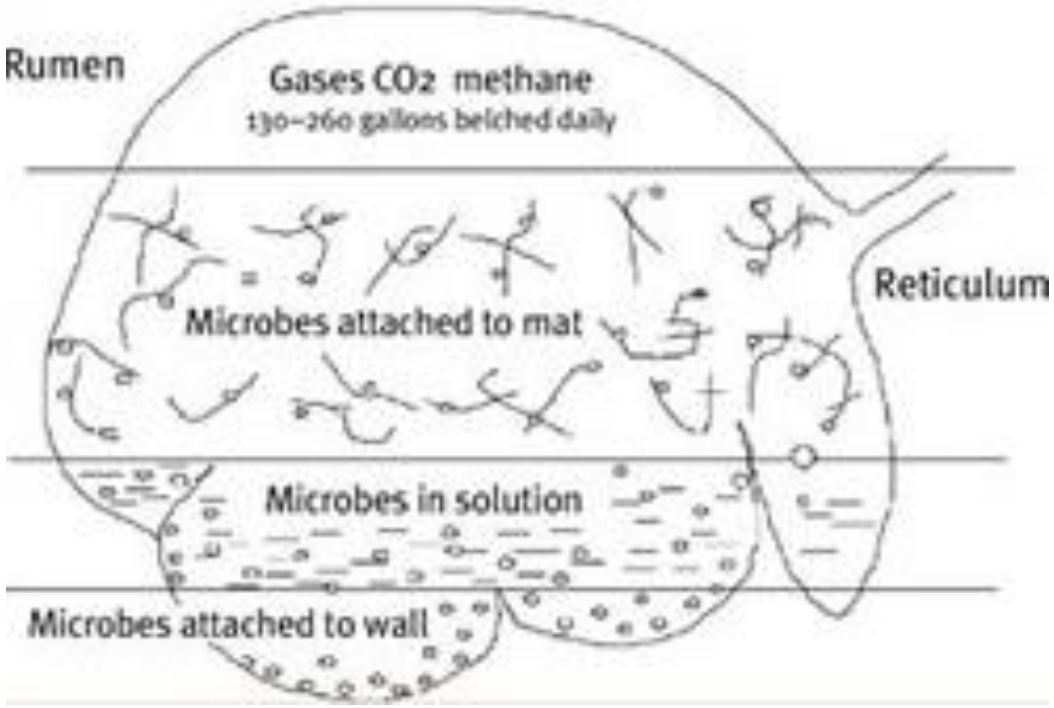
2.1 Introduction Cont'd…

- The rumen depends on microorganisms for fermentation/digestion of feeds.
- These microorganisms/microbes are bacteria, protozoa, and fungi they coexist with the cow.
- Not all kinds of nutrients (by-pass) are fermented here, some are digested in the abomasum and small intestines.



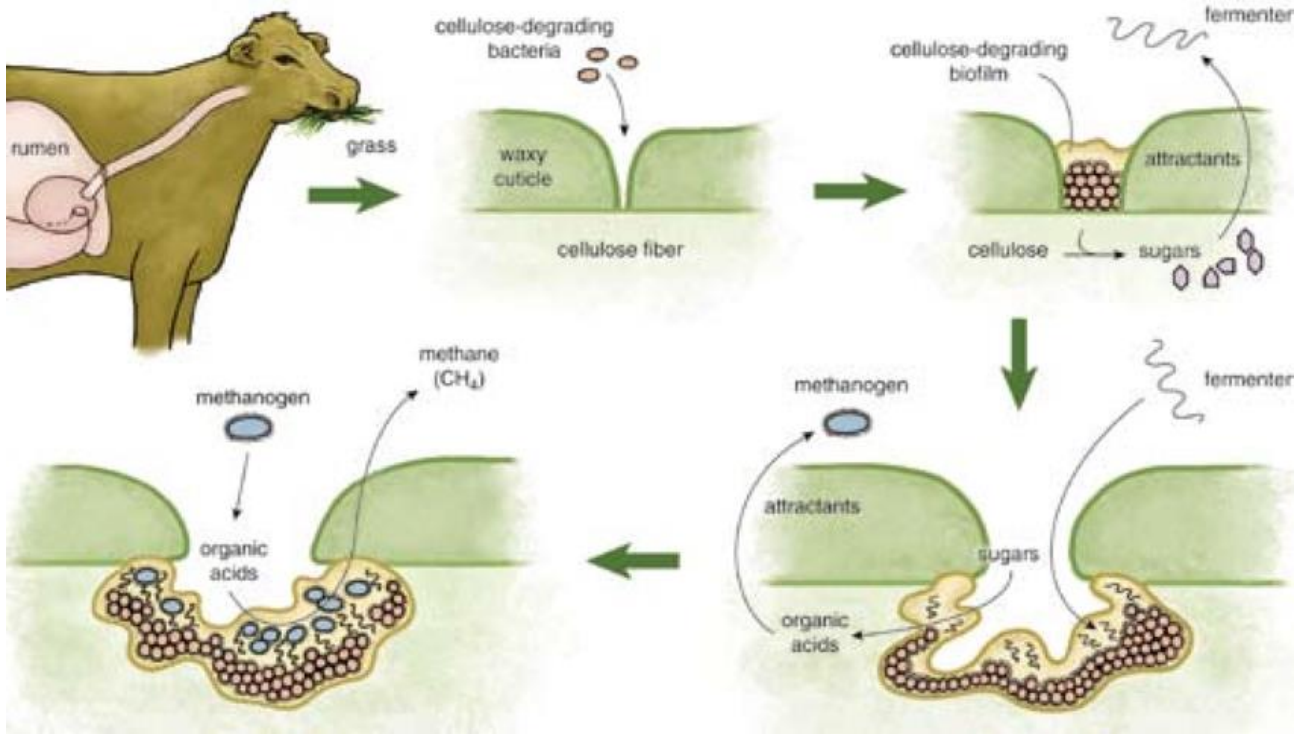
3. The rumen microorganisms

- Different microorganisms have different digestive roles in rumen.
- There are two main groups of rumen microorganisms:
  - The slow-working fiber-digesters located on the fiber mat in the rumen,
  - The fast-working microorganisms that float around in the rumen fluid, looking for easily-digested nutrients like sugars and starches.



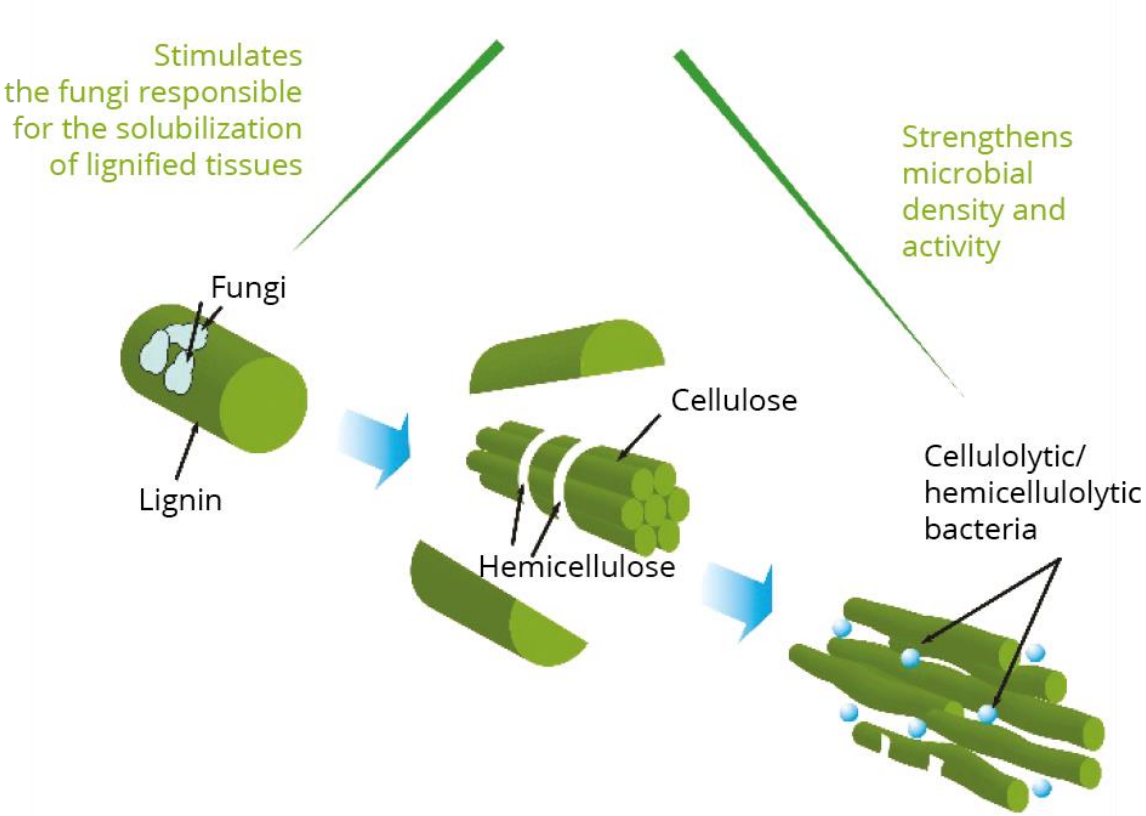
4. Rumen microorganisms: Bacteria

- The rumen bacteria have different functions depending on what they act on.
- The competition between bacteria population in the rumen is determined by several factors;
  - Preference for certain substrates,
  - Energy requirements for maintenance,
  - Resistance to certain metabolic products that can be toxic.



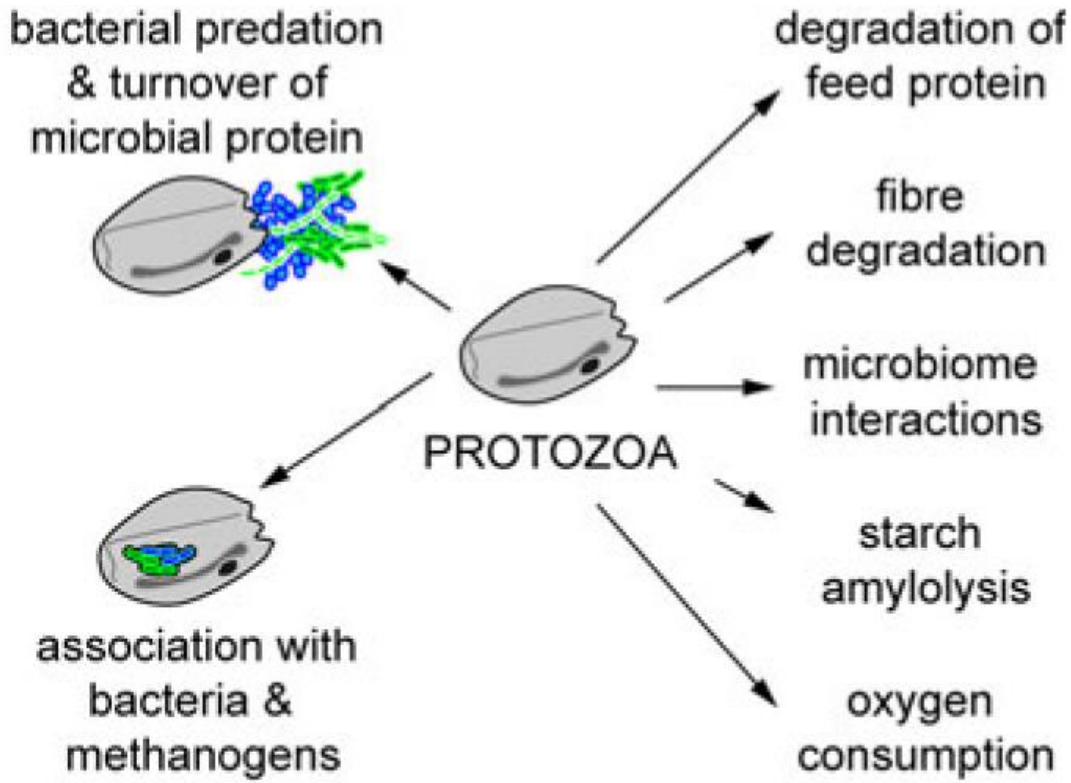
5. Rumen microorganisms: Fungi

- Fungi represent a small proportion, approximately 8%, of the biomass in the rumen ecosystem.
- They do have a role in the digestion of food consumed by the ruminant e.g. cow.
- Rumen fungal populations are favored by the consumption of fibrous forage that is mainly highly lignified.
- The fungi quickly flourish once the feed concentration is increased.



6. Rumen microorganisms: Protozoa

- The flow of rumen protozoa to the ruminant abomasum is less than that of bacteria, since they are retained in the feed particles.
- Protozoa digest and ferments cellulose, carbohydrates and protein.
- Protozoa also ingest bacteria and feeds particles.
- In the rumen environment, soluble proteins are mostly degraded by bacteria and protozoa.

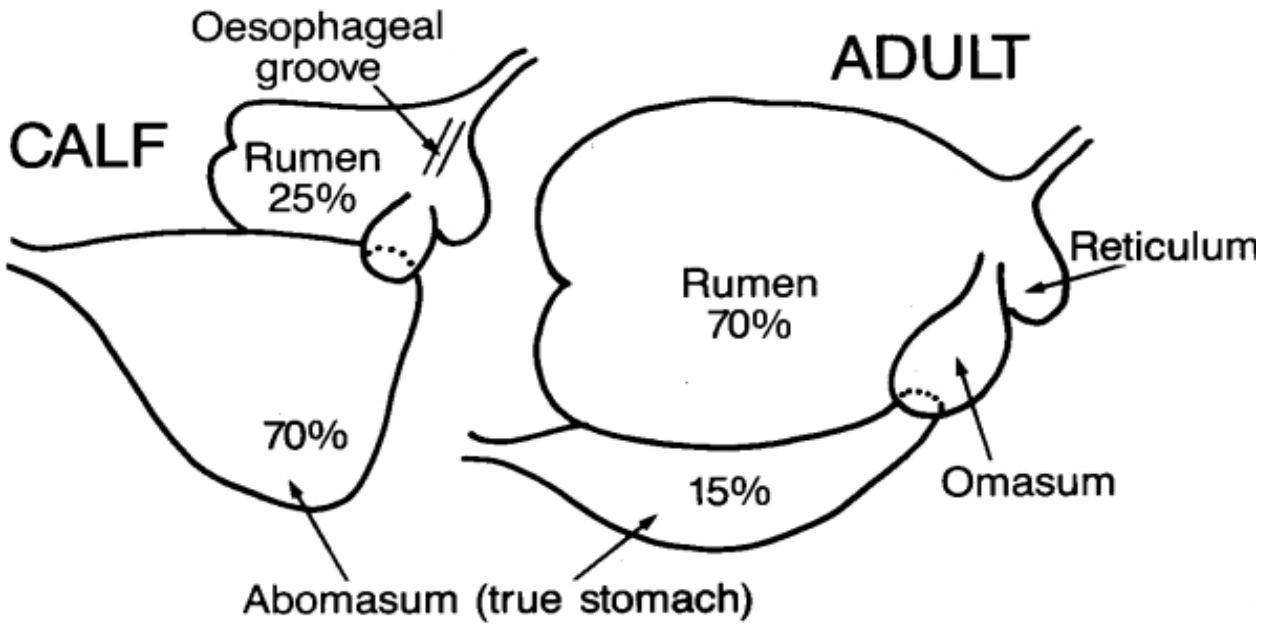


7. Features of the Rumen

- The interior surface of the rumen forms numerous papillae that vary in shape and size from short and pointed to long and foliate.
- Rumen is the largest chamber and has regular contractions to move food around for digestion, eliminating gases.
- It also send foods particles back to the mouth for remastication (chewing cud).

8. Rumen function in young stock

- The very young calf is described as "monogastric," i.e. it has a single stomach (abomasum).
- Rumen development in calf starts from 3 weeks of age and continues into the 4th month.
- After the 3rd month the rumen should be fully functioning and take over. The calf is now a ruminant and can fully utilize fibrous feeds.



8.1 Rumen function in young stock Cont'd…

- The feeding cost in the first three months is expensive because of the high quality and feed density e.g milk, milk replacer and concentrates.
- Quality fibrous feeds are cheaper and more cost effective to feed to ruminants.
- The nutrients in milk and milk replacer are most costly. In concentrates they are less costly and lesser in fibrous feeds.

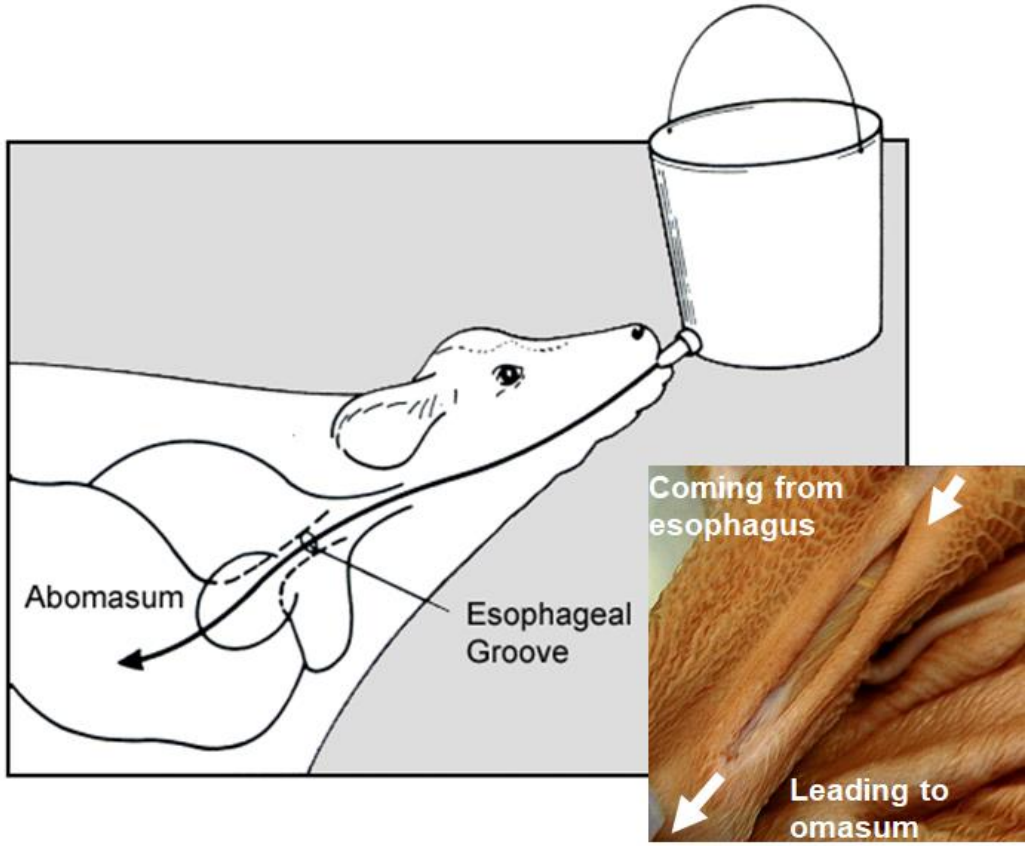
Undeveloped rumen
(Day 0)

Developing rumen
(Week 18)

Developed rumen
(24 months)

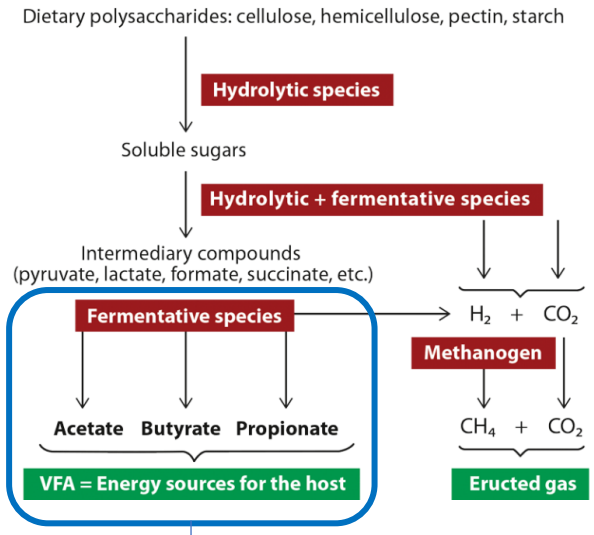
8.2 Rumen function in young stock Cont'd…

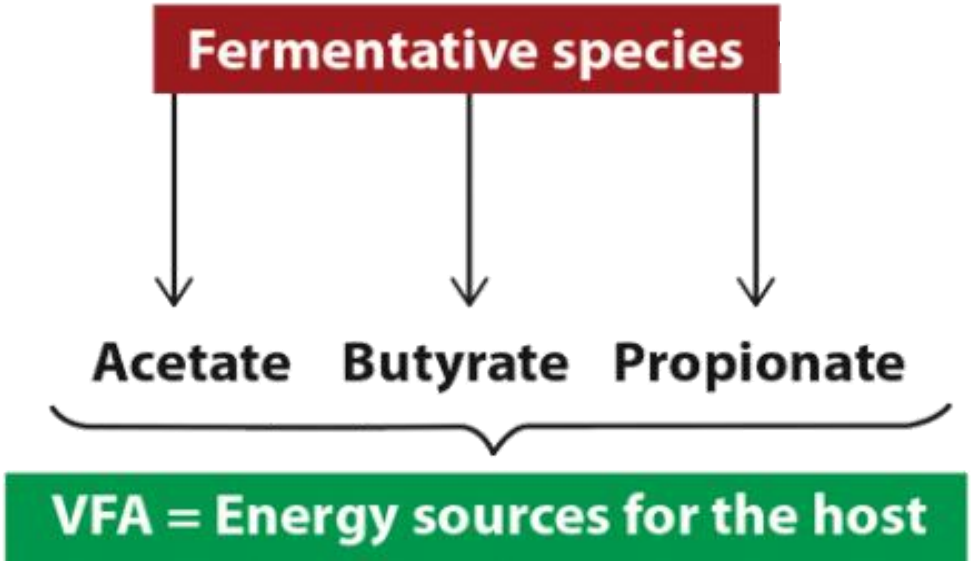
- To aid in rumen development, the calf should be introduced to fibrous feeds and concentrates in the second week after birth.
- This will also encourage the development of rumen flora.
- At early age the rumen is not functional but the calf still needs feeds. The calf is using abomasum and intestines to digest feeds.
- The esophageal grooves allows milk to bypass the rumen and directly enter the abomasum.



9. Rumen fermentation process

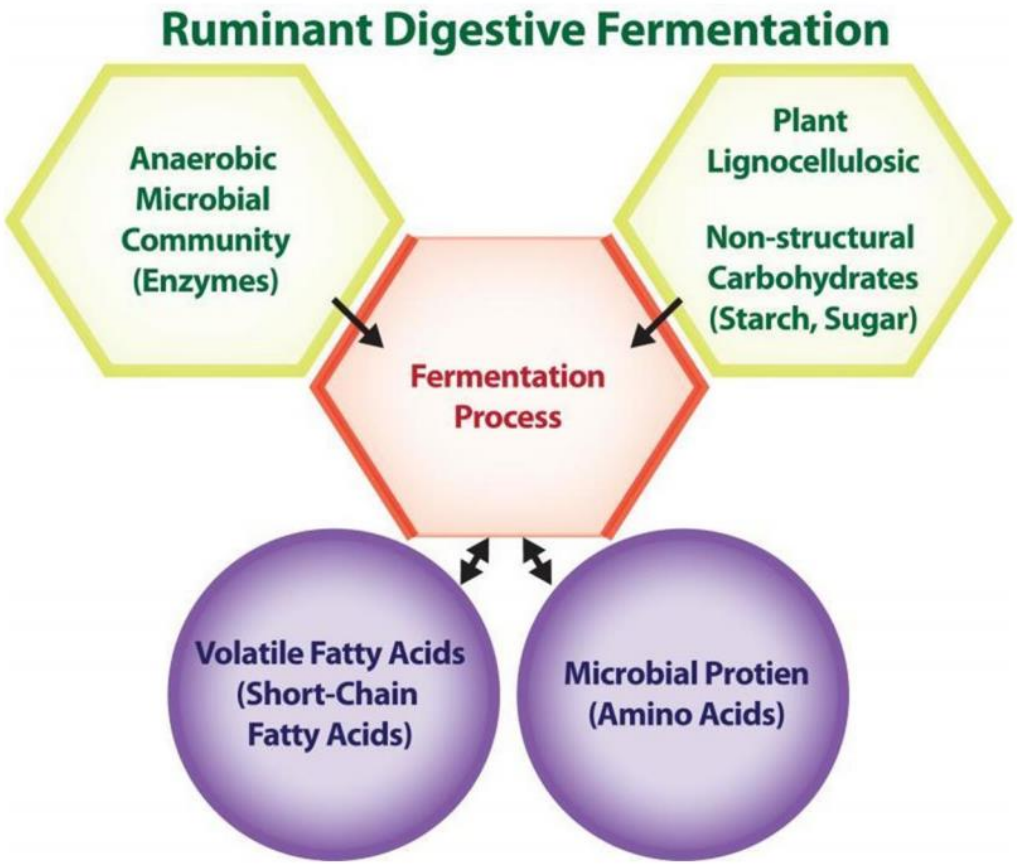
- The rumen microorganisms produce enzymes necessary for fermentation processes.
- This allows ruminants to efficiently obtain energy contained in forages.
- Their digestive system allows them to use cellulose as an energy source. However, it's not completely efficient. Some other final products are methane gas and excess ammonia.





10. End-products of rumen fermentation process

- The main product of rumen fermentation is volatile fatty acids (VFAs), which is the cow's main energy source.
- The rumen microorganisms are digested and absorbed in the small intestine as microbial protein.
- Microbial protein is the main protein source in the intestines, broken down into amino acids and taken up into the blood stream. These provide up to 70-90% of a cow´s protein requirements.
- Rumen microorganisms also produce some vitamin B and C.



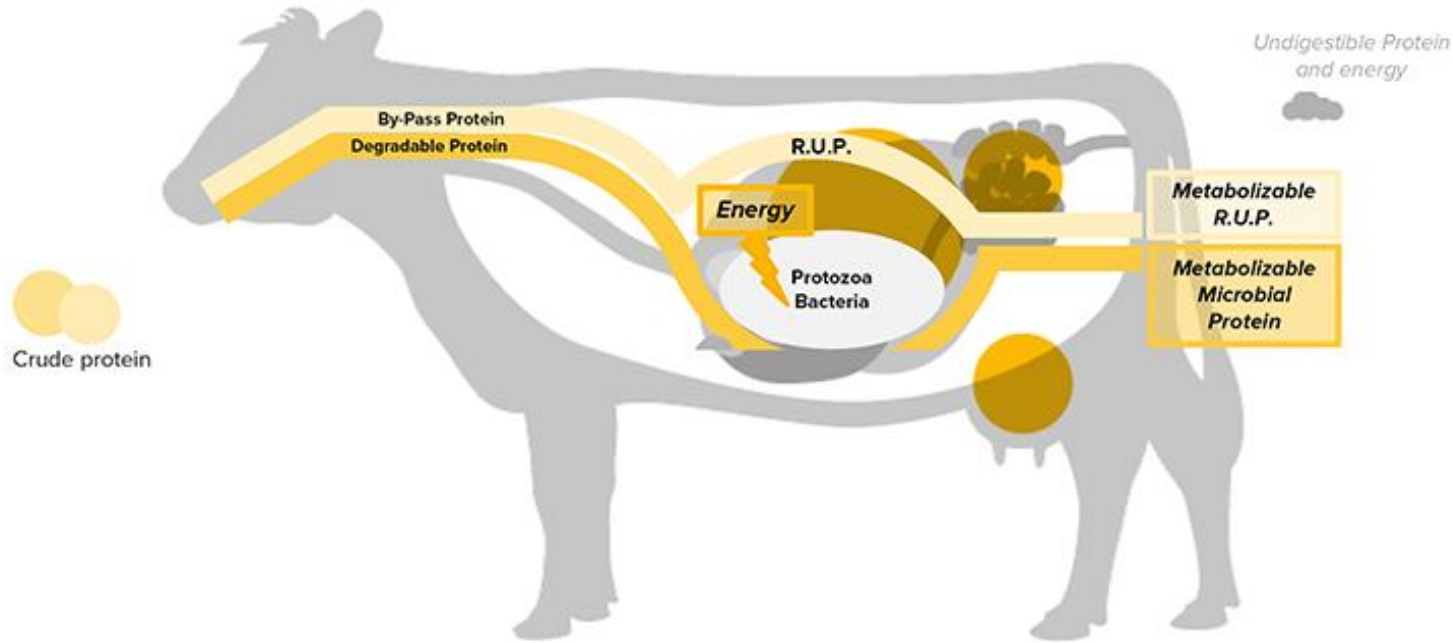
11. Rumen Degradable Protein (RDP)

- Cows get their protein from a variety of sources, and digestion occurs primarily in two ways.
- Rumen-degradable proteins are digested in the rumen by microorganisms and converted to ammonia.
- The microorganisms then use the nitrogen present in ammonia to synthesize microbial proteins.
- The rumen microorganisms are also digested and absorbed in the small intestine as microbial protein.

Protein rich
forage - Lucerne

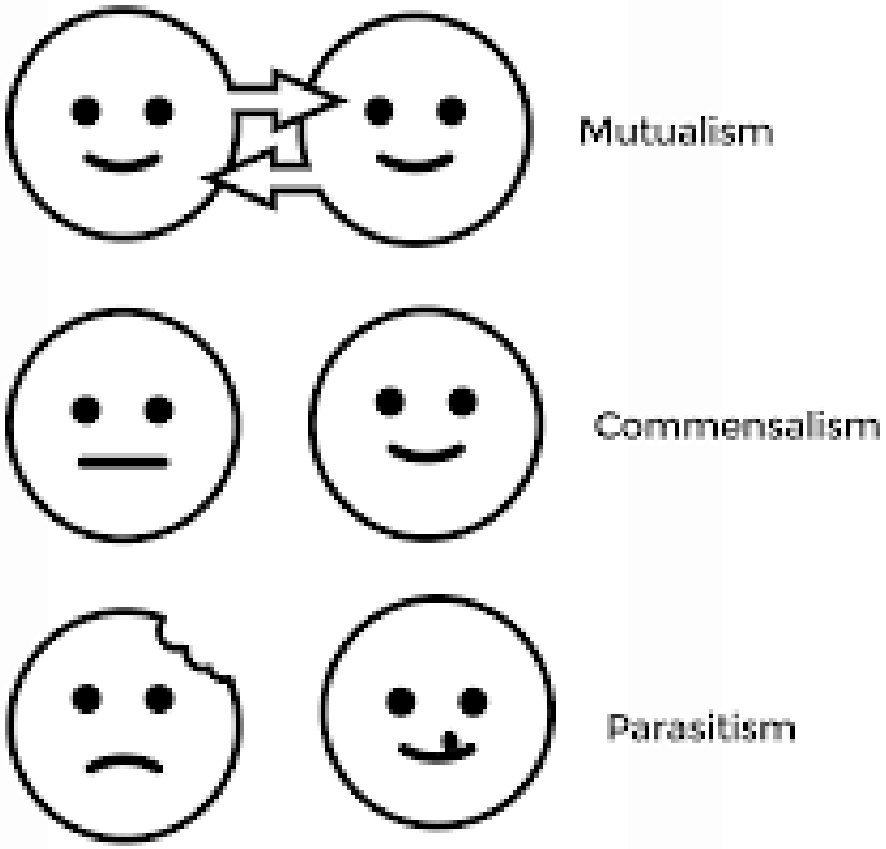
12. Rumen Un-degradable Protein (RUP)

- RUP are not fermented in the rumen, hence also known as bypass proteins.
- The RUP passes the rumen undigested directly into the abomasum and intestines. This is where they are digested with the help of proteolytic enzymes (enzymes that break down protein).
- They are broken down to amino acids and absorbed in the intestines.



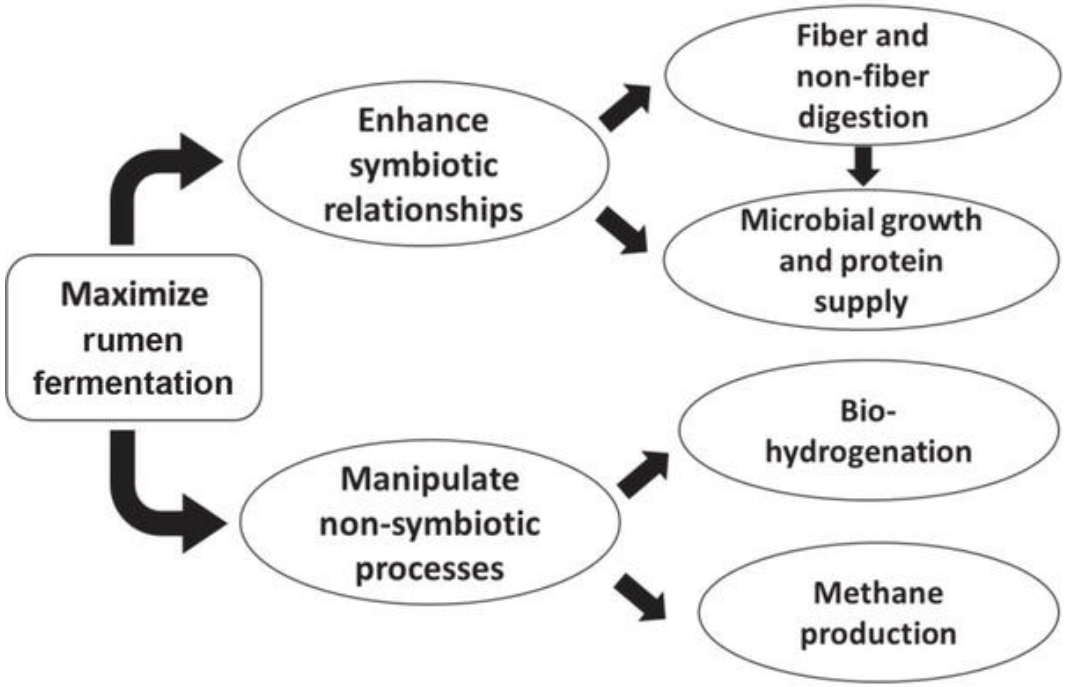
13. The symbiotic relationship

- The interaction between microorganisms and the host animal results in a symbiotic/mutual relationship.
- In the rumen the host and microorganisms relates in such a way that the host feeds on plant fibers.
- This plant fiber can only be degraded by the rumen microorganisms.



13.1 The symbiotic relationship cont'd…

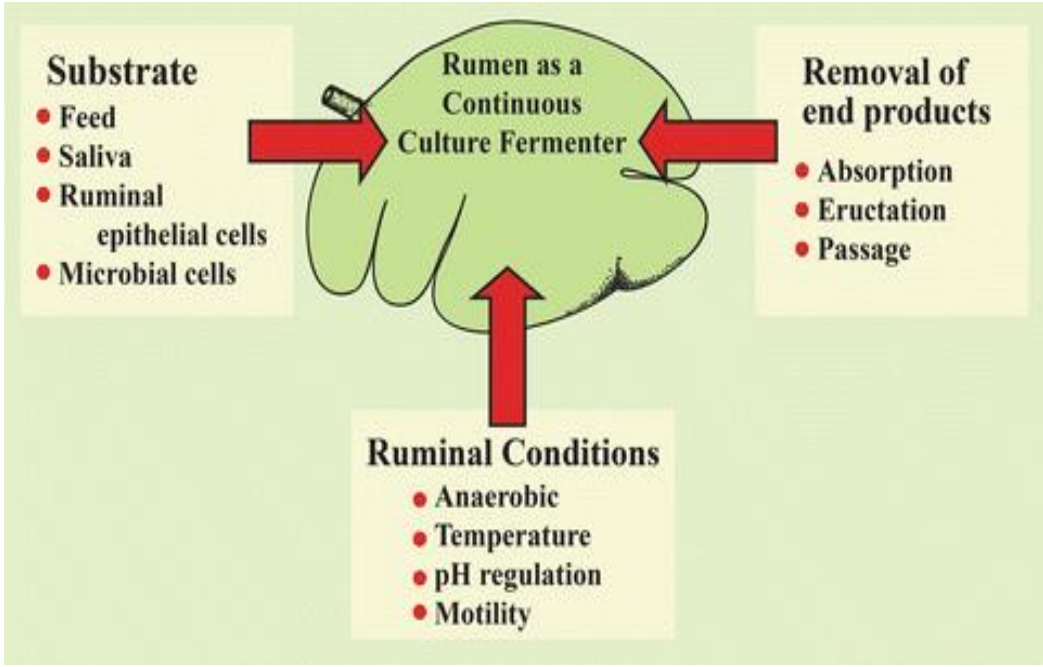
- The cow provides the necessary environment for the establishment of these microorganisms to coexist.
- The symbiotic relationship enhances digestion process in ruminants.
- Structural carbohydrates require fermentation, so microorganisms acts on them.
- Non-structural carbohydrates are readily digestible.



14. Microorganisms coexisting conditions

The microorganisms co-exist under the following conditions:

i. The chewing of cuds and saliva.
ii. The quality, nutrients and consistency of feeds.
iii. The rumen temperature.
iv. The rumen pH levels and regulation.
v. The anaerobic conditions (no oxygen in the rumen).

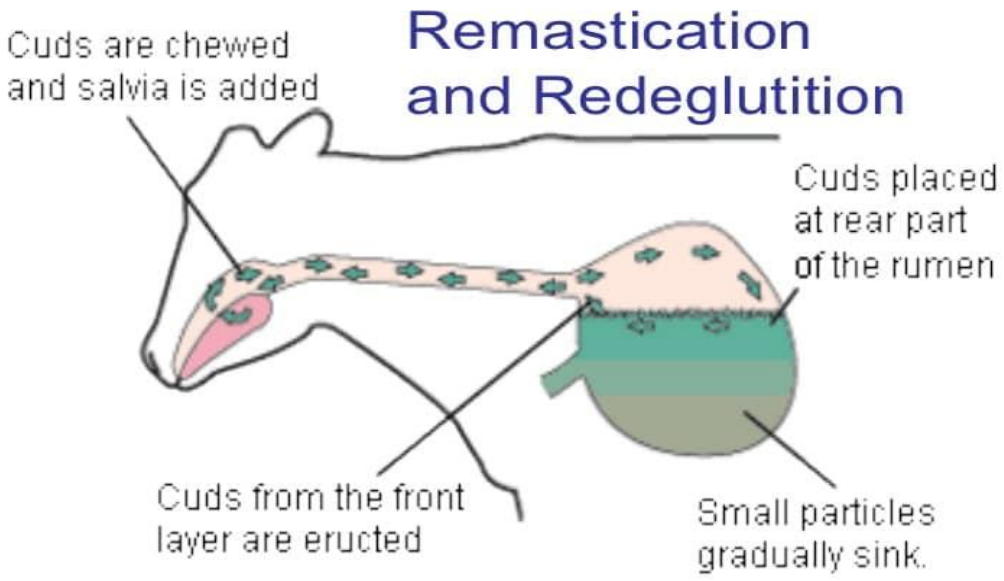


*Motility = Movement, contraction
*Eructation = Belching

15. Rumination/chewing of cud

- Food that is stored in the rumen is sent back up to the mouth through the esophagus to be re-chewed.
- This further reduces feed particle size, enhancing microbial function and feed passage.
- The produced saliva buffers the rumen to enhance microbial growth and development.

Remastication = Repeated chewing of the cud
Redeglutition = Swallowing food



16. Effective fiber content in feeds

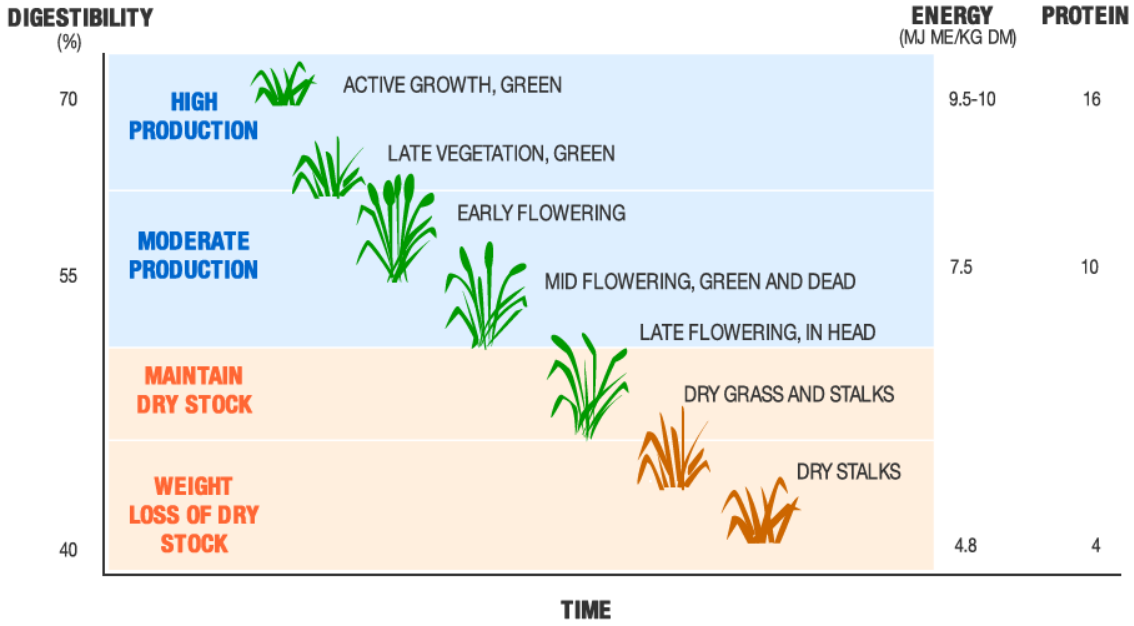
- Effective fiber, which forms the rumen material is required for optimal microbe production.
- These effective fiber stimulates cud chewing and production of saliva for buffering the rumen pH.
- Effective fiber therefore influences the type of microorganisms in the rumen and stimulates the speed of digestion.
- It also stimulates the contraction of rumen muscles wall.
- Effective fiber affects the total intake of dry matter and nutrients.

Lucerne hay

Boma Rhodes grass hay

17. Fiber digestibility

- Feeds such as concentrates and lush forage (young vegetative stage) contain lower amounts of fiber.
- The easily digestible fiber builds up the quick working ´floating´ microorganisms population.
- It also causes feed to move more quickly through the rumen and digestive system.
- The fast movement through the digestive system will trigger the cow to take in more feeds, which will potentially increase total feed intake.



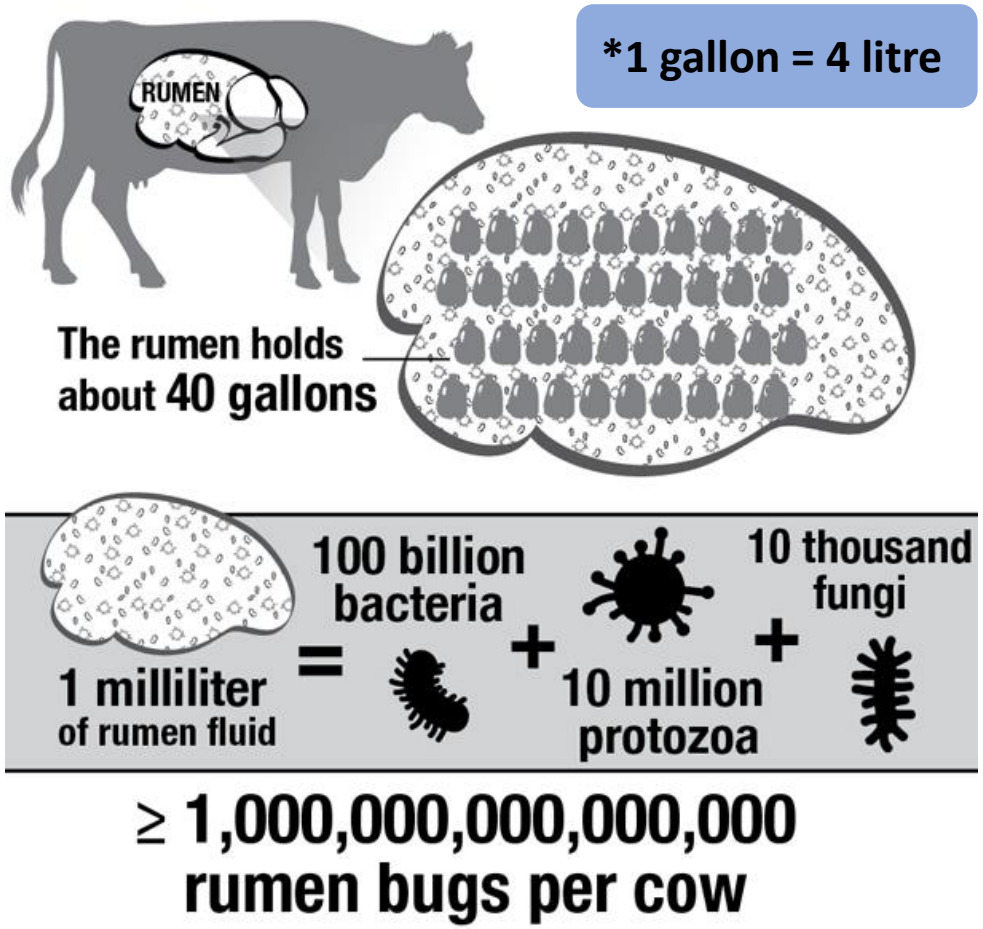
Lush forage

17.1 Fiber digestibility Cont'd…

- Higher feed intake and higher digestibility can result in higher milk production, but it is important that the ration is balanced.
- The mature forages have a higher fiber content and lower soluble carbohydrates (sugar and starch) content.
- These type of fiber builds up the slow-working, fiber-digesting microorganisms hence causes feed to move more slowly through the digestive system.
- As a result the cow feels less hungry because the fibrous feed stays longer in the rumen and therefore feed intake is reduced.

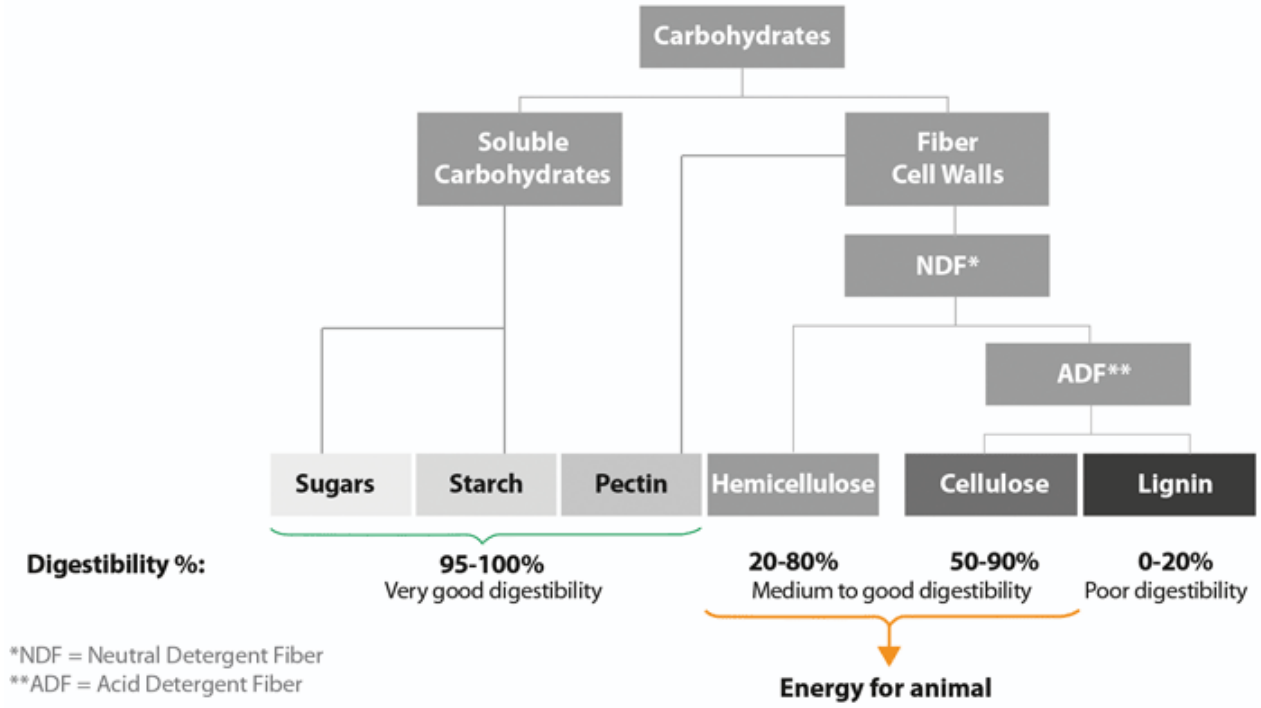
18. Importance of ration consistence

- When feed is changed suddenly, the microbe population in the rumen changes and a new balance between the different types of bacteria will be established. This however takes some time (1-2 weeks).
- Forage fiber-digesting microorganisms may take 4-6 weeks to populate.
- Starch-digesting (grain or grain by products) microorganisms take 4-5 days to populate.
- Therefore regular diet change is not optimal because it takes time for microbial population to reestablish.



19. Energy as an essential nutrient for microorganisms

- Most of the energy needed for microorganisms to grow and multiply is sourced from:
  - Sugars (e.g. lush forages, molasses and citrus pulp)
  - Starch (e.g. cereal grains and agro-industrial by products)
  - Digestible fiber (e.g. forages, cottonseed hulls, palm kernel extract and brewer´s grain).



20. Protein as an essential nutrient for microorganisms

- Microorganisms use both true protein (e.g. protein meal and pastures) and non-protein nitrogen (e.g. urea).
- In turn, rumen microorganisms become the largest source (greater than 70%) of dietary protein for the cow.
- Feeding excessive amounts of protein to cows is not good for their health (and not cost effective).
- Excess protein is converted to urea, which can have hazardous effects on and could compromise cow fertility.

Lucerne pellets

21. Minerals as essential nutrients for microorganisms

- Calcium, phosphorus, sulphur and magnesium are essential for microorganisms to grow and multiply.
- Young stock should be introduced to minerals and salts as early as the first week.
- These minerals are important for a healthy rumen development in young stock.

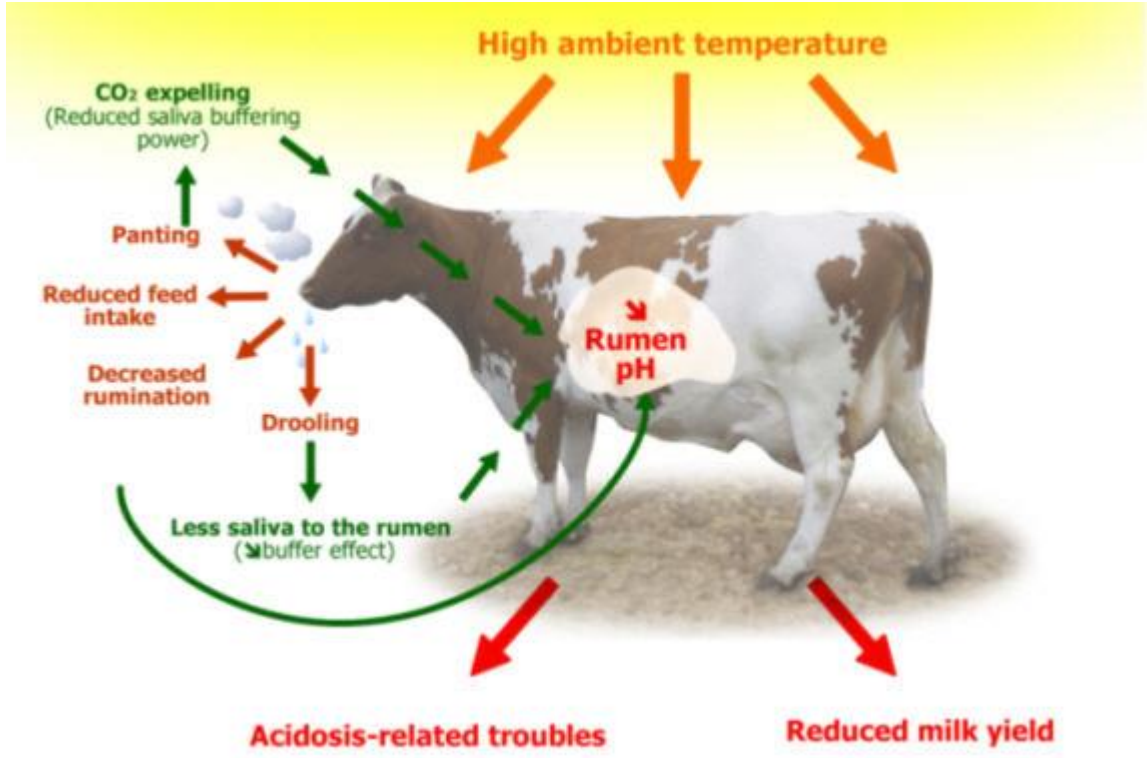
22. Water for microorganisms function

- Cows can drink depending on their milk production level i.e. 50-100 liters a day.
- Cow should always have free access to water 24hours a day to be able to drink as much water as they need.
- Cows are particularly thirsty after milking. Water at the exit and entry points is necessary.
- Water intake is affected by for example, size of the animal, milk production levels, dry mater intake, water cleanliness, salt/mineral content, and environmental temperature.

Further reference: Module on water supply and demand.

23. Rumen temperature

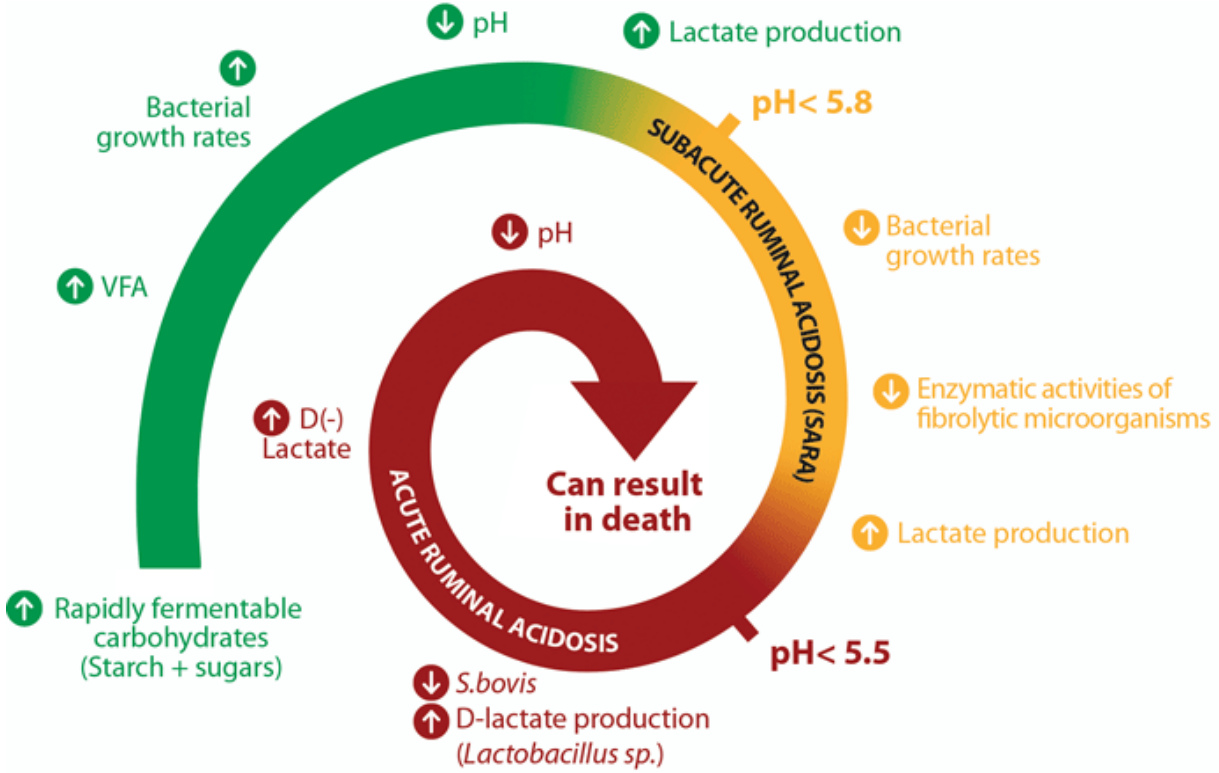
- The rumen temperature is maintained in the range of 39 to 39.5°C.
- The rumen temperature may increase up to 41°C immediately after the animal eats. This is because the fermentation process generates heat.
- Other factors that may affect rumen temperature are;
    - The cow being on heat (cycling).
    - The general health status of the cow.
    - The temperature of the feeds/water.
    - Changes in environmental temperature.



24. Rumen pH and buffering capacity

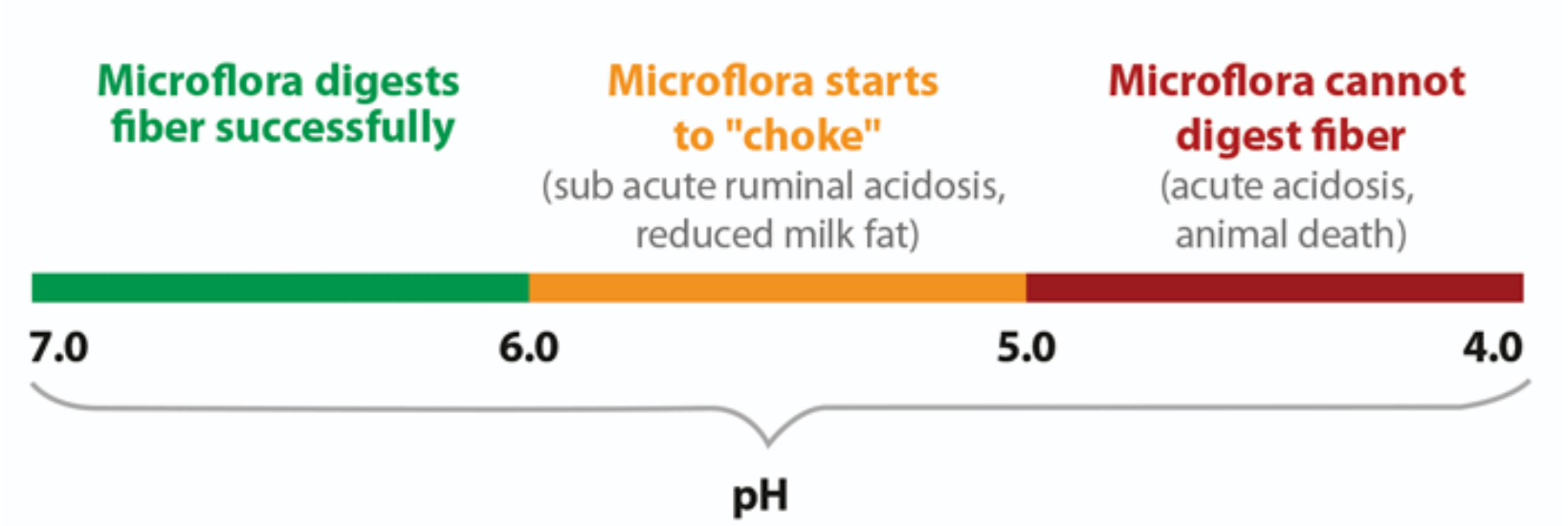
- Every meal which contains fermentable carbohydrates leads to a drop in pH.
- Fermentable carbohydrates produces free fatty acids which reduce the pH levels in the rumen.
- At pH 6-7 the rumen function is optimal; below pH 5.8 indicates rumen acidity that affects the micro flora negatively.

Further reference:
See module on Metabolic Disorders - Rumen acidosis



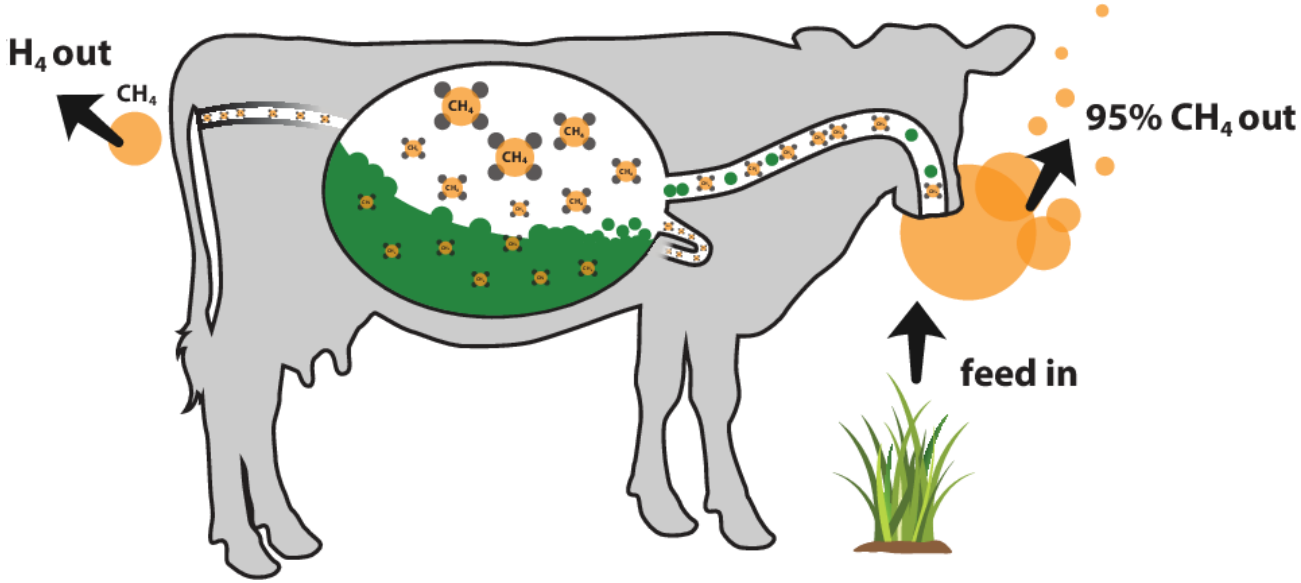
24.1 Factors affecting pH levels in the rumen

- The production of saliva (contain bicarbonates that has buffering capacity, pH of 8.2).
- Fibrous feeds play an important role in saliva production through chewing of cud.
- The frequency of feeding carbohydrates; Total mixed ration is important to maintain a good pH levels.
- Ensuring carbohydrates is spread within several feeding in a day.
- The exchange of bicarbonates and phosphates through the rumen epithelium.



25. Rumen osmotic pressure

- The rumen osmotic pressure depends on the presence of ions and molecules, which generate gas.
- Immediately after feed intake, the osmotic pressure increases and then decreases gradually over a period of 8-10 hours.
- The osmotic pressure increases with the presence of volatile fatty acids (VFAs) produced by fermentation processes.
- It has a direct relationship with the pH in diets rich in carbohydrates.



26. Indicators of poor rumen health

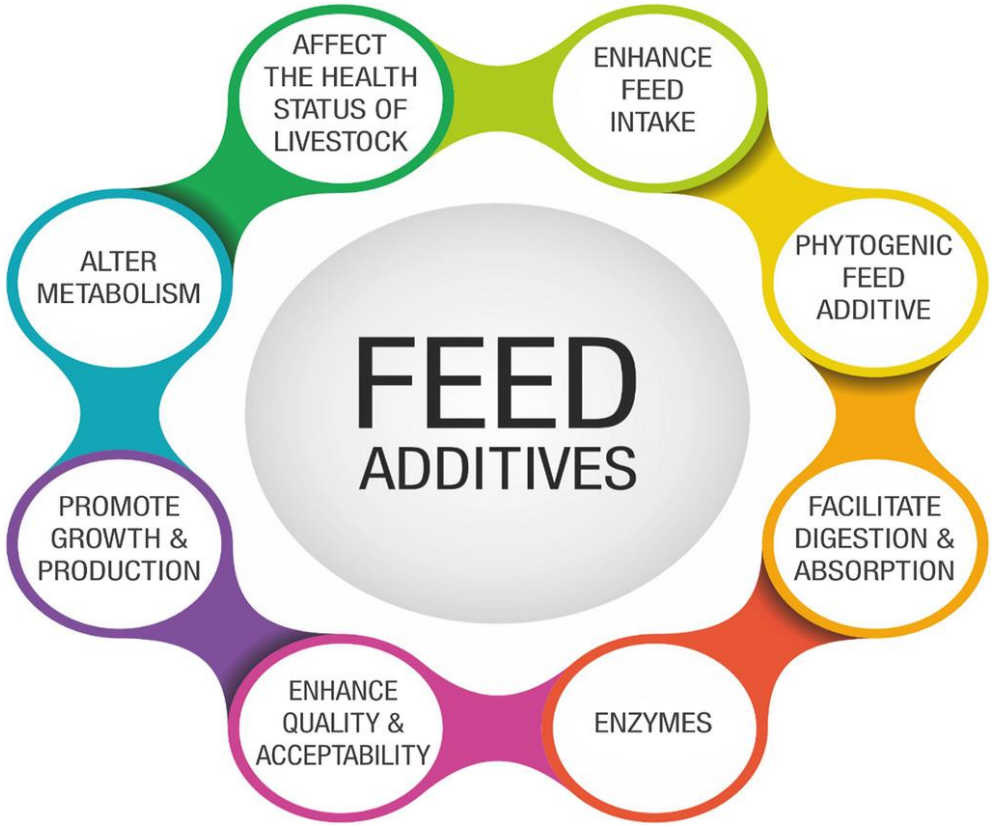
- Low milk production, milk fat & protein ratio reduction.
- Increase in liquid/thin manure due to undigested feeds.
- Drop in both weight and body condition of cows.
- General cow performance drops such as reproductive performance.

27. Manipulation of rumen fermentation

- Biotechnology additives have been used to modify rumen fermentation. This is by promoting or diminishing certain fermentation processes.
- However, these additives are mostly not recommended due to their economical constrains.
- With the best feeding practices (including balanced rations) that maintain rumen health a farmer should be able to achieve good milk production and cut cost of production.

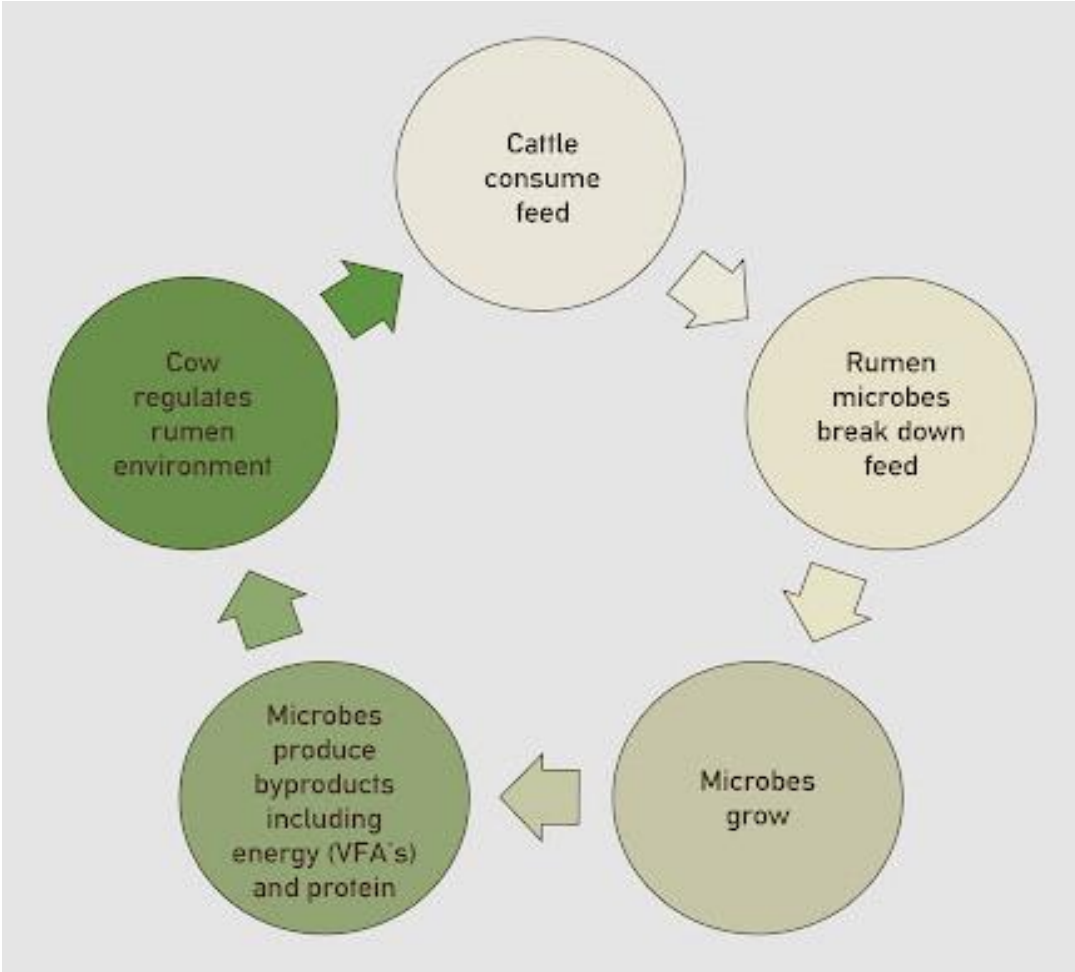
28. Categories of rumen manipulation

1) Modification of diet and fermentation profile, e.g. treating low quality forage with urea.
2) Transformation of food before consumption, e.g. heating.
3) Manipulation of rumen microorganisms, e.g. reducing protozoa.
4) Use of micro-organism fermentation activators, e.g. adding probiotics.
5) Use of substances with rumen activity such as; buffering substances.



29. Take home message/Summary

- Rumen fermentation is a result of metabolism of microorganism that are present in the rumen environment.
- Their metabolic pathways are interwoven so that the end product is the substrate of another.
- Achieving the end products of rumen fermentation is necessary for ruminant nutrition.
- Some farmers can manipulate the rumen ecosystem and micro-flora by using additives but this is not highly recommended due to the costs implication.



Summary of basic functioning of the rumen

- END -