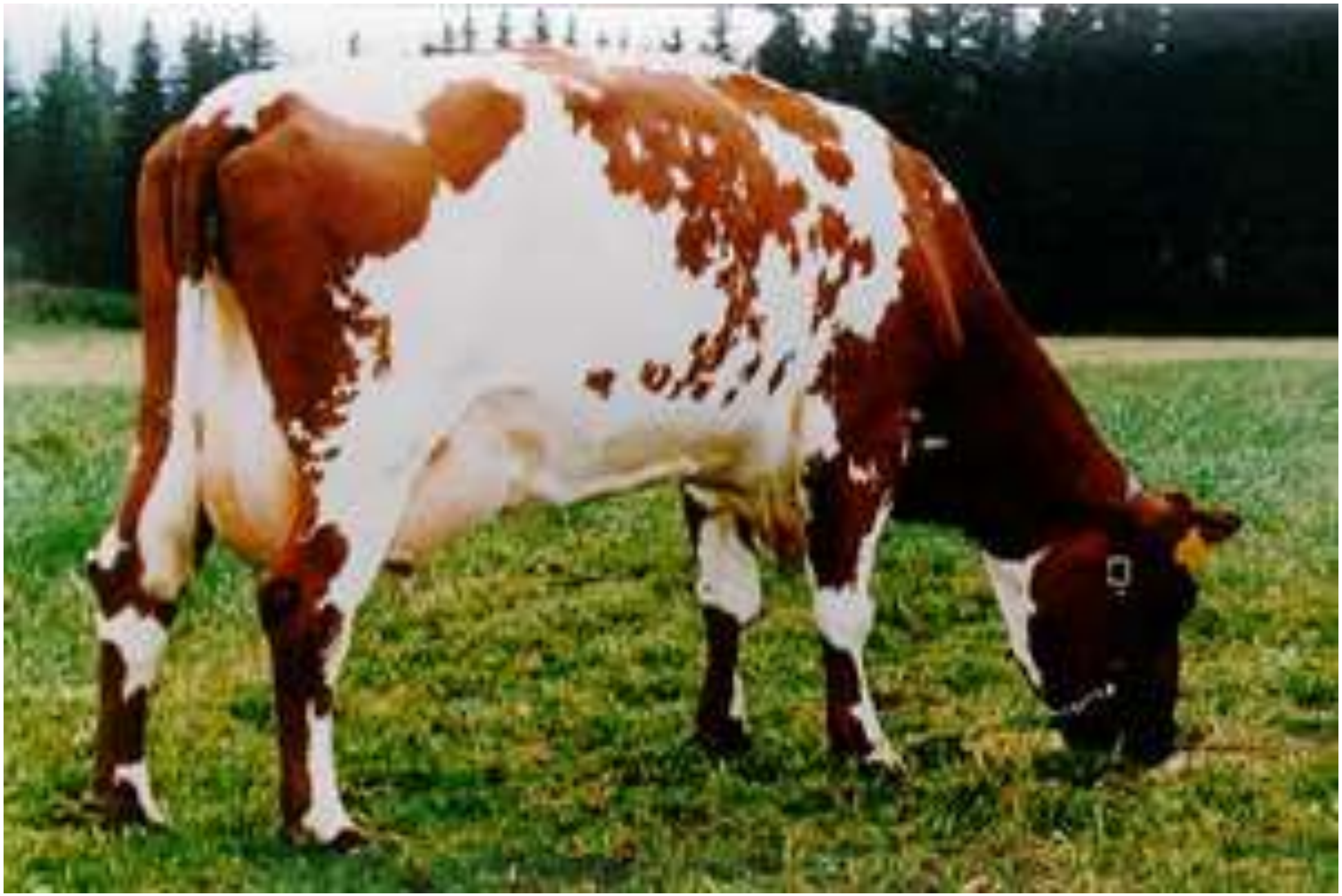
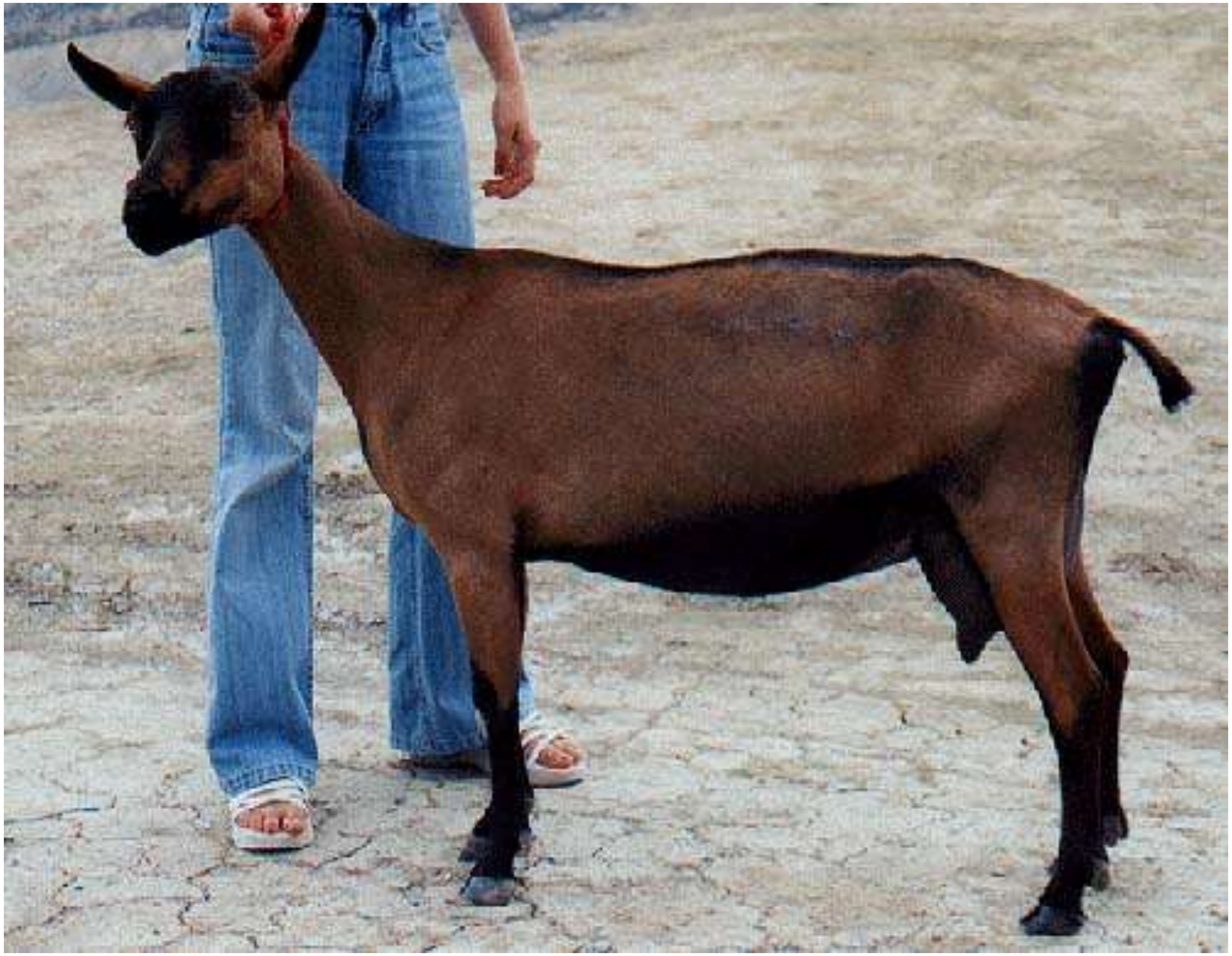
RUMINANTS

LESSONS 63-68



Hungarian grey cattle

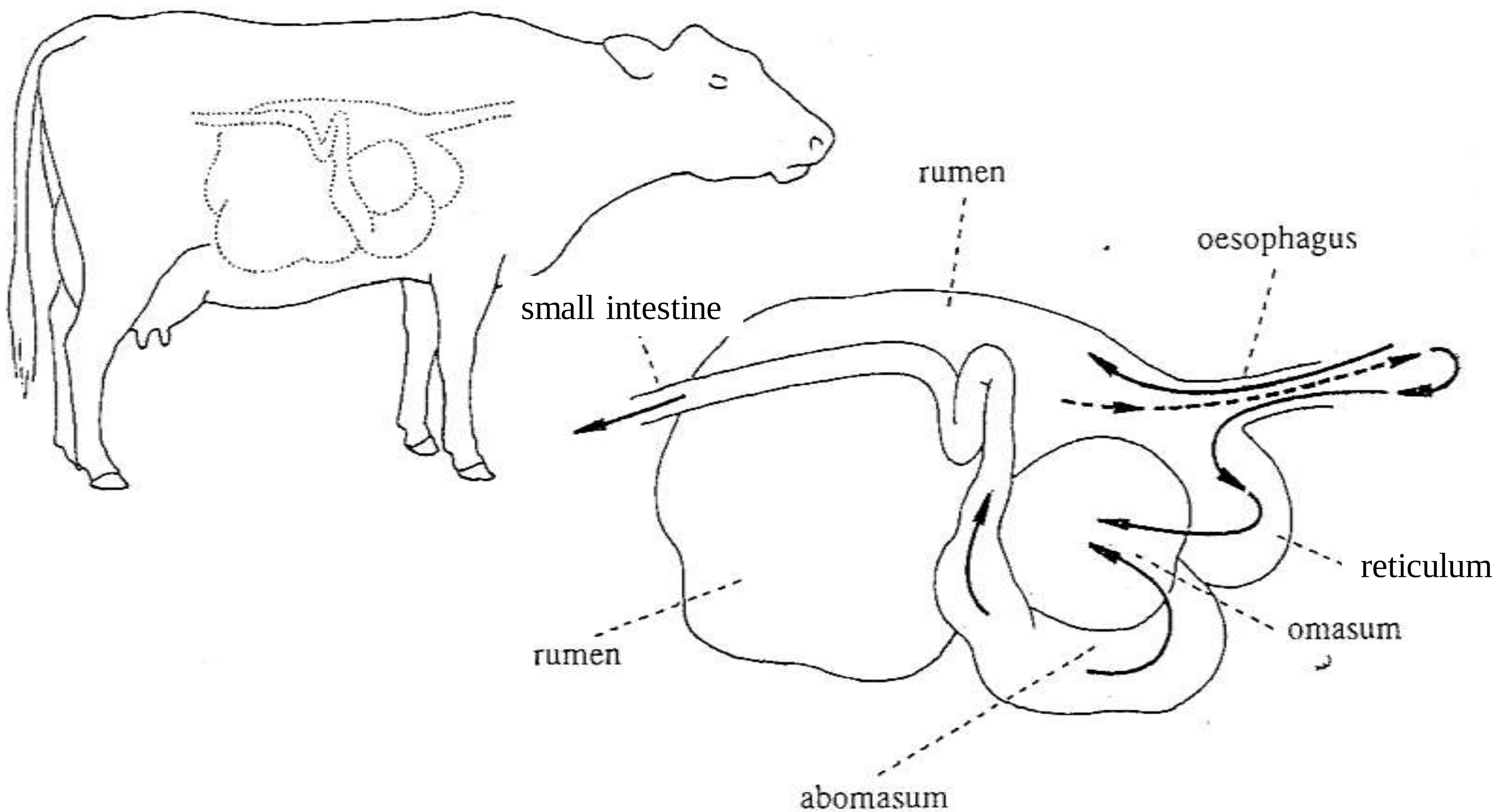


The Dik-dik is one of South Africa's smallest antelopeone (one of the smallest ruminants)

- Body mass: 4-6 kg

Langur monkey: ruminant-like digestion: 4 chambers of the stomach with symbiontic microbes www.flickr.com/photos/chrissie64/119462178/

Anatomy of forestomachs



Ruminant stomach courses.washington.edu/chordate/453photos/gut...

Rumen courses.washington.edu/chordate/453photos/gut...

Reticulum courses.washington.edu/chordate/453photos/gut...

Omasum courses.washington.edu/chordate/453photos/gut...

Abomasum courses.washington.edu/chordate/453photos/gut...

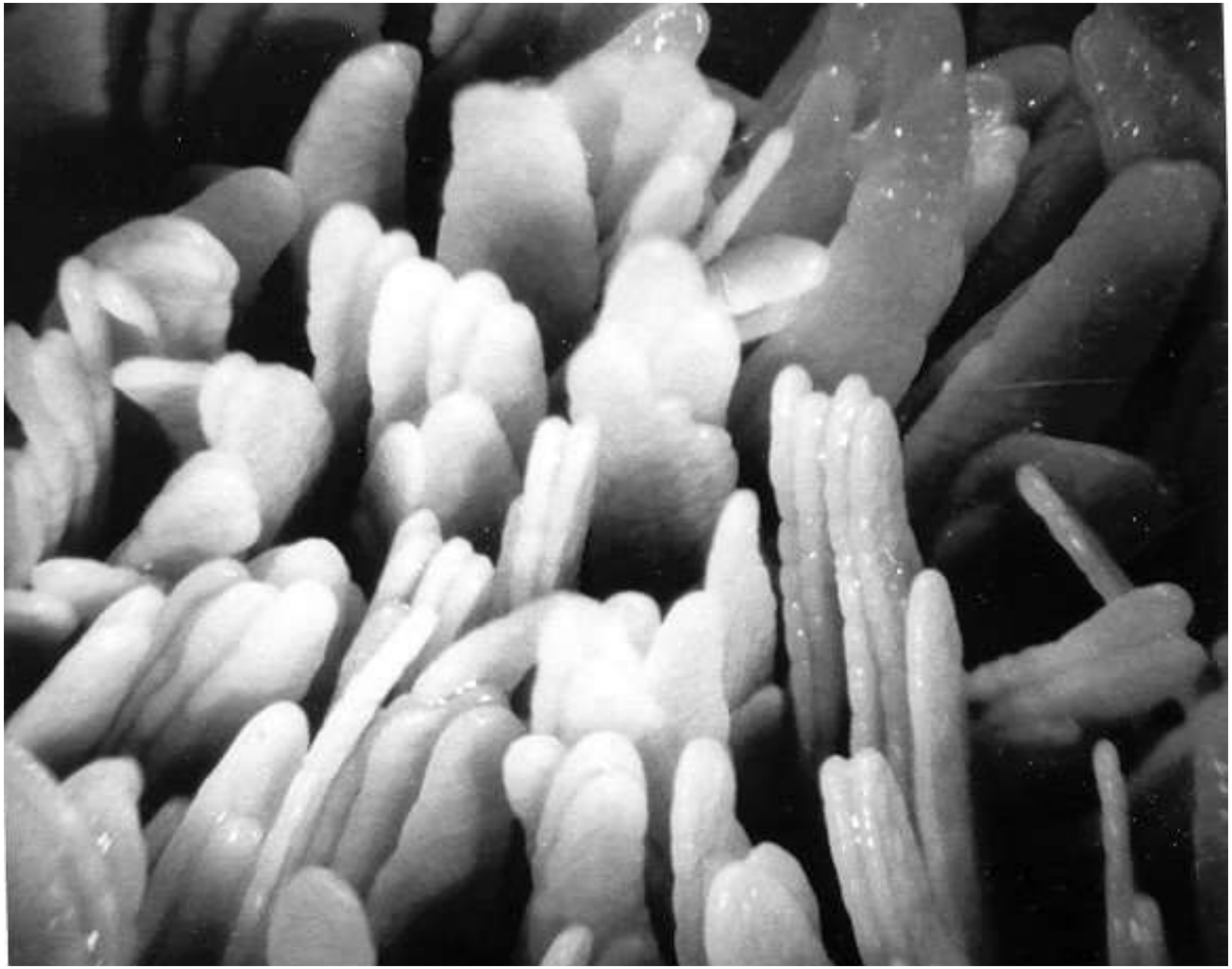
Young ruminants

www.sheep101.info/cud.html

- At birth, the lamb's rumen and reticulum are not yet functional. As lambs begin to nibble on dry feeds, these two compartments become

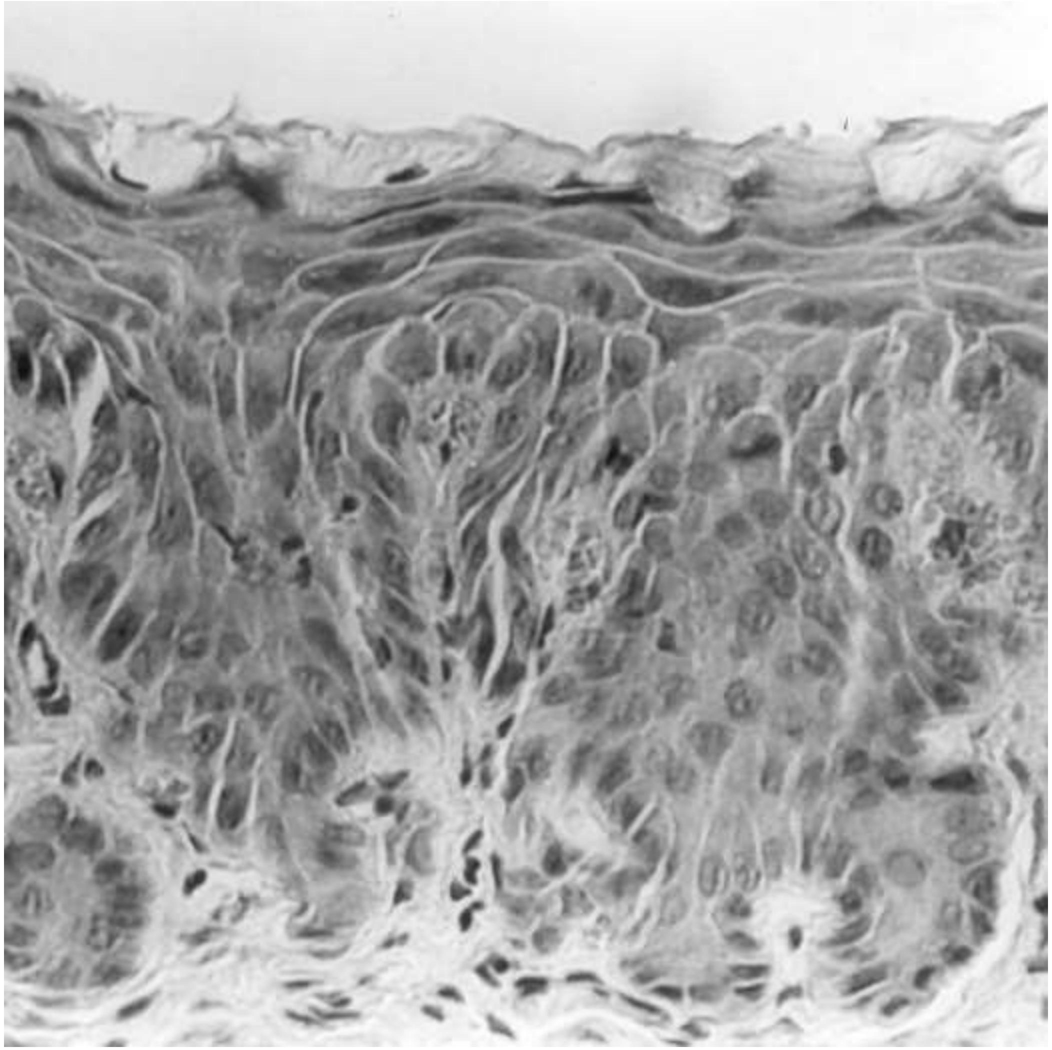
"innoculated" with microogransims. As the **microbes** multiply and begin to digest feed, they stimulate the growth and development of the rumen and reticulum. The lamb's rumen and reticulum are usually functional by the time it is 50 to 60 days old.

Macroscopic structure of ruminal epithelium

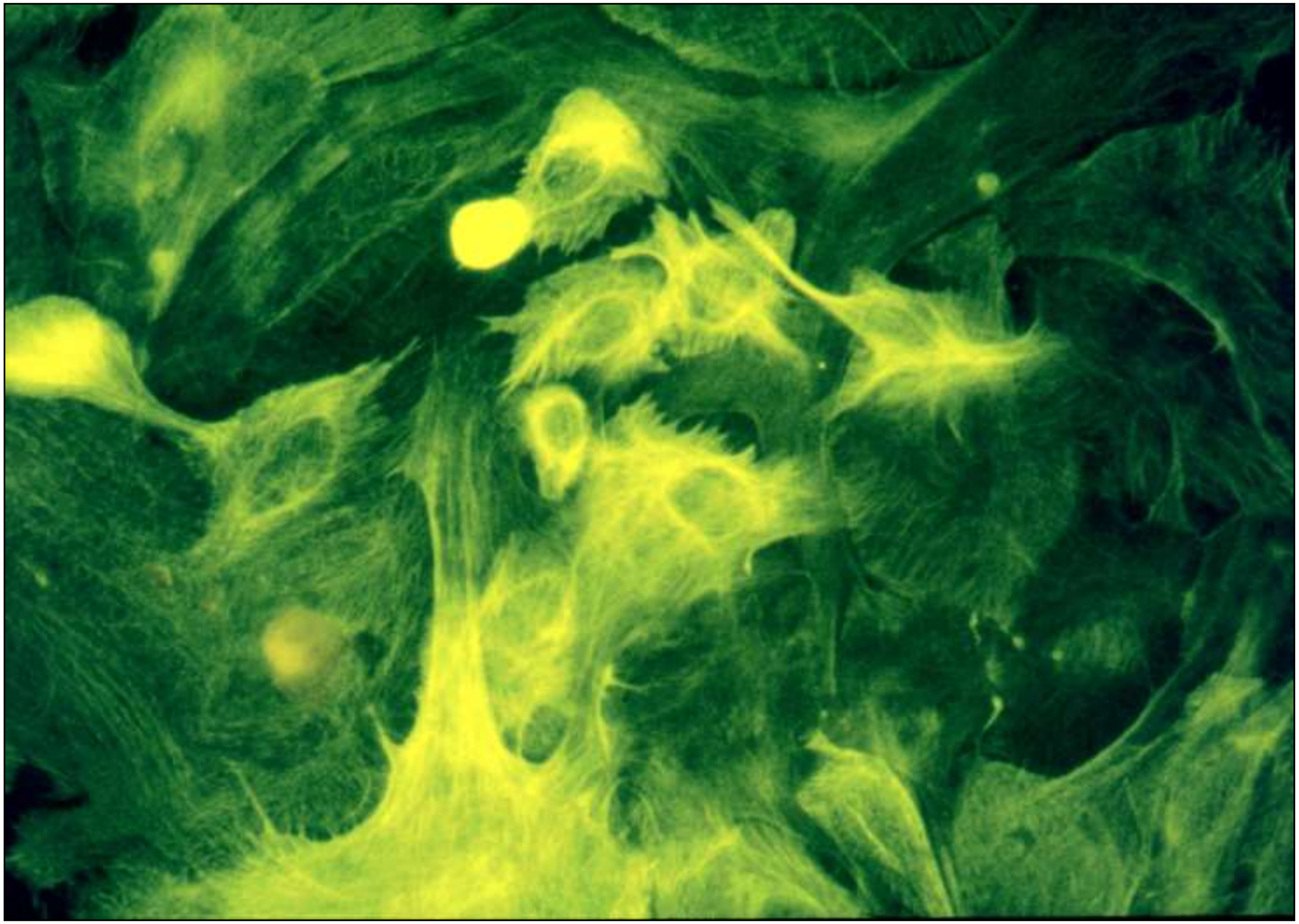


Ruminal papillae

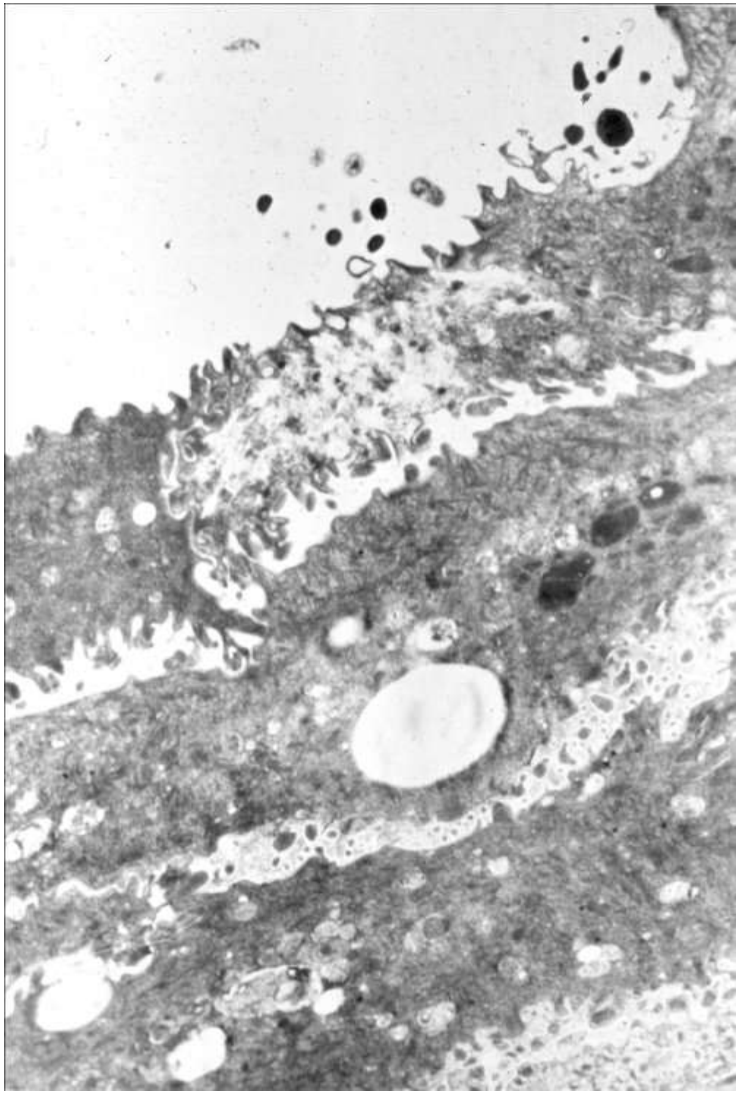
Microscopic structure of ruminal epithelium



Rumen epithelial cell culture

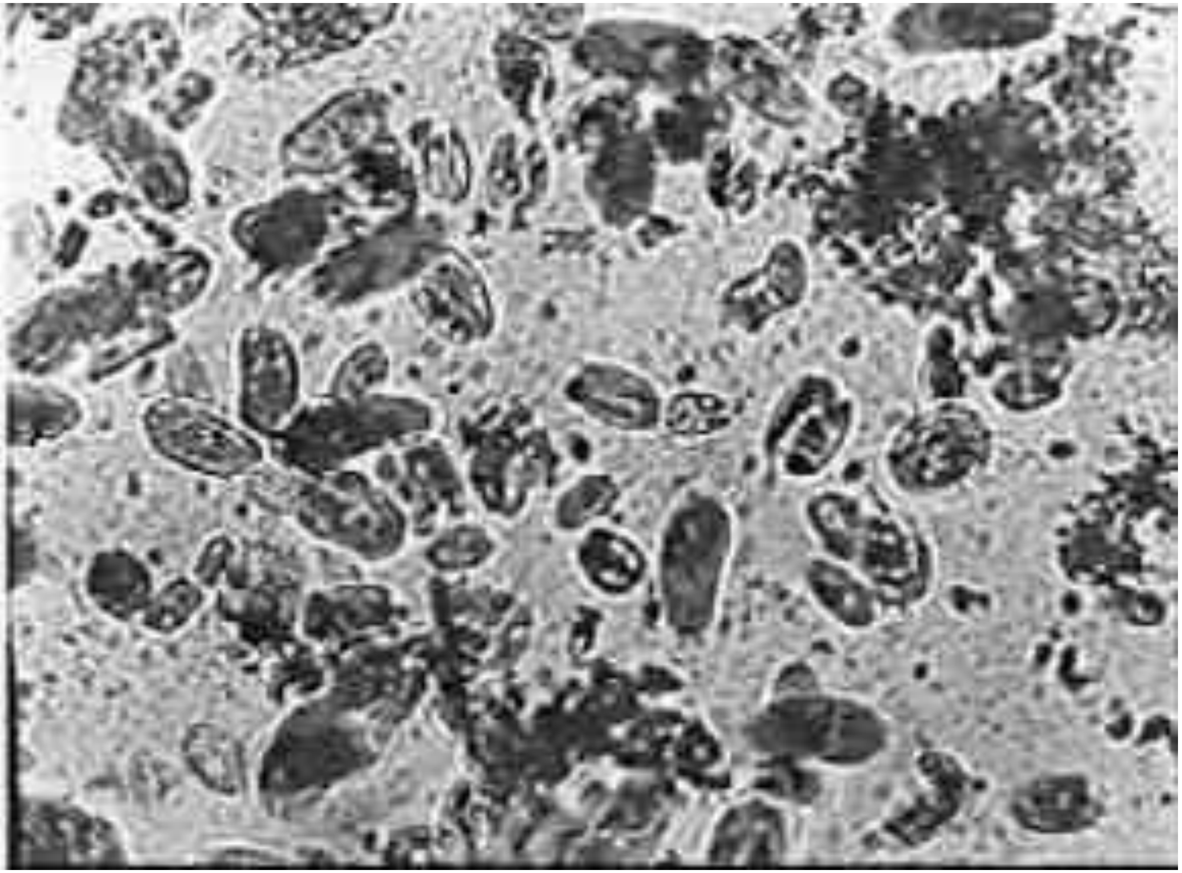


Electronmicroscopic structure of ruminal epithelium



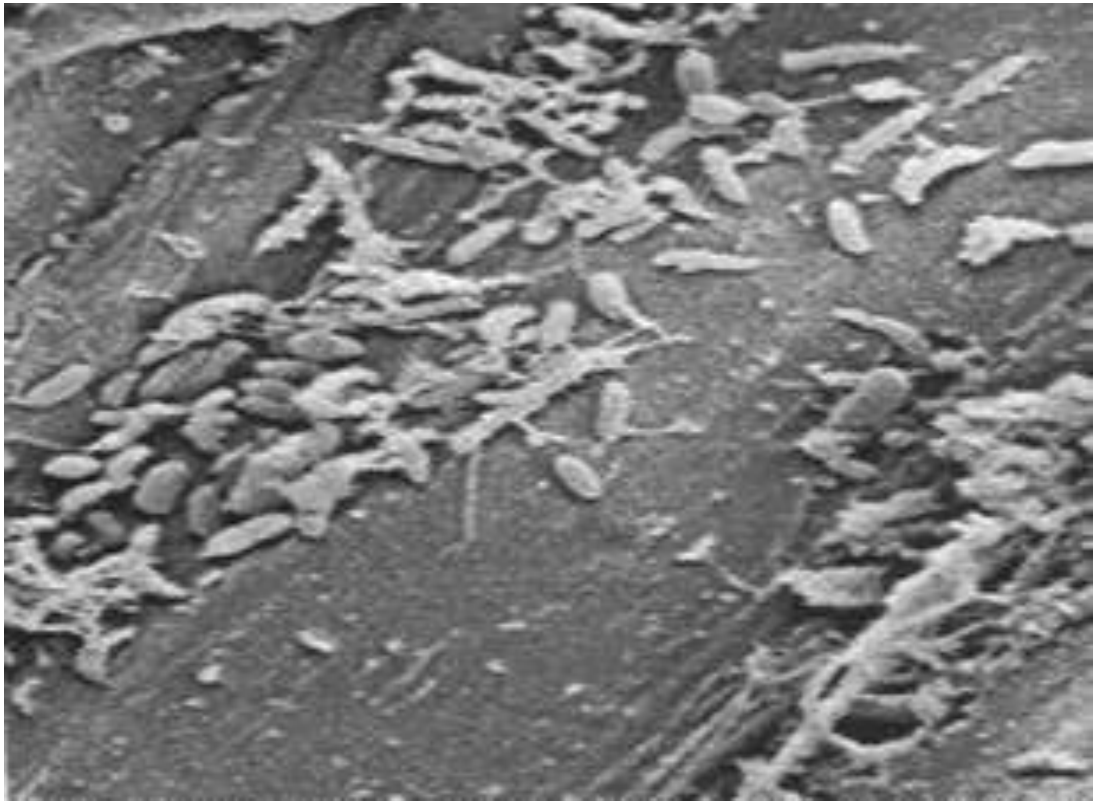
Ruminal microbes in the rumen fluid: mixed culture (bacteria, protozoa, fungi)

www.admani.com/AllianceBeef/TechnicalEdge/Rum...



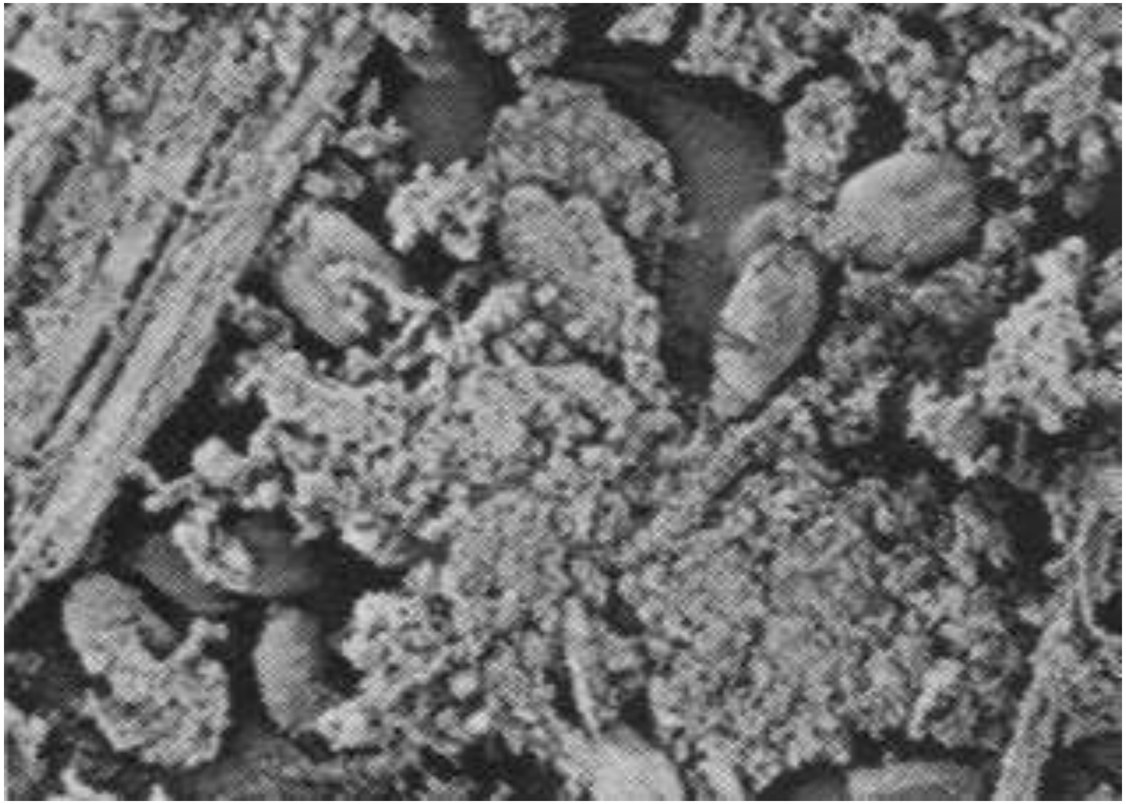
Ruminal microbes in the rumen fluid: rumen **bacteria** www.mekarn.org/procbuf/wanapat.htm

- Attachment of rumen bacteria on rice straw of swamp buffalo, Bar = 16 μm



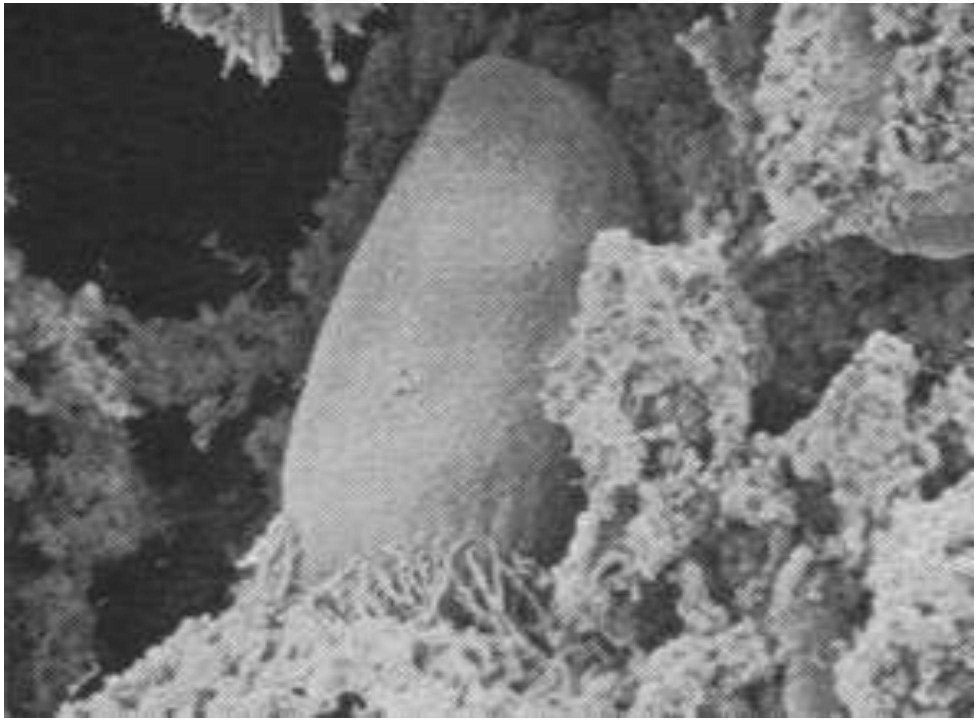
Ruminal microbes in the rumen fluid: rumen **protozoa** www.mekarn.org/procbuf/wanapat.htm

- Rumen protozoa



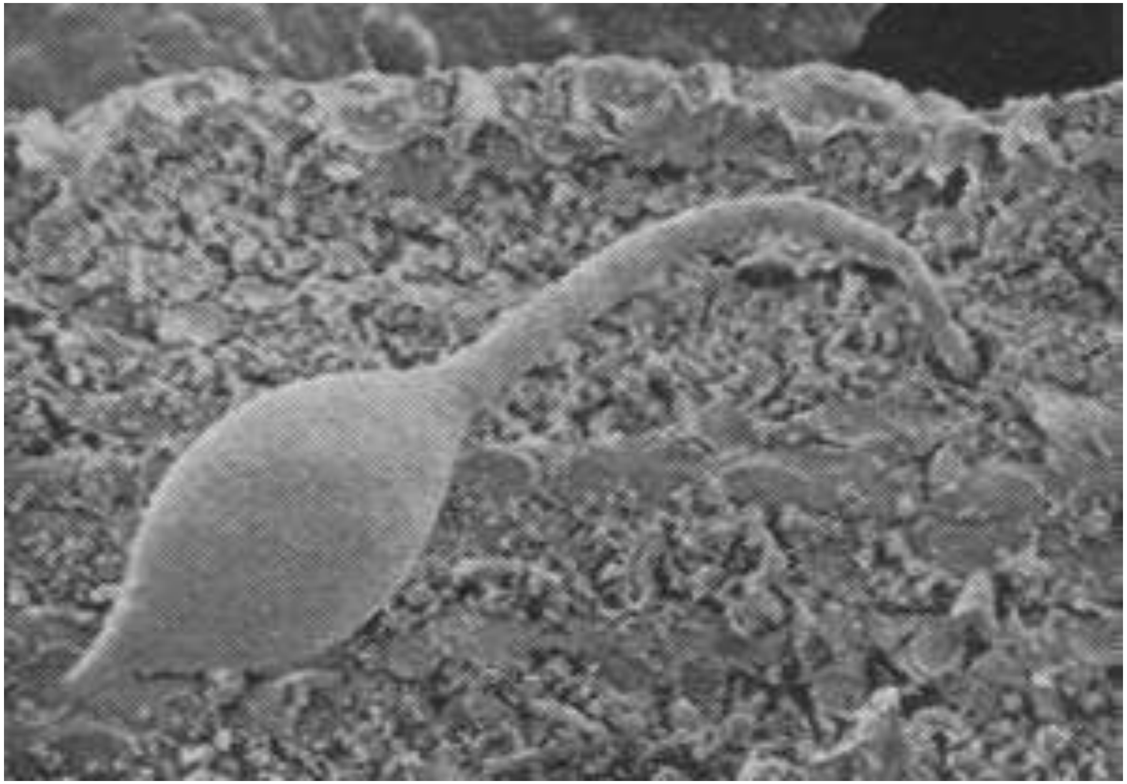
Ruminal microbes in the rumen fluid: rumen **protozoa** www.mekarn.org/procbuf/wanapat.htm

- Rumen protozoa, *Entodiniomorph* sp. of swamp buffalo



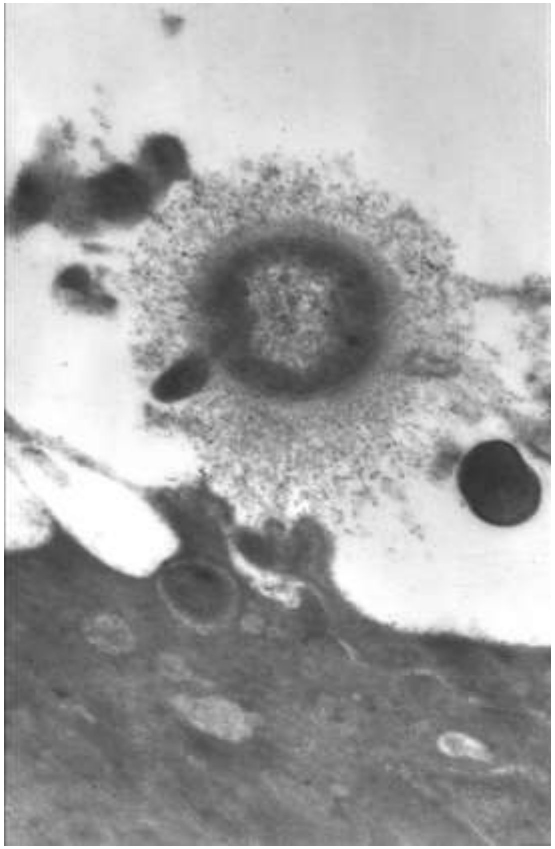
Ruminal microbes in the rumen fluid: rumen **fungi** www.mekarn.org/procbuf/wanapat.htm

- Rumen fungus of swamp buffalo, *Anaeromyces* sp.

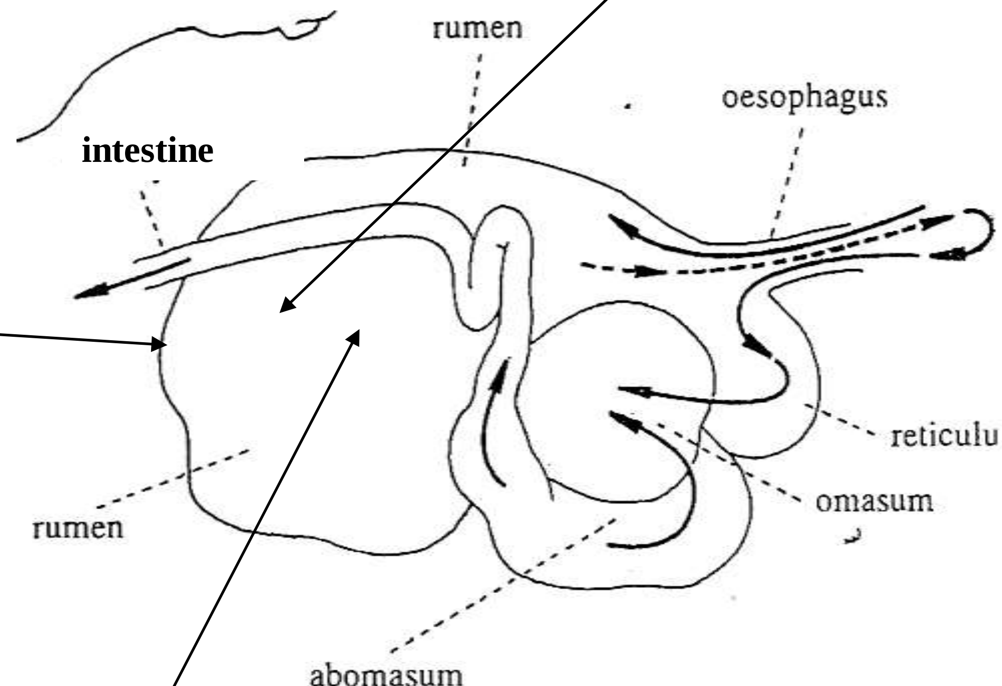


Distribution of microbes in the rumen

Non-attached



Attached to the rumen wall

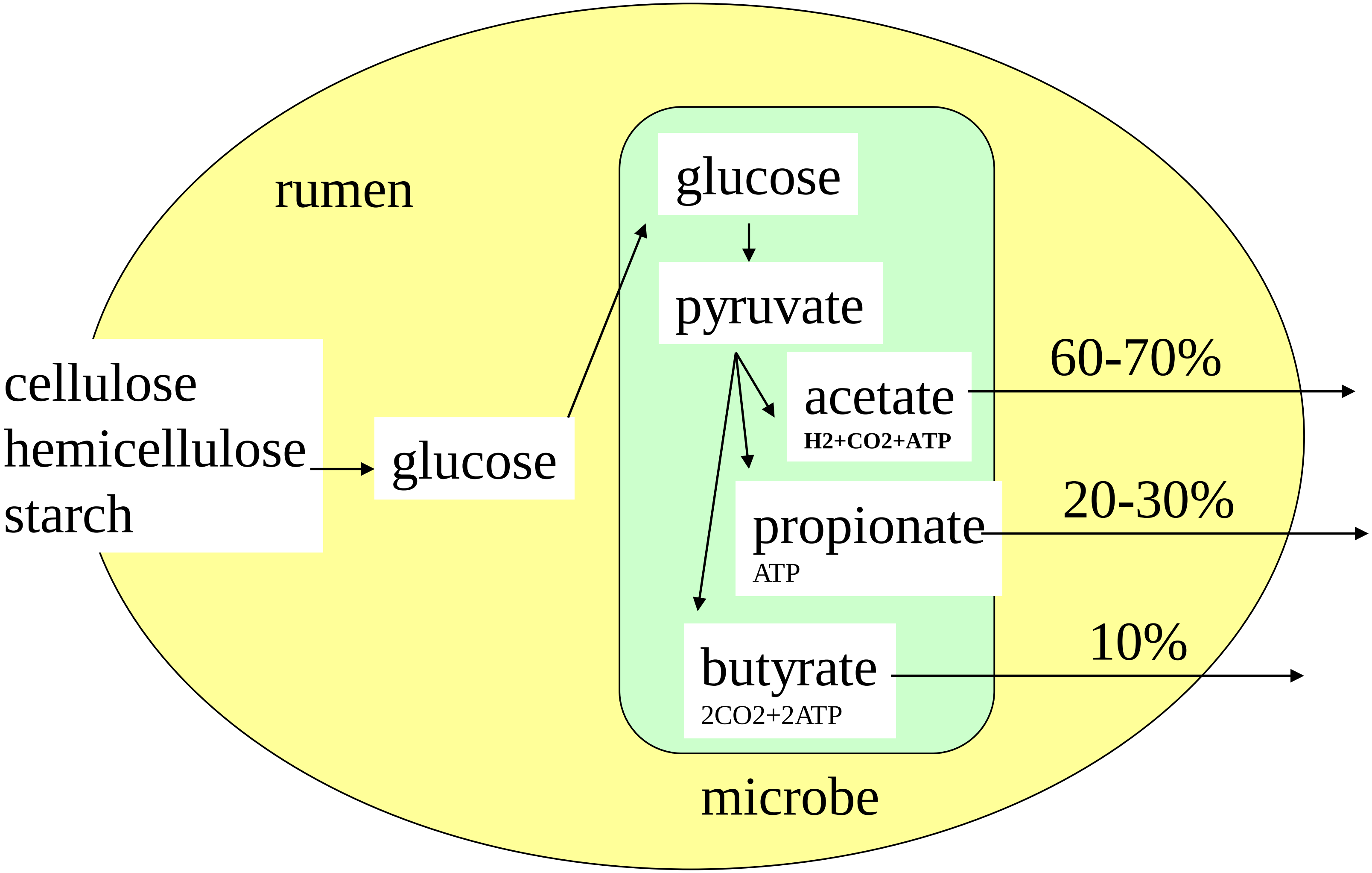


Attached to the feed particles

Microbial population www.admani.com/AllianceBeef/TechnicalEdge/Rum...

- The type of microbes which are most efficient at deriving nutrients from feedstuffs will be the dominant population in the rumen.For example, a forage-based diet will encourage a forage-digesting microbial population to dominate the rumen. Changing diets will cause a shift in the microbial population from one set of species to another. The change in microbial population is one reason why diets should be changed gradually. Rapid changes in type or quantity of diets can result in rapid changes in the microbial populations, which in turn can cause digestive upsets, such as acidosis or bloat.

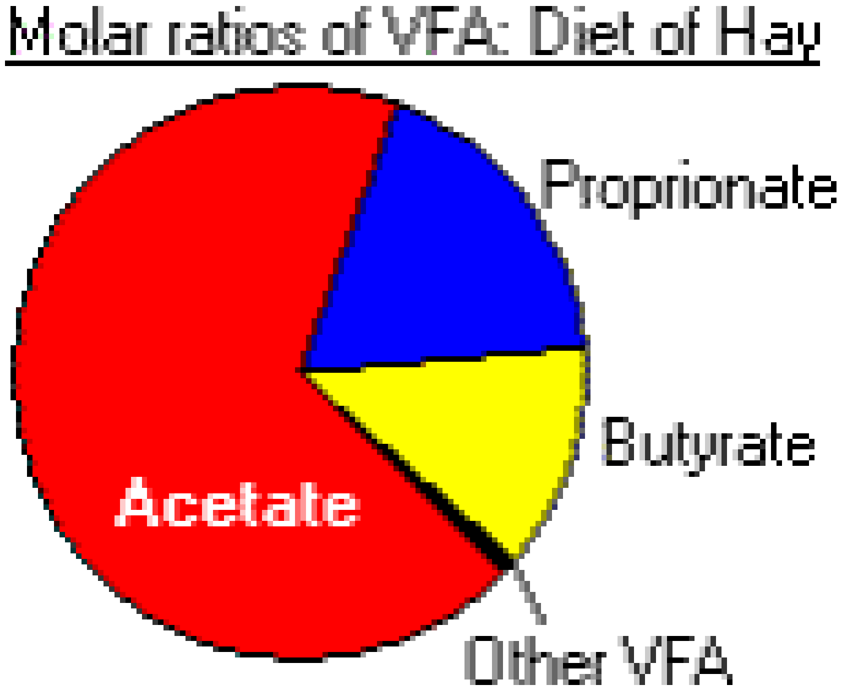
Microbial carbohydrate degradation in the rumen



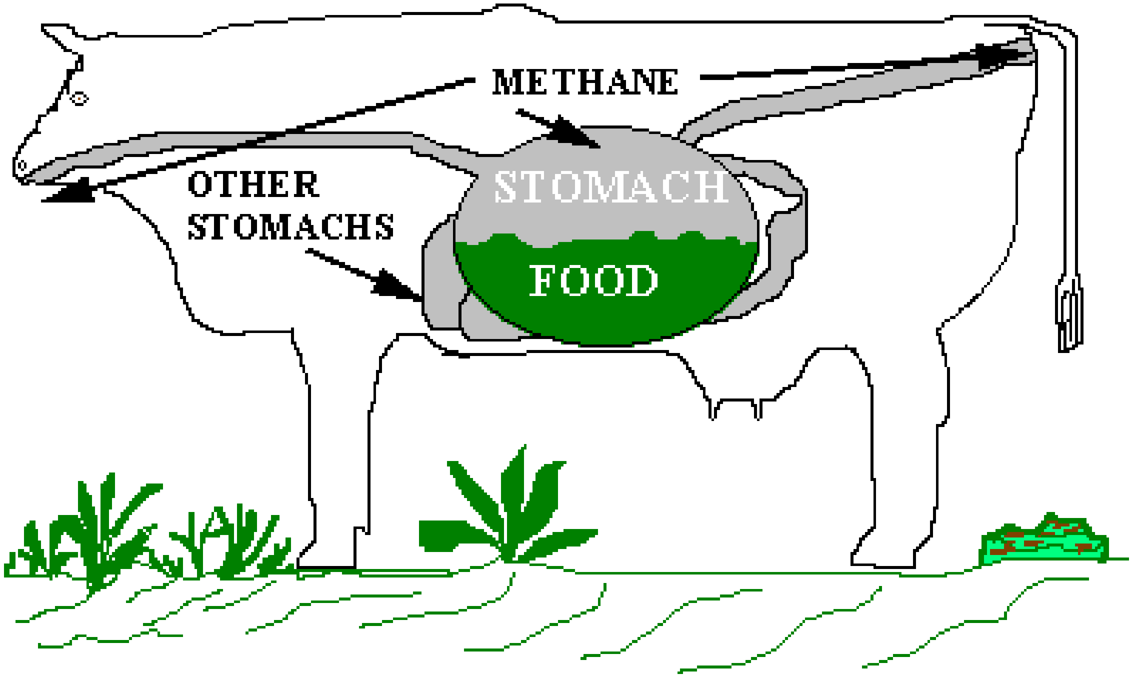
VFA=acetate, propionate, butyrate

capra.iespana.es/.../fermentacioning.htm

Ratio of VFA in the rumen fluid



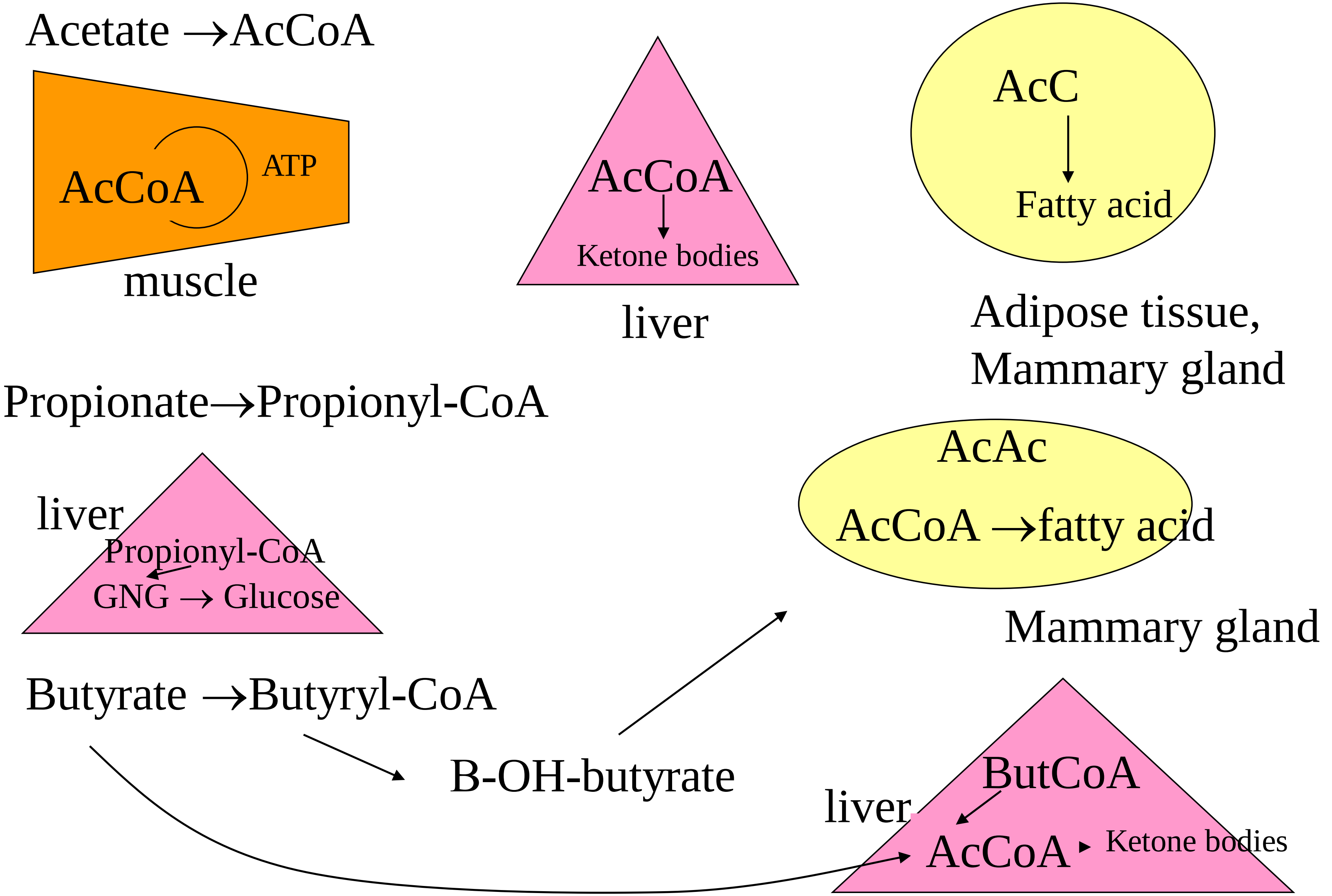
Loss of methane by eructation www.slic2.wsu.edu:82/.../pages/Chap20.html



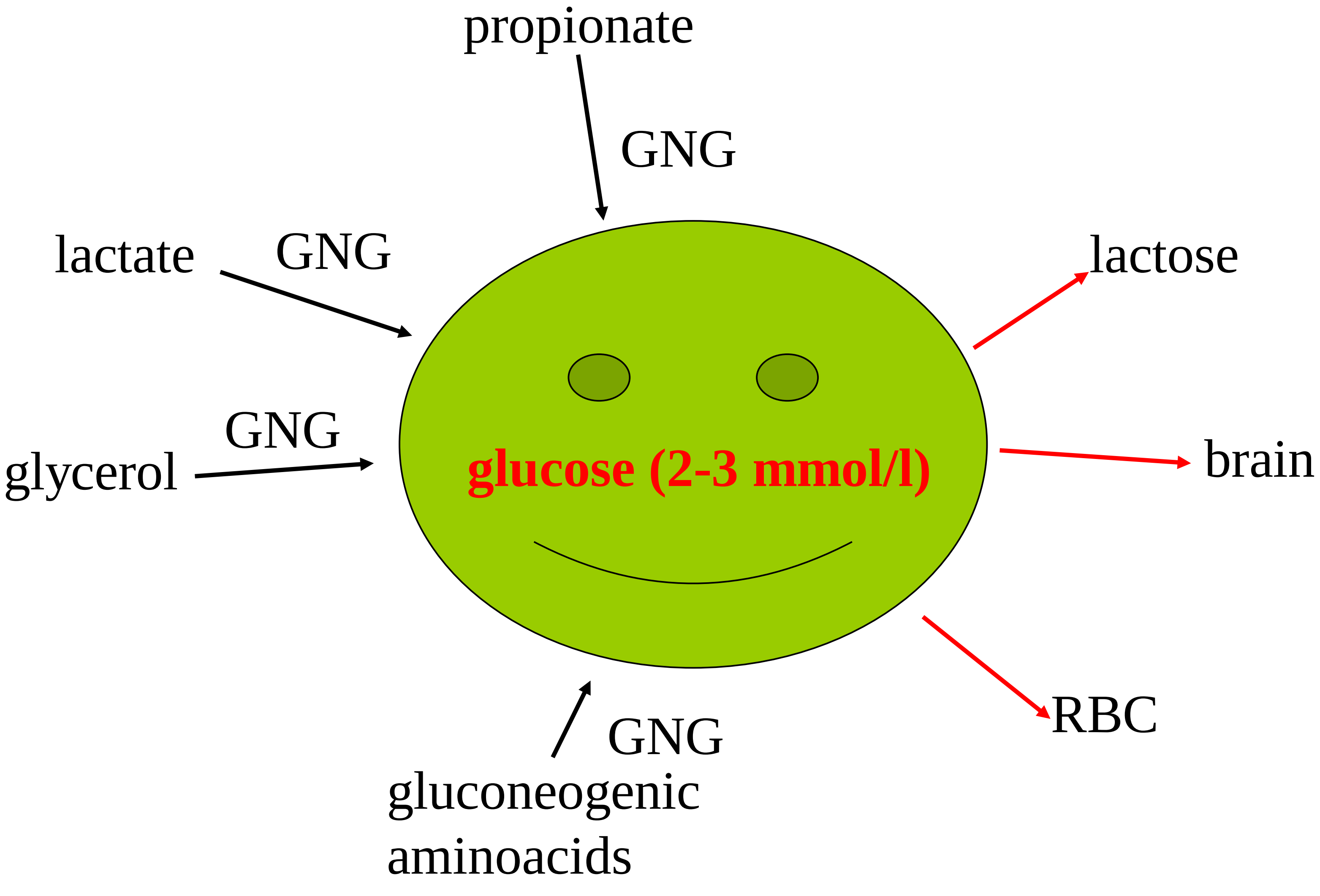
Energy produced from degradation of VFA (%)

Species	Forestomach	Large intestine
cattle	70-80	0-15
sheep	57-79	0
goat	37-46	
deer	25	
langurmonkey	100	
rabbit		8-12
rat		9
pig		5-28
human		0,7-10

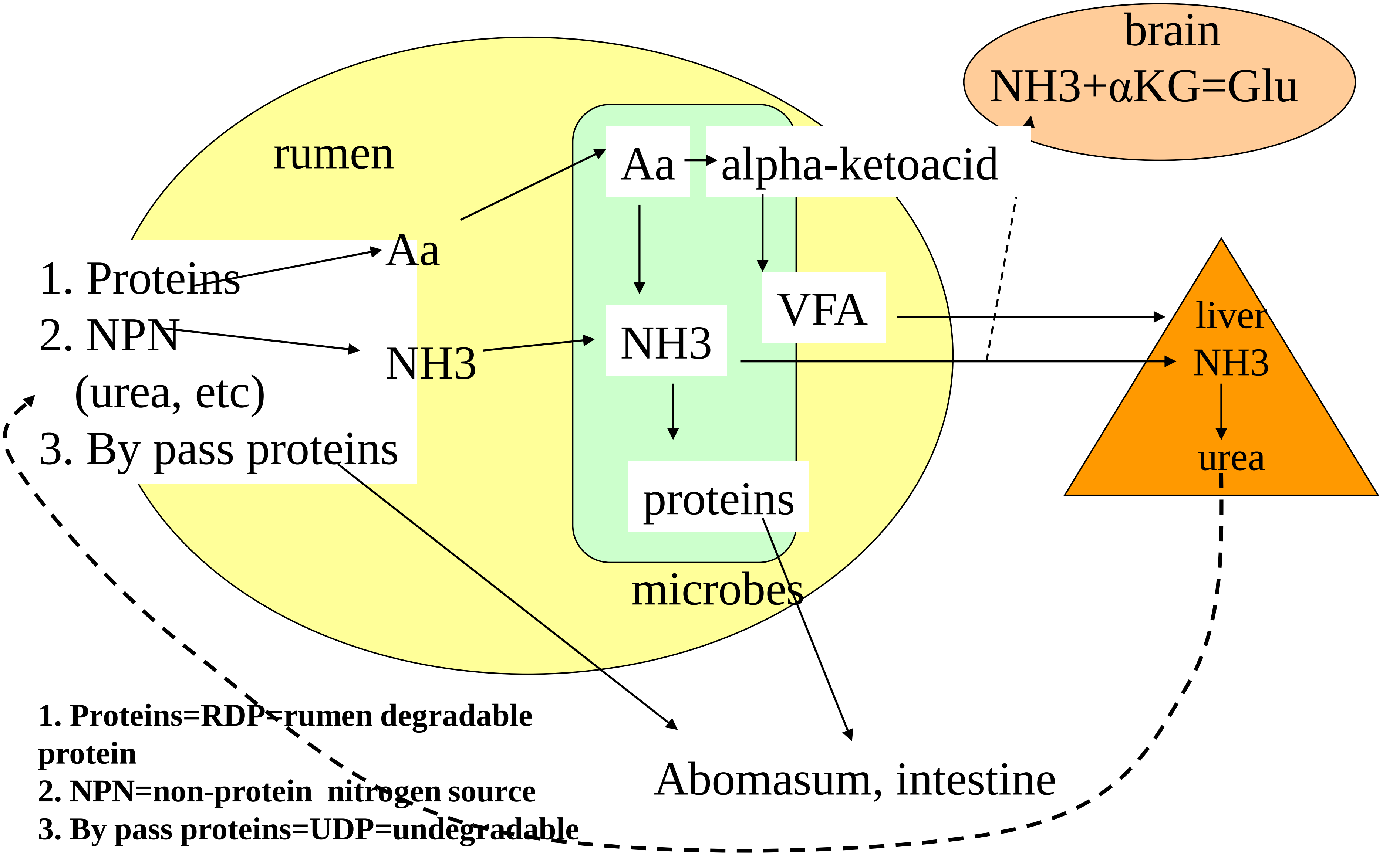
Fate of absorbed VFA in the tissues of the host



Glucose metabolism of the host



Microbial protein metabolism in the rumen



1. Proteins=RDP=rumen degradable protein
2. NPN=non-protein nitrogen source
3. By pass proteins=UDP=undegradable proteins

Degradation of microbial protein

http://www.laboratoires-abia.com/en/change-in-levels-of-chymosin-and-pepsin-in-the-abomasum-of-cattle.html

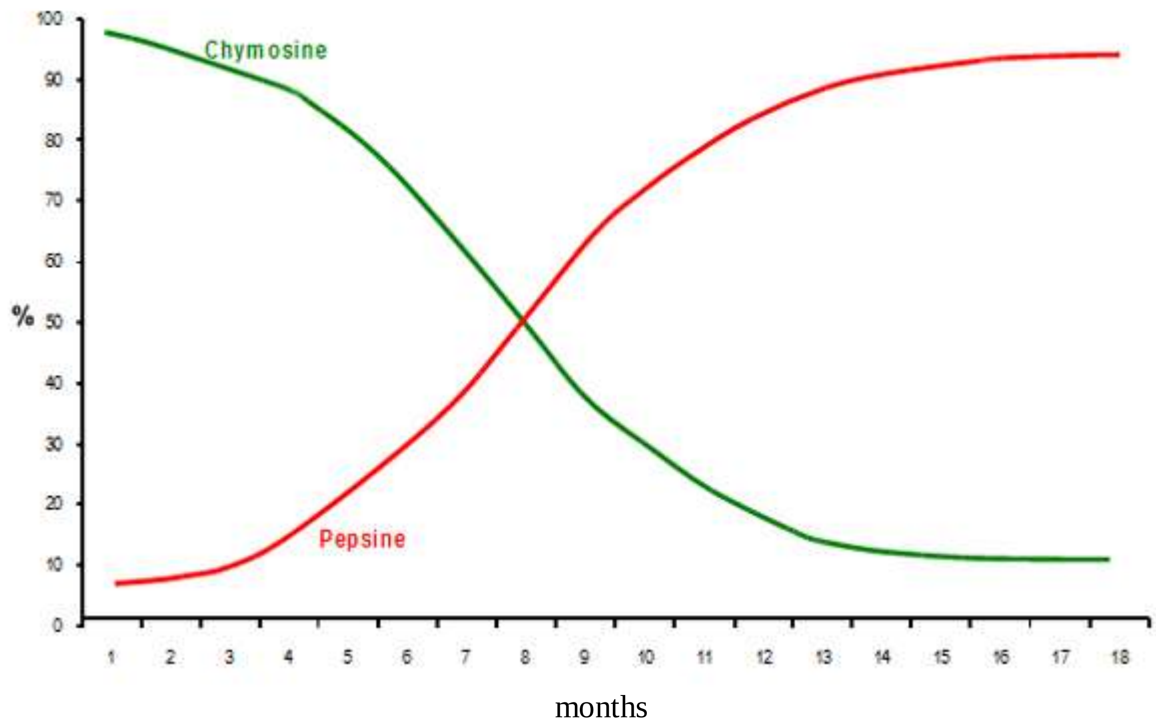
- By pepsin in the abomasum
- By pancreatic trypsine

- At the birth of the animal, the abomasum of young calves contains mainly chymosin=rennin (> 80% of the enzyme content). This is because that the animal consumes only milk.
- Chymosin is the specific enzyme of milk digestion, hence the major secretion.
- Gradually, as the animal grows its nutrition evolves from a diet based on milk to a mixed diet. The consequence of this food change is a drop in the rate of chymosin for the benefit of increased secretion of bovine pepsin. To eight months, the content of pepsin in the stomach becomes higher than that of chymosin. At this stage, we speak of weanlings. In adulthood, pepsin is practically the only enzyme present. See next slide!

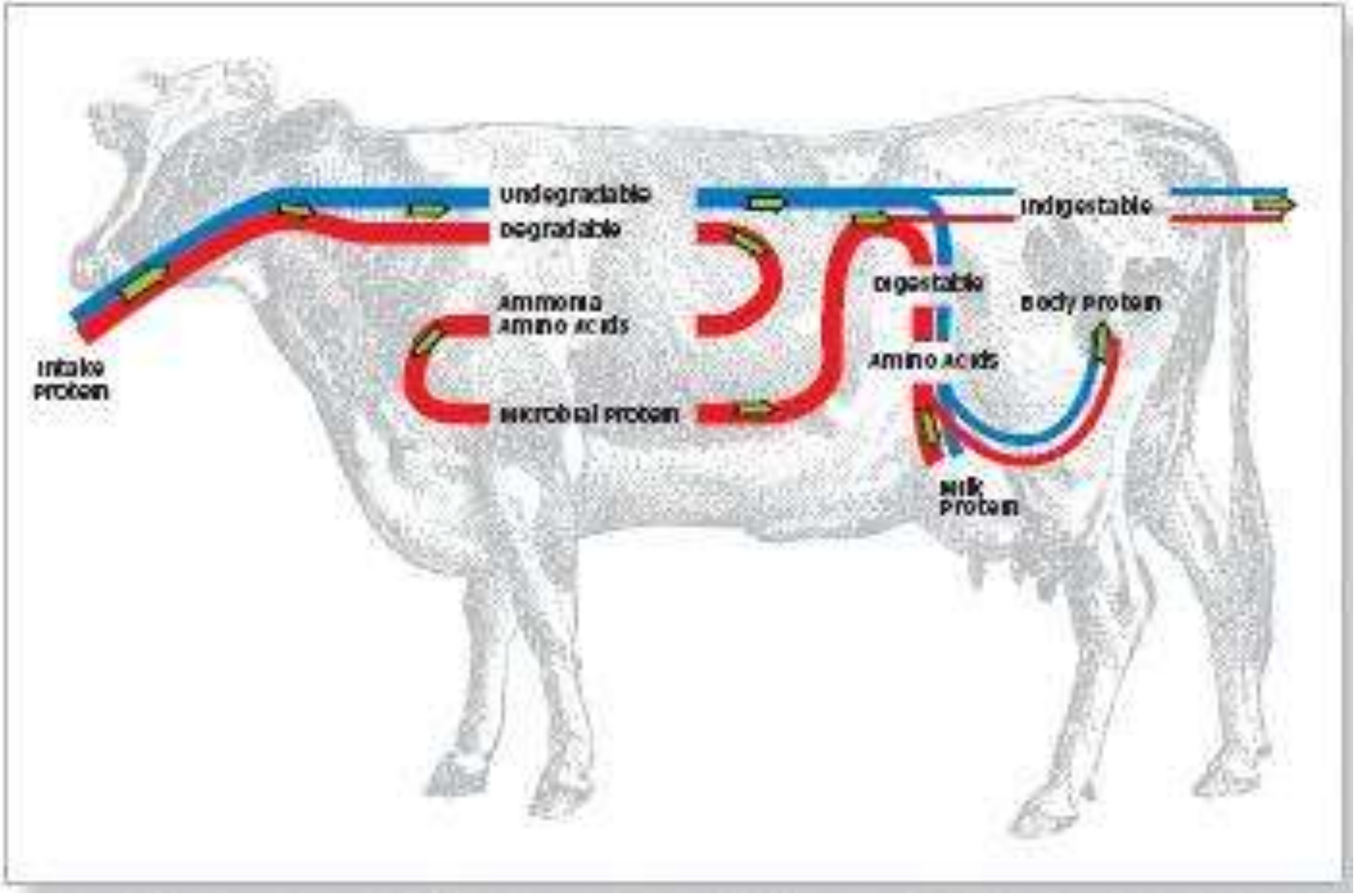
Change in levels of chymosin and pepsin in the abomasum of cattle

http://www.laboratoires-abia.com/en/change-in-levels-of-chymosin-and-pepsin-in-the-abomasum-of-cattle.html

Pepsine and chymosine secretion at different ages (1-18 months of life)



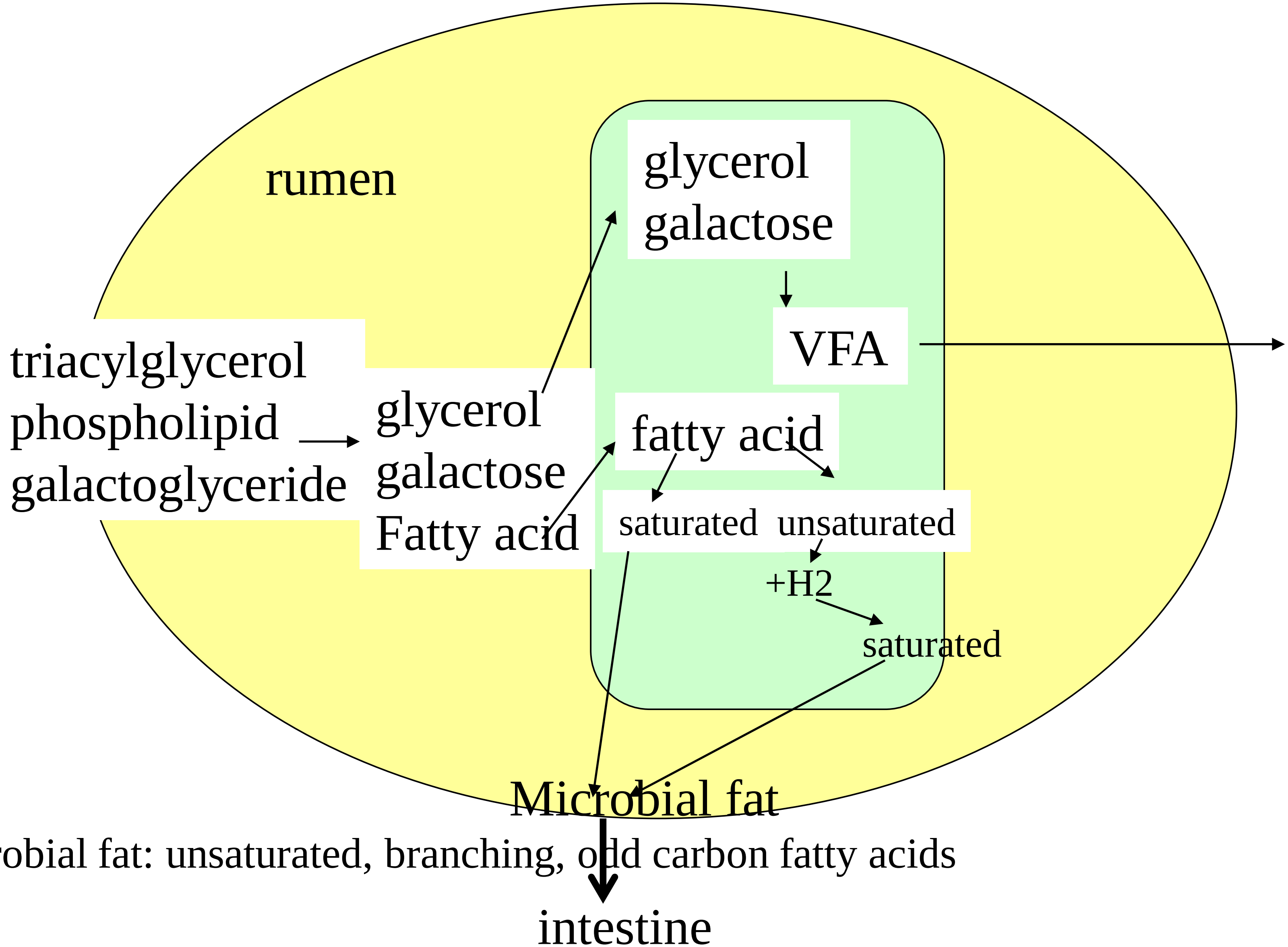
Bypass proteins www.farmwest.com/index.cfm?method=library.sho...



Bypass protein made: from soymeal

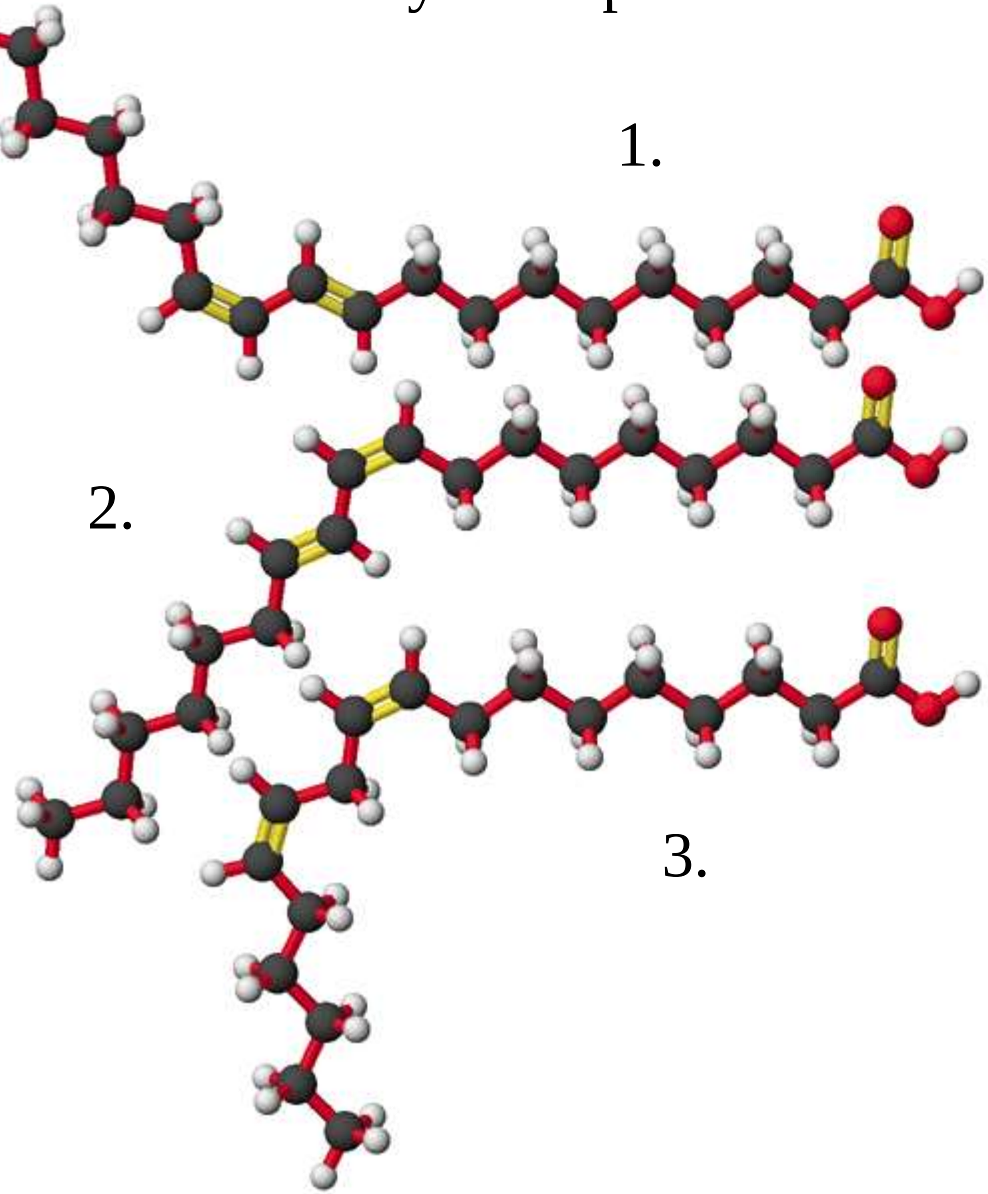
- SoyPass

Microbial fat metabolism in the rumen



Trans fatty acids produced in the rumen

CLA (1. and 2.)
„normal” linoleic acid (3.)



Products of biohydrogenation:
1.) 18 carbon, 11 trans double bond=vaccenic acid

2.) CLA=conjugated linoleic acid=18 carbon, 9 cis, 11 trans double bonds=rumenic acid

Synthesis of fats in ruminants' tissues

- **Origin of fatty acids:**
- 1. dietary
- 2. microbial
- 3. „de novo" synthesis in adipose tissue

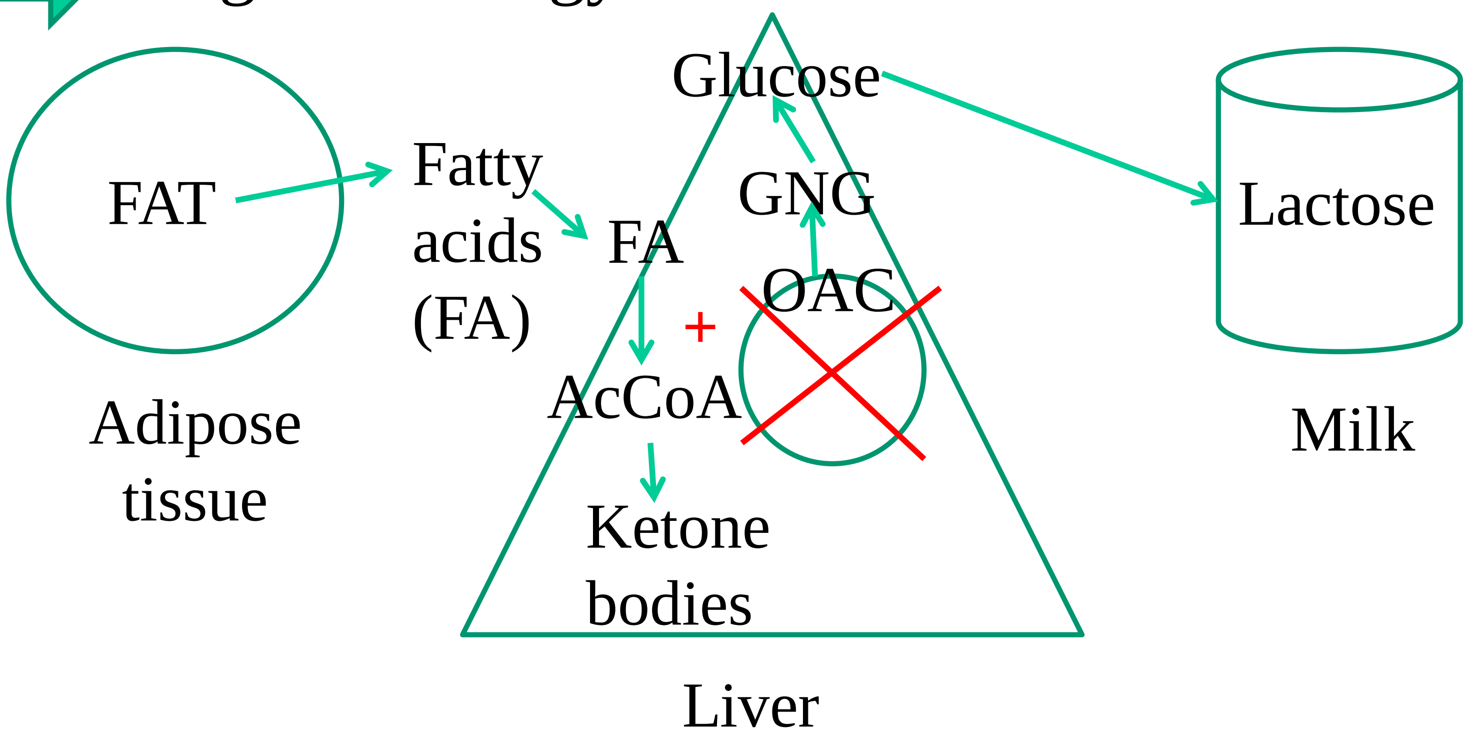
Comparison of „de novo" fatty acid synthesis in the tissues of ruminants

	Non-ruminants	**Ruminats**
Source of carbon	Glucose	Acetate
Starting compound of fatty acid synthesis	AcCoA	AcCoA
Source of NADPH+H$^+$	1. Pentose phosphate pathway 2. Malate (=malic) enzyme	1. Pentose phosphate pathway 2. Cytosolic isocitrate dehydrogenase

Correlation between gluconeogenesis (GNG) and ketogenesis

- Early lactation → High yielding cows

→ Negative energy balance

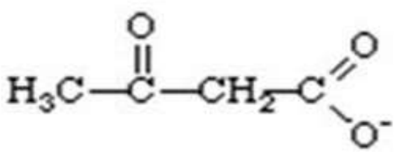


Ketone bodies

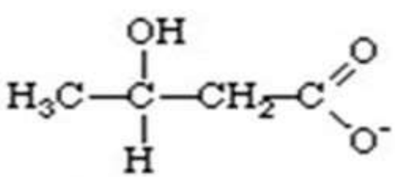
- **During high rates of fatty acid oxidation, primarily in the liver, large amounts of acetyl-CoA are generated. These exceed the capacity of the TCA cycle, and one result is the synthesis of ketone bodies, or ketogenesis.**

- **Liver mitochondria** have the capacity to convert acetyl CoA derived from fatty acid oxidation into ketone bodies.

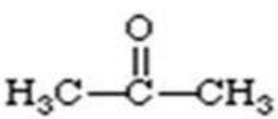
- **The ketone bodies are acetoacetate, β-hydroxybutyrate, and acetone.**



Acetoacetate



D-β-Hydroxybutyrate



Acetone

https://www.google.com/search?rlz=1C1KMZB_enHU571HU572&biw=1280&bih=933&tbm=isch&sa=1&ei=ZSK3XNbdEamTlwThiqngAg&q=ketone+bodi es&oq=ketone+bodies&gs_l=img.3..0i19l10.2020188.2027449..2028021...0.0..2.108.3149.35j2......2....1..gws-wiz-img.....0..35i39j0i67j0j0i30.pdr2z6oYp9o#imgrc=F1_xF44OmPLxtM:

Ketogenesis, ketolysis

- Ketogenesis: liver (mammary gland, rumen wall: only beta-OH-butyrate)
- Ketone bodies (acids): **negative role: ketoacidosis**
- **Positive role: energy source** (ketolysis)
- Ketolysis: extrahepatic tissues

Primary and secondary ketosis

- 1. **Primary:** because of a high energy demand → energy intake is not sufficient
- 1a. Early lactation of high yielding cows
- 1b. Pregnancy toxaemia in sheep and goats (ewes/does pregnant with twins or triplets)
- 2. **Secondary:** because of insufficient quantity of feed or an other illness (gastrointestinal diseases, mastitis, metritis, no appetite) → energy intake is not sufficient.

Milk fat: cca. 3.5%

- Triacylglycerols (uptake from blood plasma and synthetized in the mammary gland from acetate or butyrate)
- Phospholipids (uptake from blood plasma)
- Cholesterolesters (uptake from blood plasma)
- Free fatty acids (uptake from blood plasma and synthetized in the mammary gland from acetate or butyrate)
- Fat soluble vitamins (uptake from blood plasma)

Effect of diet on the VFA production and milk fat %

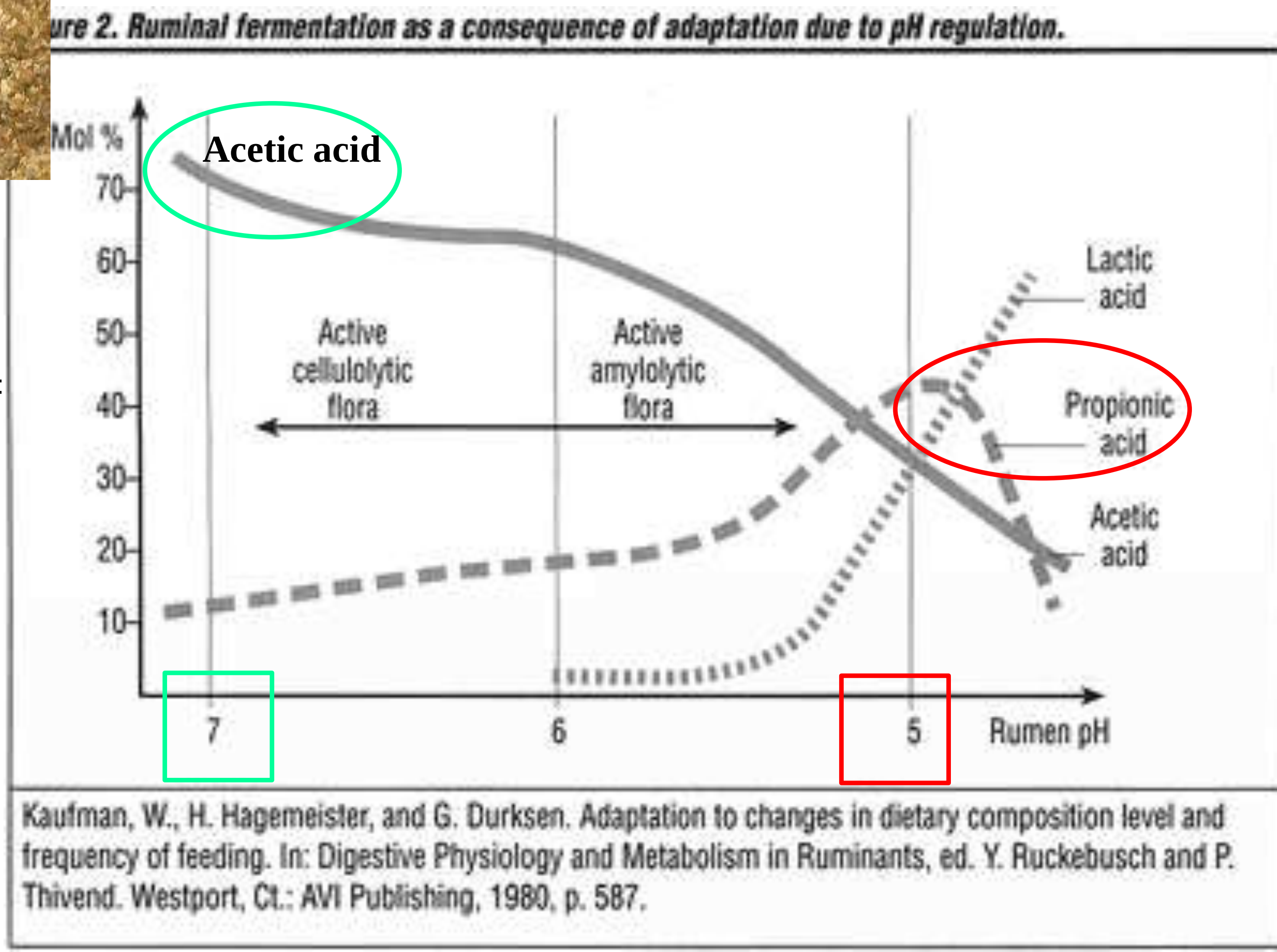
http://animsci.agrenv.mcgill.ca/courses/450/extra/feed_to_milk/microbio.htm

http://beyondorganicinside.blogspot.com/l

More forage-(concentrate=**grain**) rich diet → Less saliva →

Lower pH →

Less acetate and milk fat%



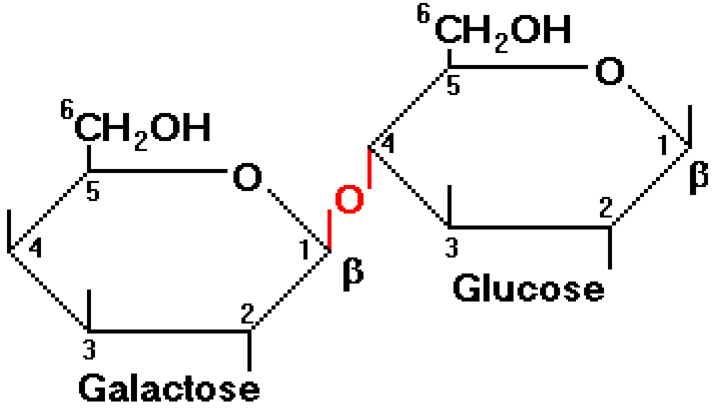
Effect of diet on the VFA production and milk fat%

http://www.sciencenews.org/sn_arc98/9_19_98/food.htm

- More roughage (**fiber**) hay ↓
- More saliva ↓
- Higher pH ↓
- **More acetate**-producing microbes ↓
- **Higher milk fat%**

Milk sugar=lactose: cca. 4.8%

- De novo synthesis in the mammary gland: from propionate in the gluconeogenesis (GNG) is produced glucose, from glucose galactose and then lactose (see: Galactose metabolism)



Lactose: Galactose and Glucose bound by Beta 1, 4 bond

Milk protein: cca. 3.3%

- Casein: 2.6% („de novo” synthesis in the mammary gland)
- Beta-lactoglobulin: 0.3% („de novo” synthesis in the mammary gland)
- Alpha-lactalbumin: 0.1% („de novo” synthesis in the mammary gland)
- Milk serumalbumin and immunglobulins: 0.1% (uptake from the blood plasma)

Structure of casein (milk protein): different caseins (α-s1, α-s2 and ß) held together by calcium phosphate bridges on the inside, surrounded by a layer of κ-casein which helps to stabilize the micelle in solution

- http://www.milkfacts.info/Milk%20Composition/protein.htm

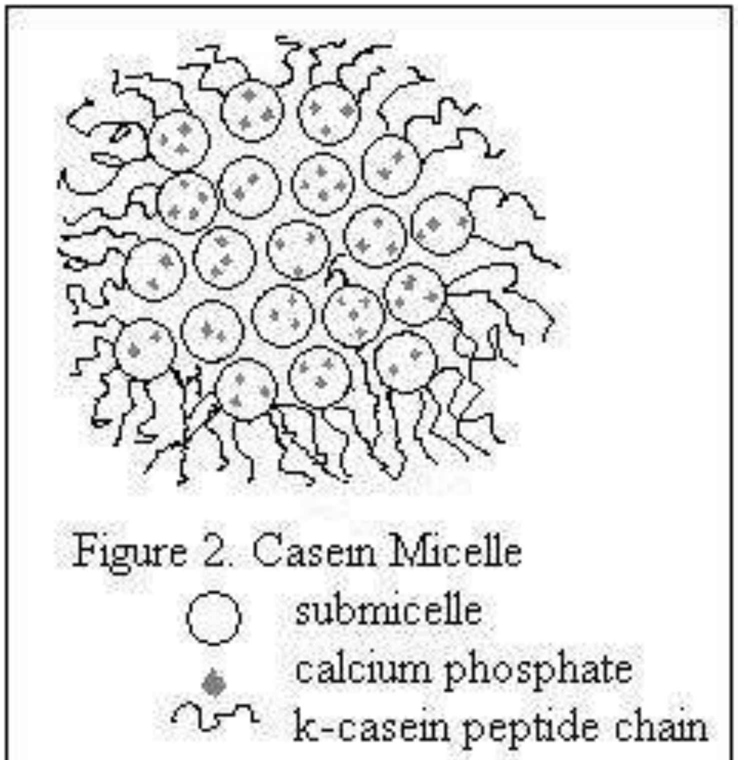


Figure 2. Casein Micelle

Colostrum

- Colostrum, or first milk produced by the mother after birth, is high in nutrients and antibodies. A newborn calf lacks disease protection because antibodies do not pass across the cow's placenta to the fetus' circulatory system. Antibodies in colostrum provide calves with their initial protection.
- Calves need about two quarts of colostrum (or at least five percent of the calf's body weight) within four hours of birth – ideally within 30 minutes – and one gallon within 12 hours.
- Time is important because a newborn calf's digestive tract allows antibodies to pass directly into the blood. After 24 hours, the calf's intestines cannot absorb antibodies intact. The absorbed antibodies protect against systemic invasion by pathogens while antibodies that are not absorbed play an important role in protection against intestinal disease.

https://beef.unl.edu/beefwatch/importance-colostrum-newborn-calf

Milking in Pakistan

usaid.gov/.../news/050715_dairy/index.htm

www.seprom.cz/index.php?lang=1&page=zarizeni

Milking equipment