

# Beef cattle feeds and feeding



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AG177441 Applied Animal Nutrition

**More  
microbes**



**More Fiber and  
Starch Digestion**



**More Energy +  
More Microbial  
Protein**



**More VFA  
Production**

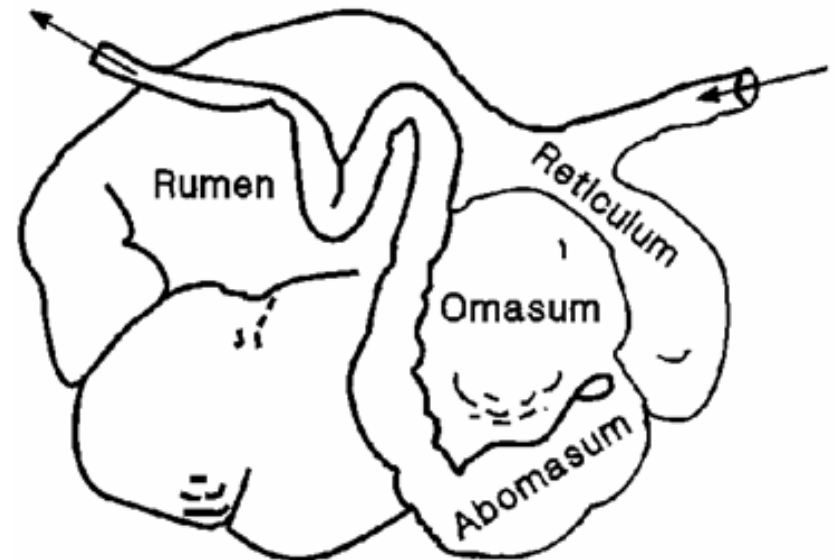


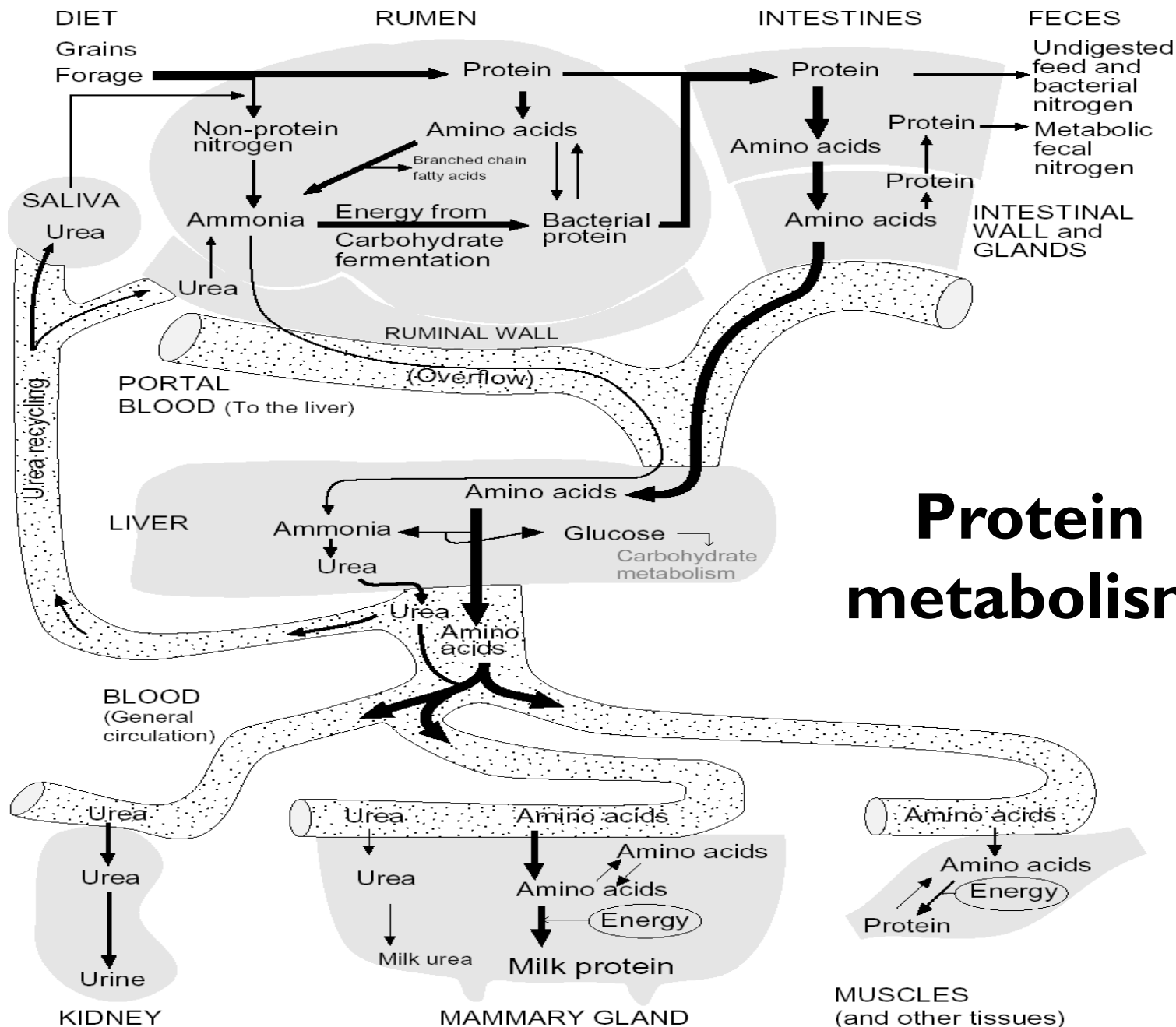
**More  
products**

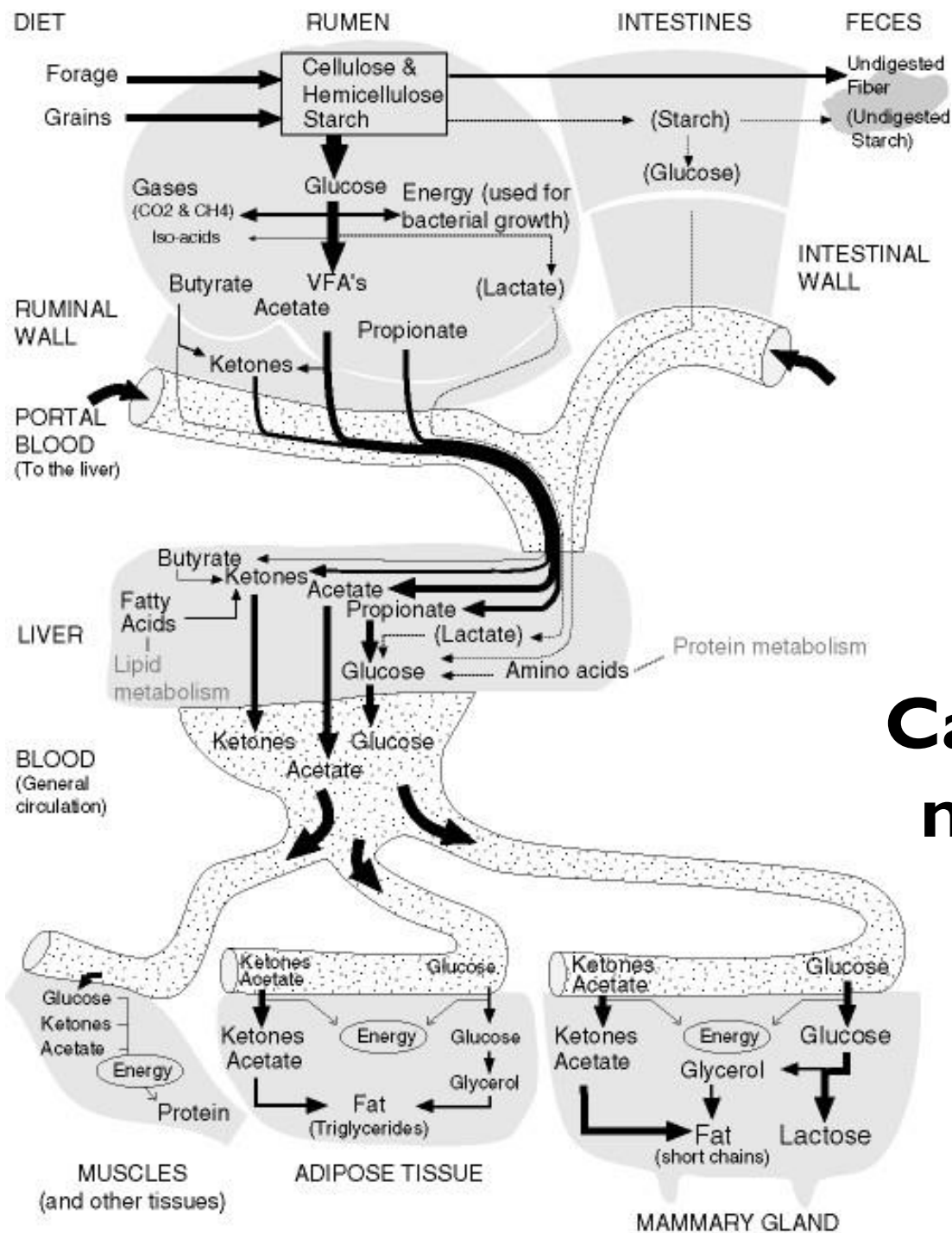


# Outline

- Digestive physiology
- Rumen microorganisms
- Feeds and utilization



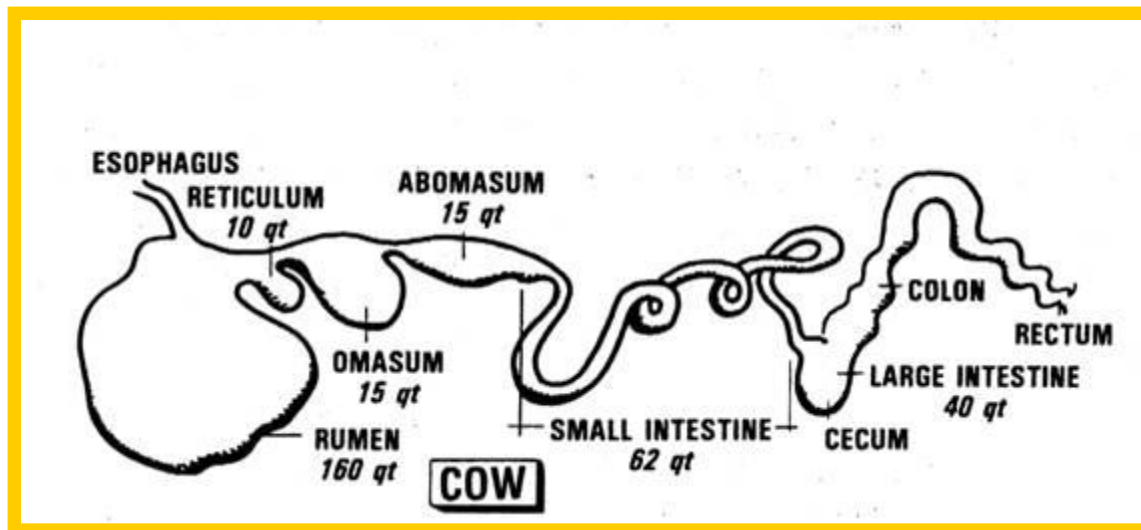




# Carbohydrate metabolism

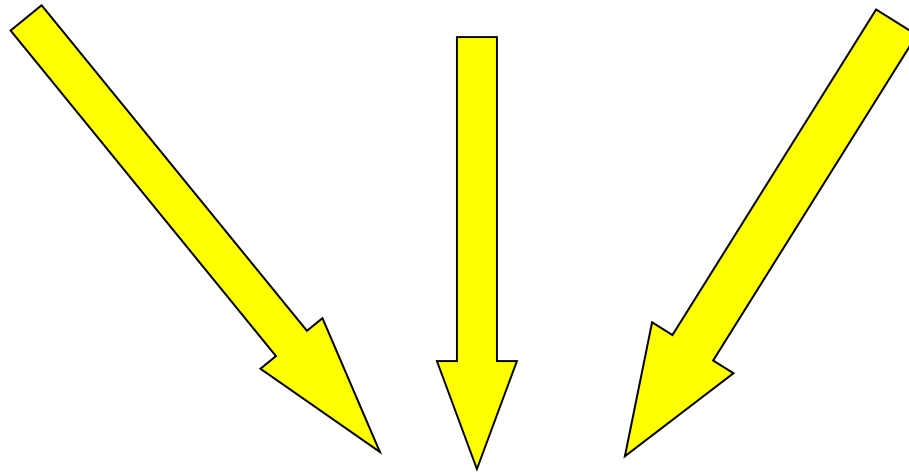
# Ruminant

- Most herbivores
- Four compartment stomach
- Fore-gut fermentation vat



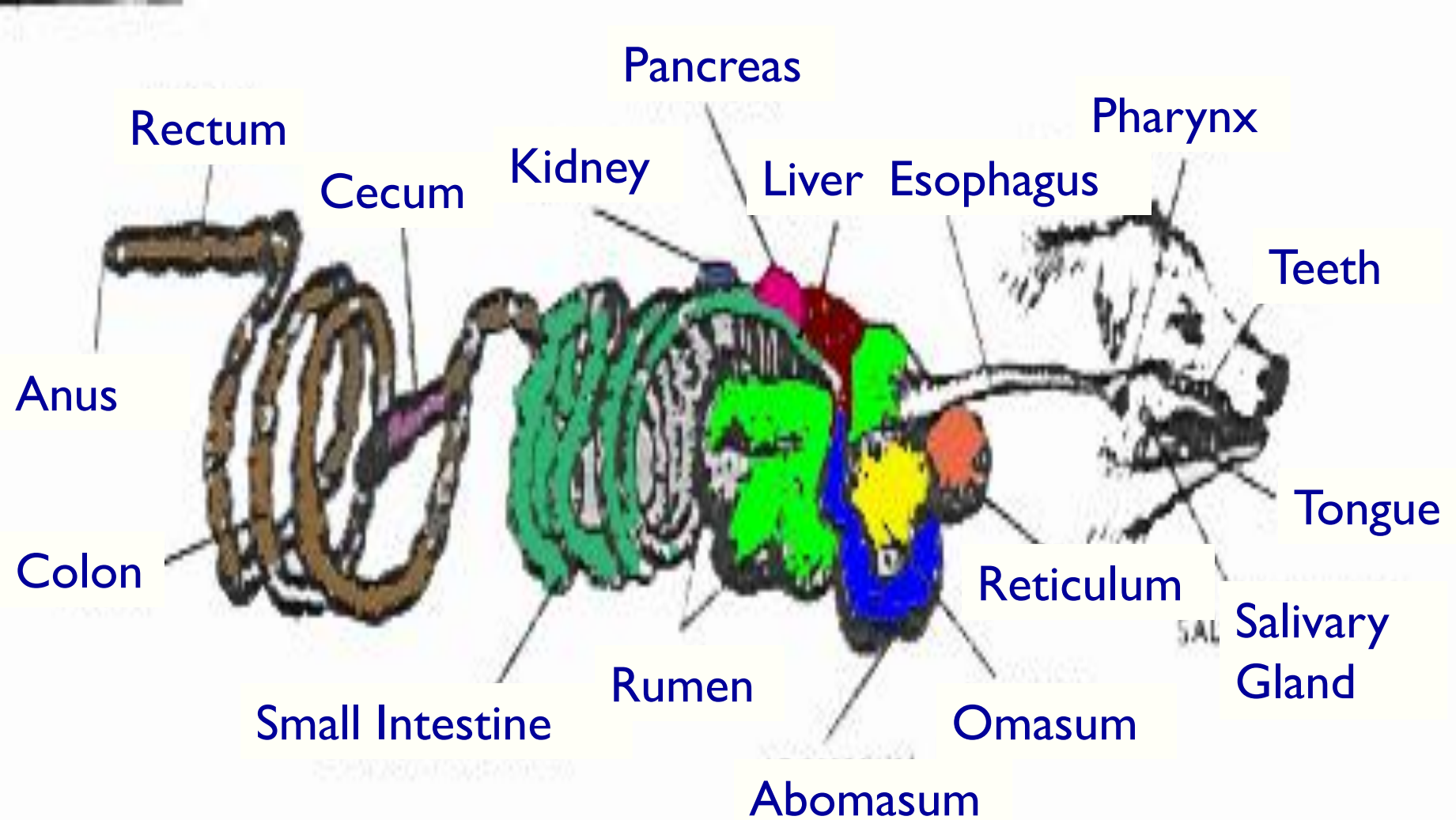
# **Ruminant Nutrition and Feeding:**

**Feeds      Rumen      Microorganisms**



**Productivity**





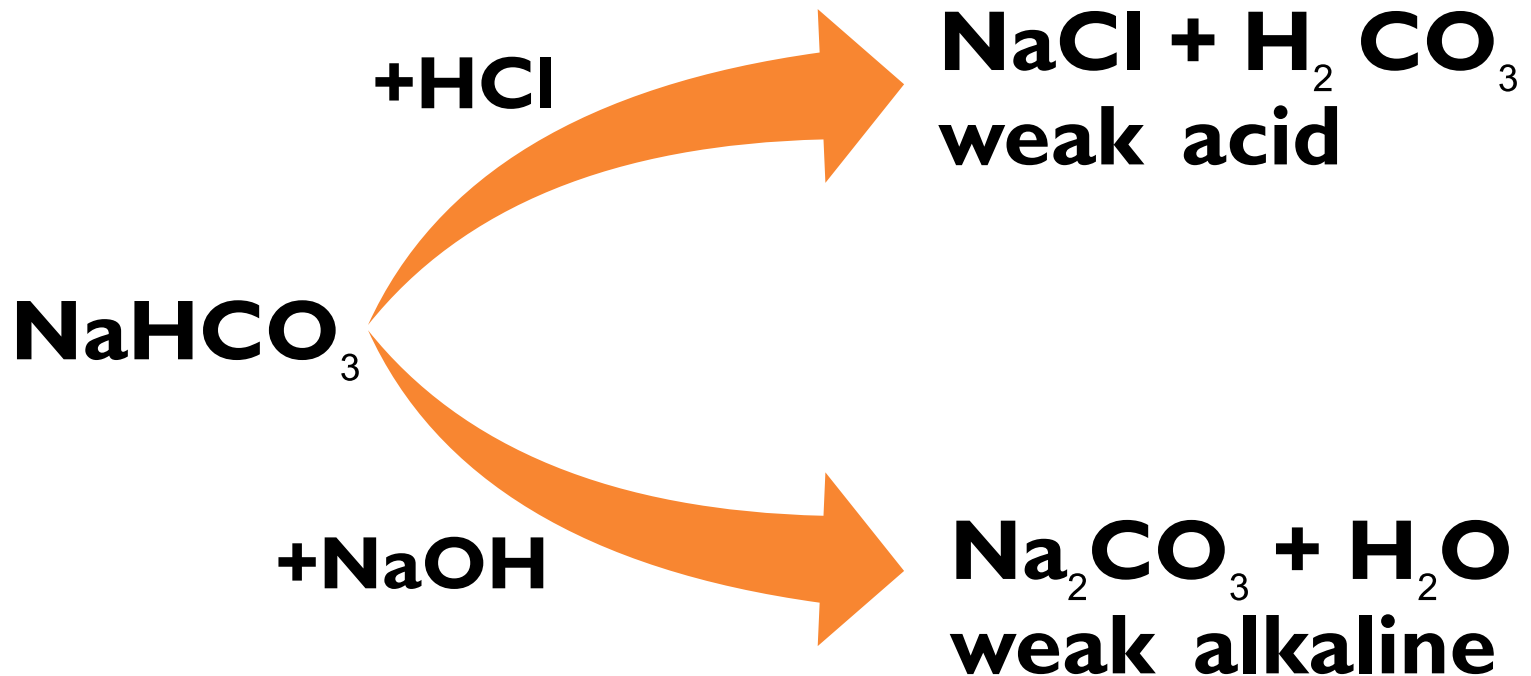
# Ruminant Digestive Systems



# Ruminants..

- ❖ Saliva of a cow contains no salivary amylase
- ❖ To digest the plant material, herbivores need to depend on the cellulase-secreting microorganism in its digestive system

# Saliva and rumen buffering capacity



**\*\*Maintain rumen pH 6.5-7**

# **Stomach Compartments**

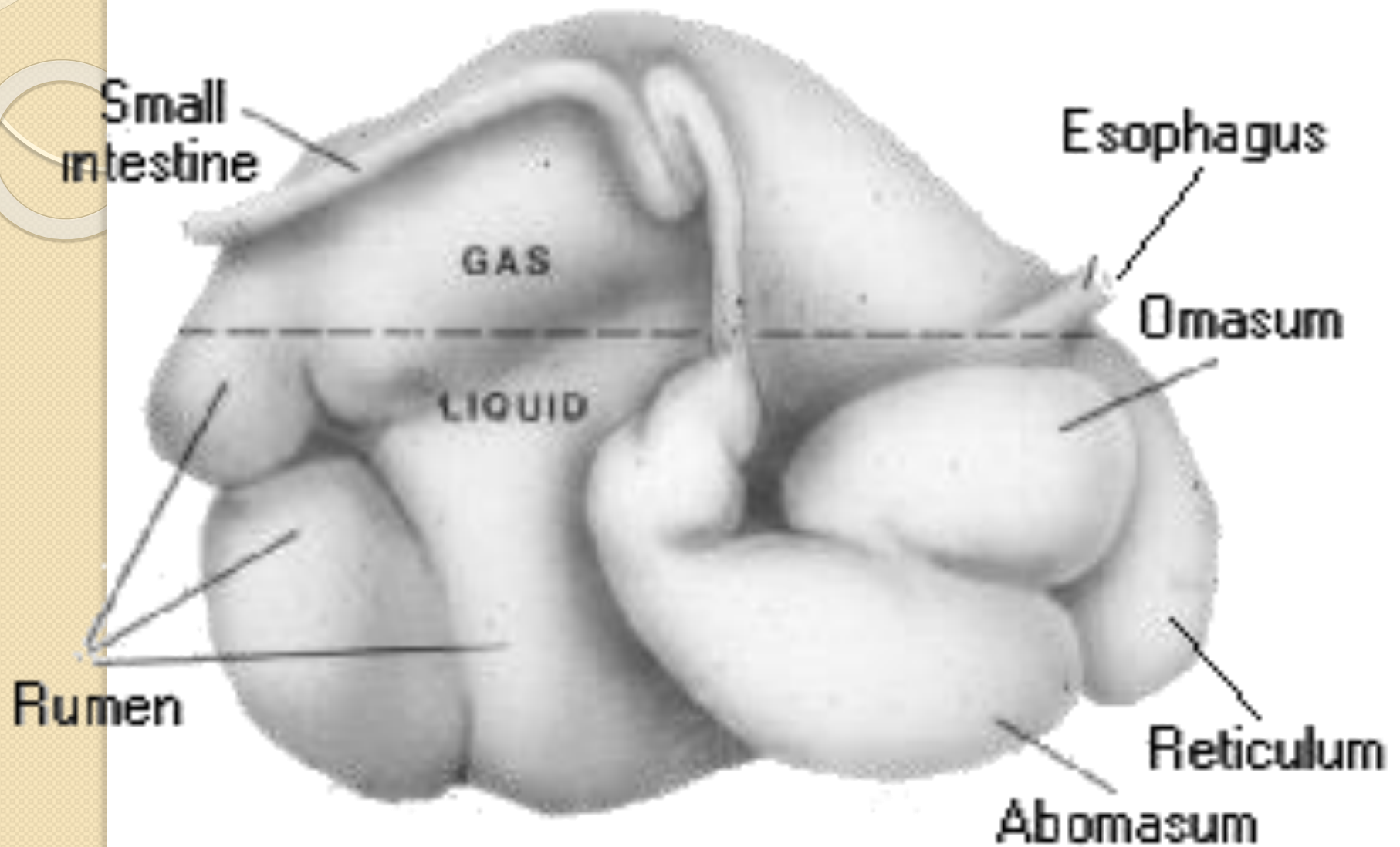
- **Rumen - fermentation vat**

- **Reticulum - rumen's  
“assistant”**

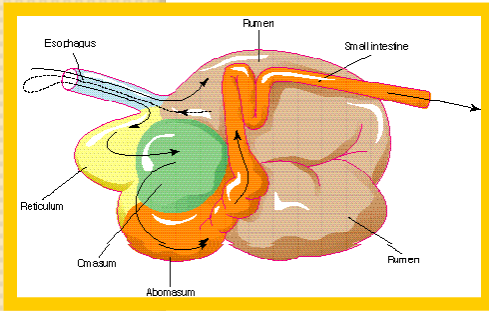
- **Omasum - dehydrator**

- **Abomasum - glandular  
stomach**









# Rumen

- Largest compartment
- On left side of animal
- Contains micro-organisms
- Ferments cellulose
- Absorbs VFA's
- Divided into chambers
- Continually contracting
- Contains papillae
- Produces  $\text{CO}_2$  and  $\text{CH}_4$
- pH close to neutral (6.5 - 7)







**Papillae in Rumen**



# Papillae in Rumen

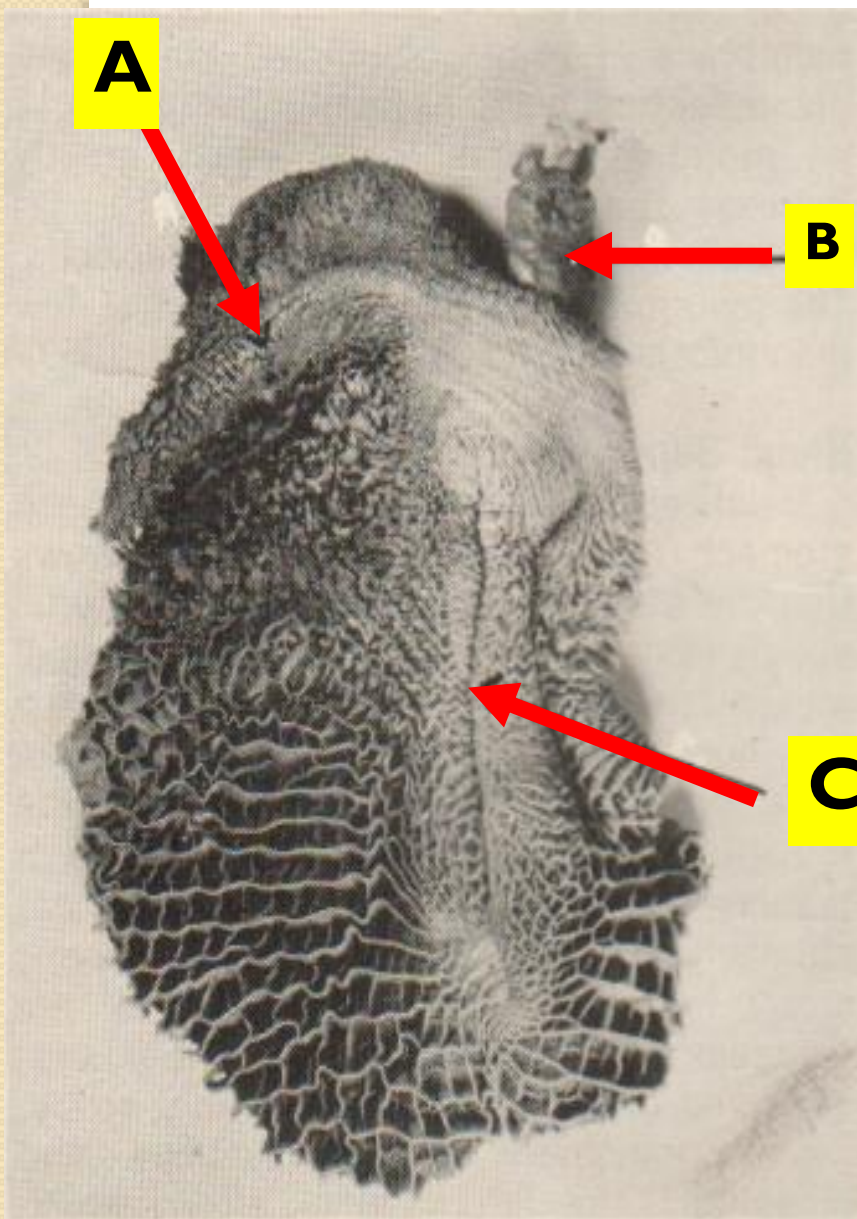




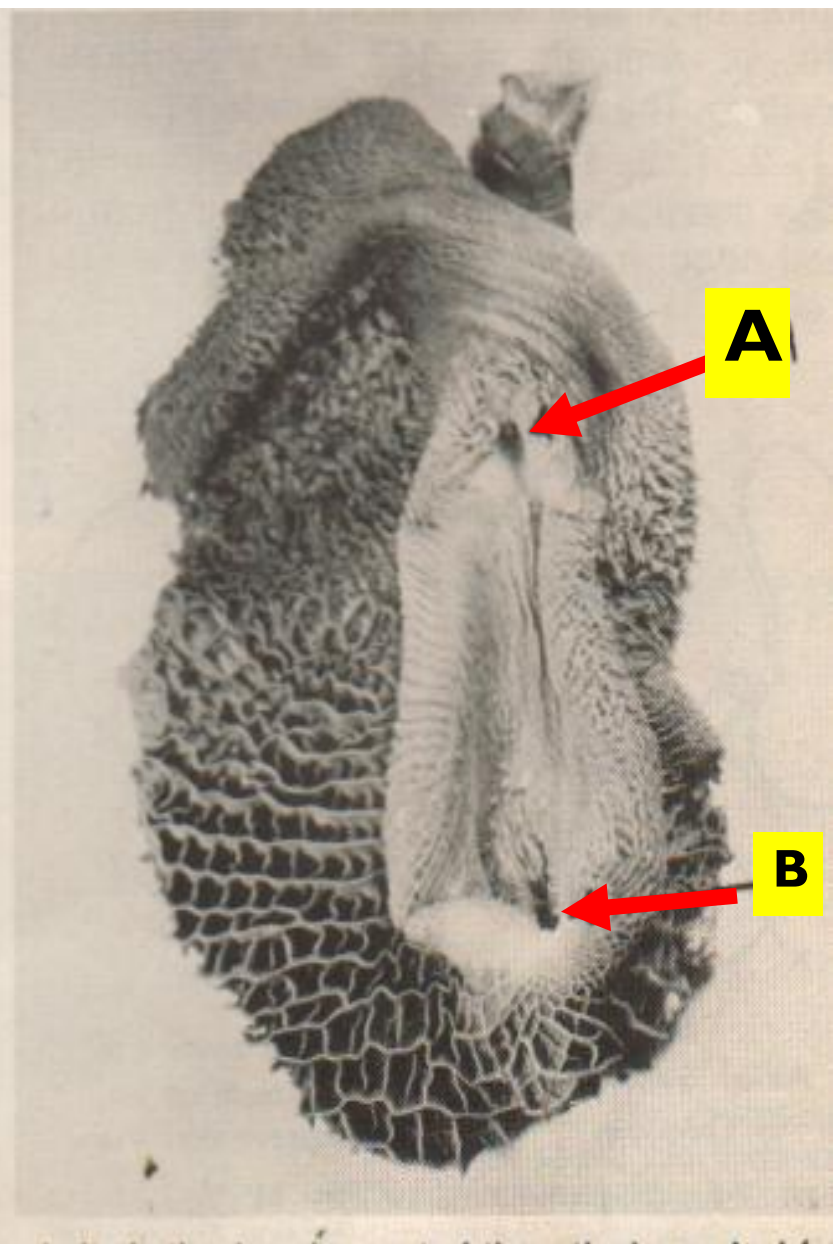








**A= reticulo-ruminal fold**  
**B=esophagus**  
**C= esophagus/reticular groove**



**A = cardia**  
**B= reticulo-amasal orifice**







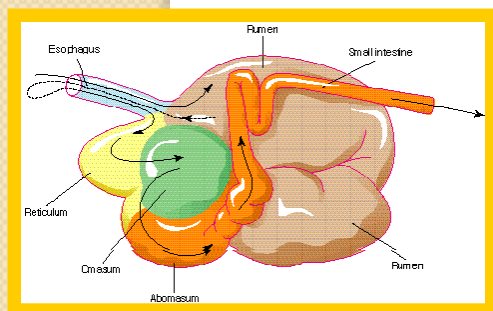


10/07/2008



03/12/2006

# Reticulum



- **Smallest compartment**
- **Lies close to the heart**
- **Small sac - part of rumen body**
- **Catches dense, heavy feed for later rumination**
- **Contracts for regurgitation**
- **“Honeycomb” lining**
- **Catches hardware and stores it**



Omasum - full





Reticulum - full





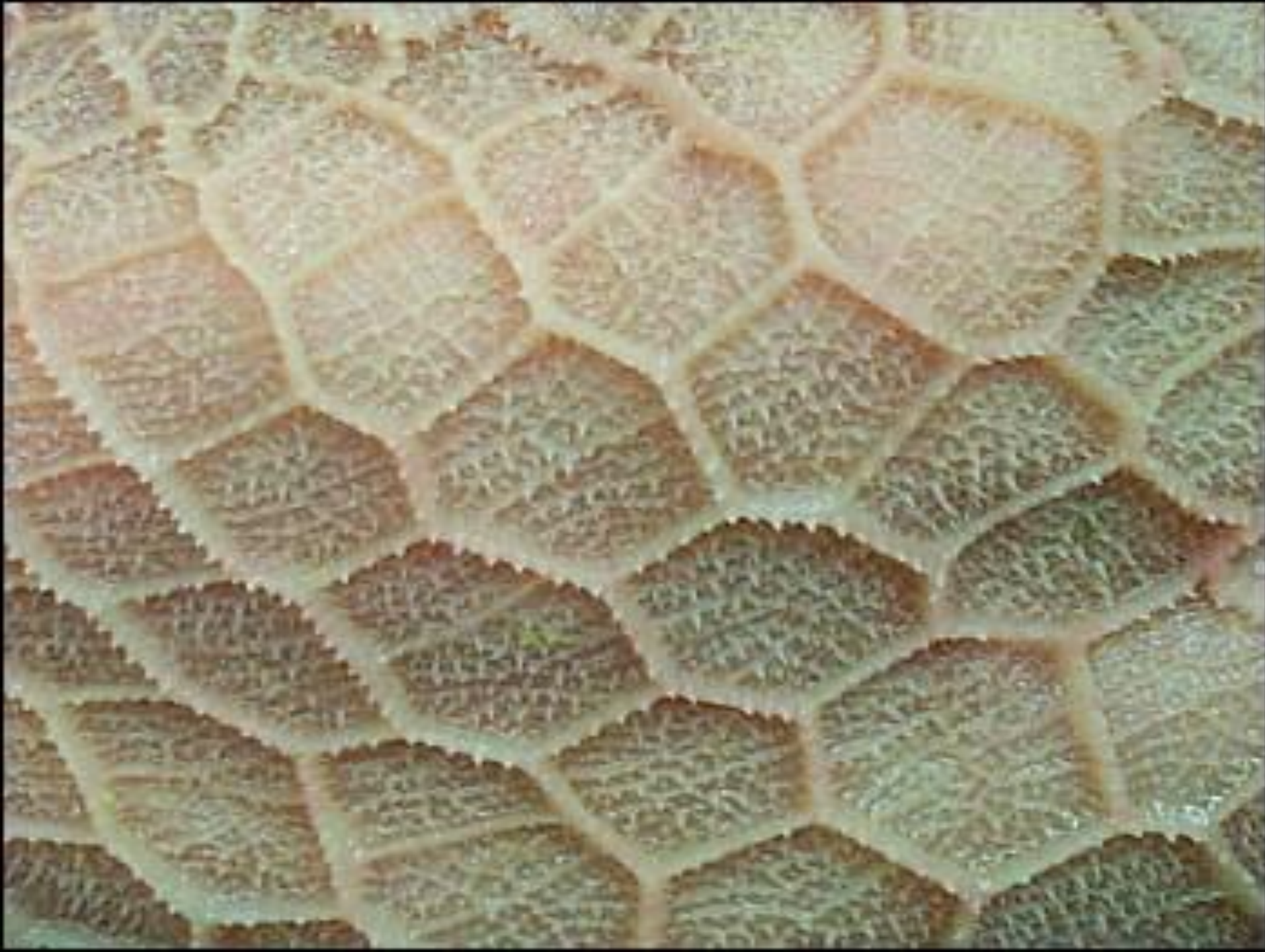
Reticulum - cleaned

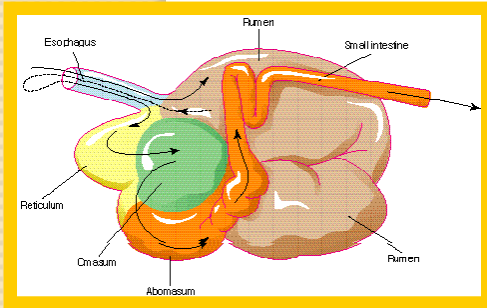












# Omasum



- Third compartment
- Globe-shaped
- Lining called “many plies”
- Reduces feed particle size
- Absorbs water and dries out ingesta
- Absorbs volatile fatty acids





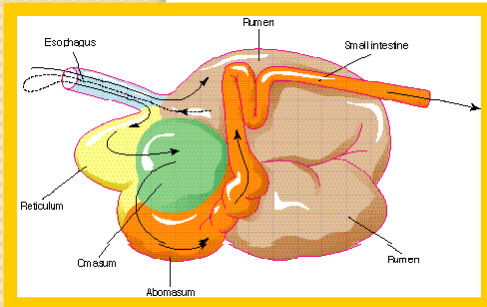






# Abomasum

- Final compartment
- Tubular in design
- “True” stomach (glandular)
- Secretes HCl and enzymes for chemical digestion
- Reduces pH to 2.5
  - Dissolves minerals
  - Kills rumen bacteria
  - Breaks down proteins
- Passes ingesta to small intestine







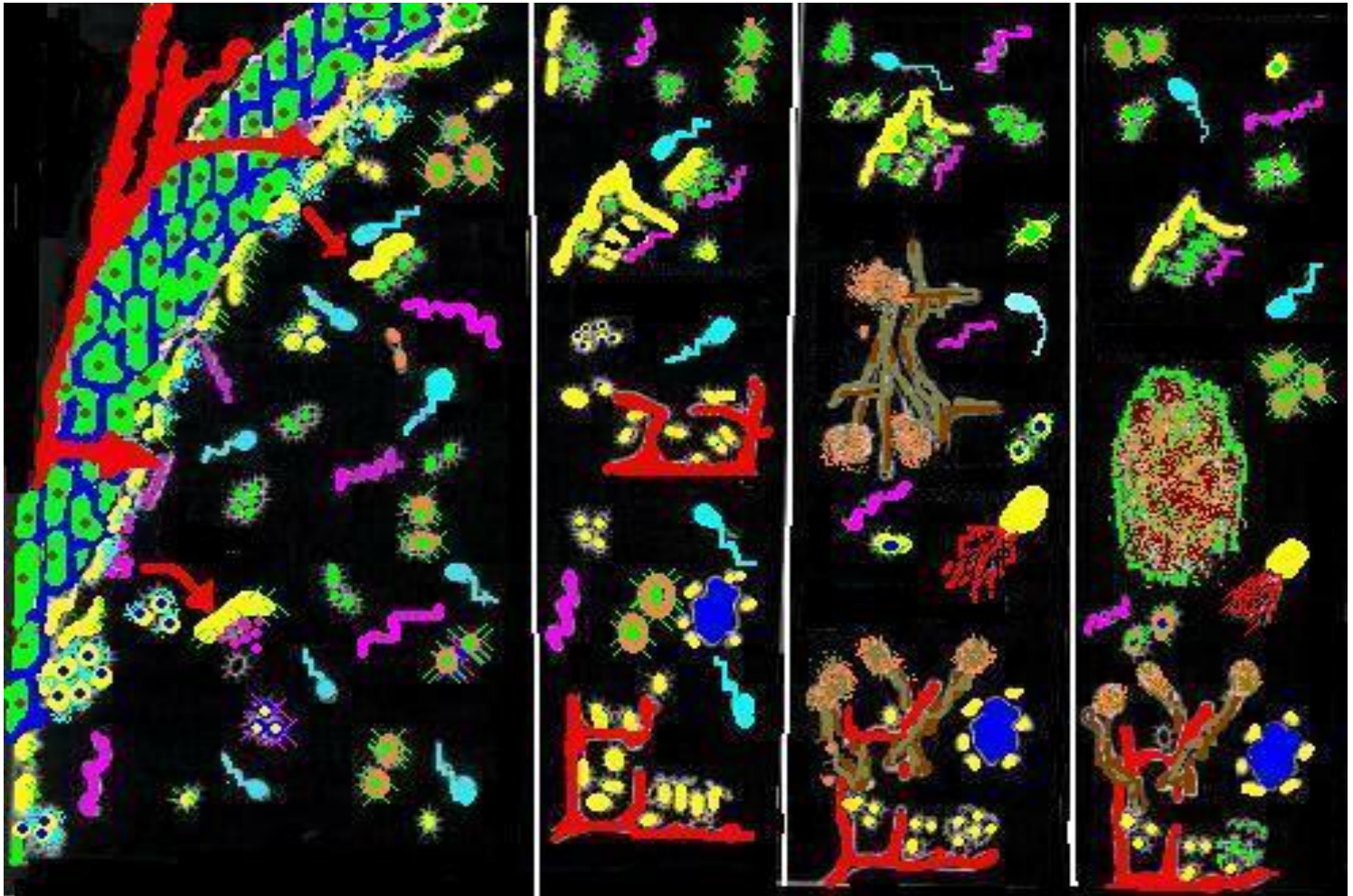
**Abomasum – inside view**

# Ruminant Digestive Systems

- Small Intestine - where most of the food material is absorbed into the bloodstream
  - Contains three sections:
    - ***duodenum***
    - ***jejunum***
    - ***ileum***



# Rumen microorganism





Feeding the bugs,  
feeding the cows

# Rumen as a Fermentation Vat :

## Rumen ecology :

### # Microorganisms

# Bacteria

# Protozoa

# Fungi

# pH

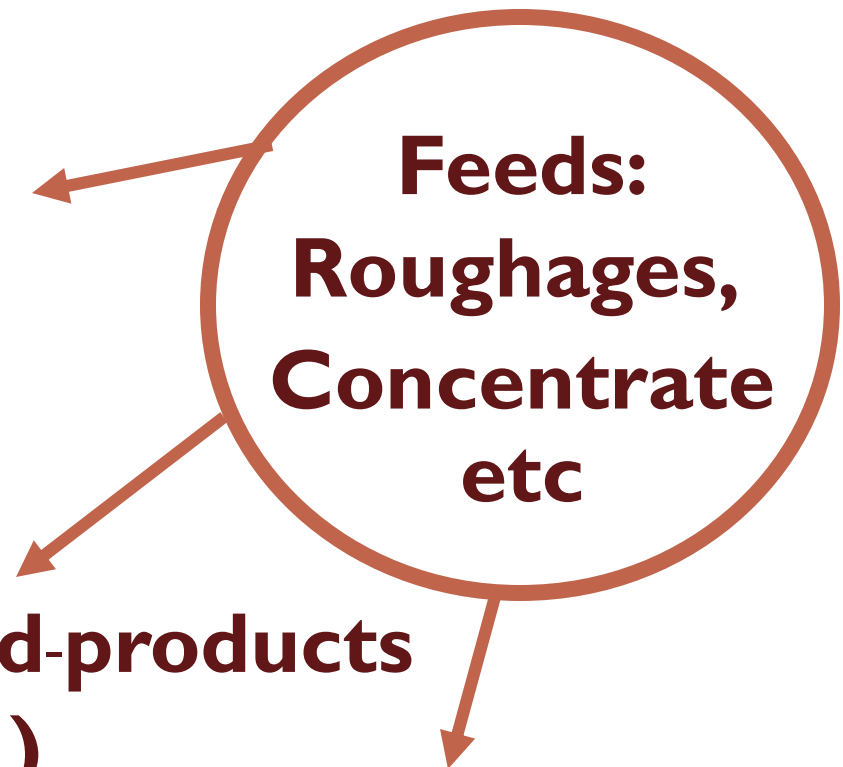
# Fermentation end-products

# VFA ( $C_2$ ,  $C_3$ ,  $C_4$ )

#  $NH_3$ -N

# rumen by-pass nutrients, protein

# etc (Wanapat, 2000)



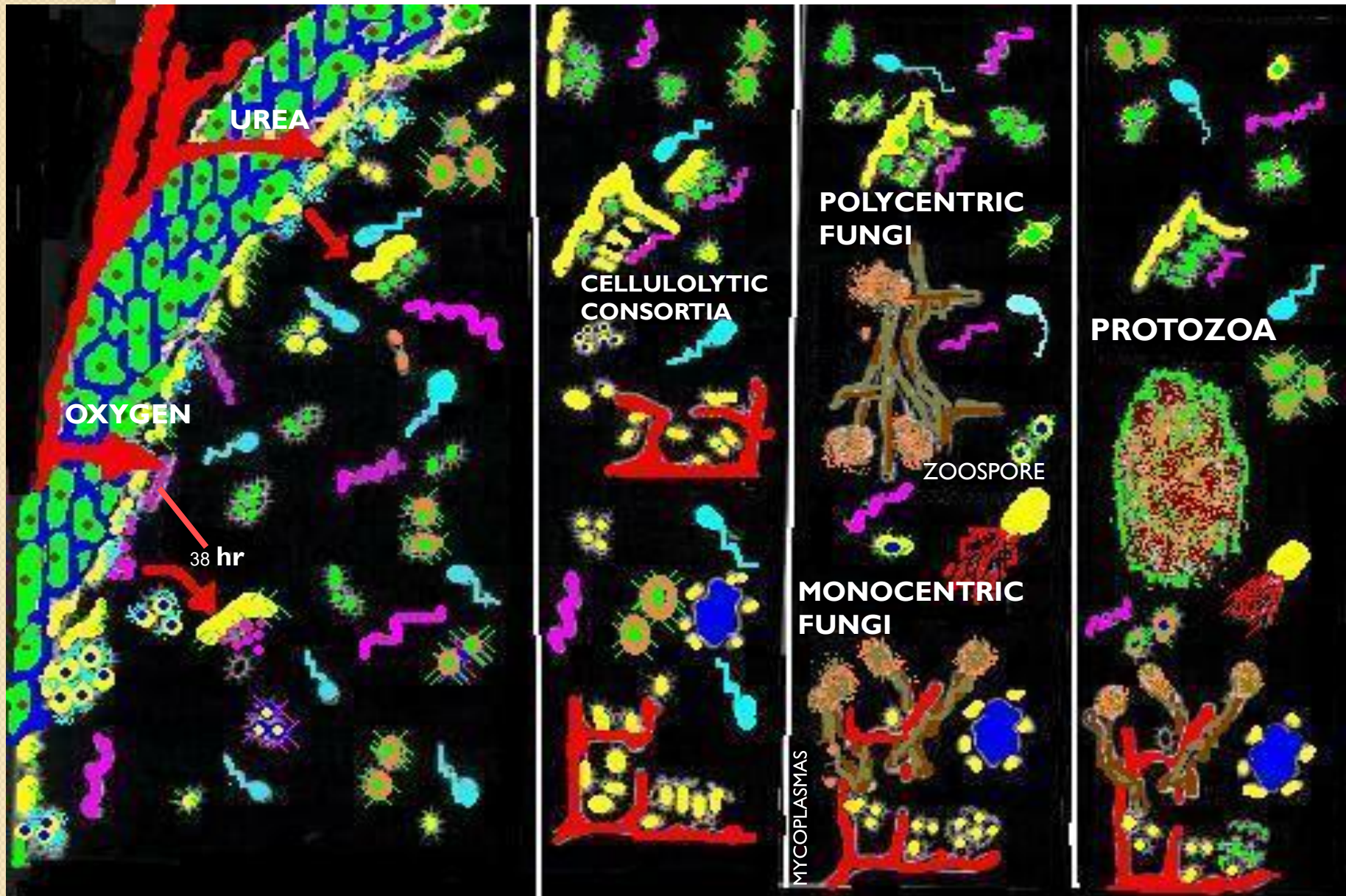


2 DAYS

4 DAYS

8-10 DAYS

12-20 DAYS



**Diagrammatic representation of the sequential development of the microbial ecology of the newborn ruminant.**



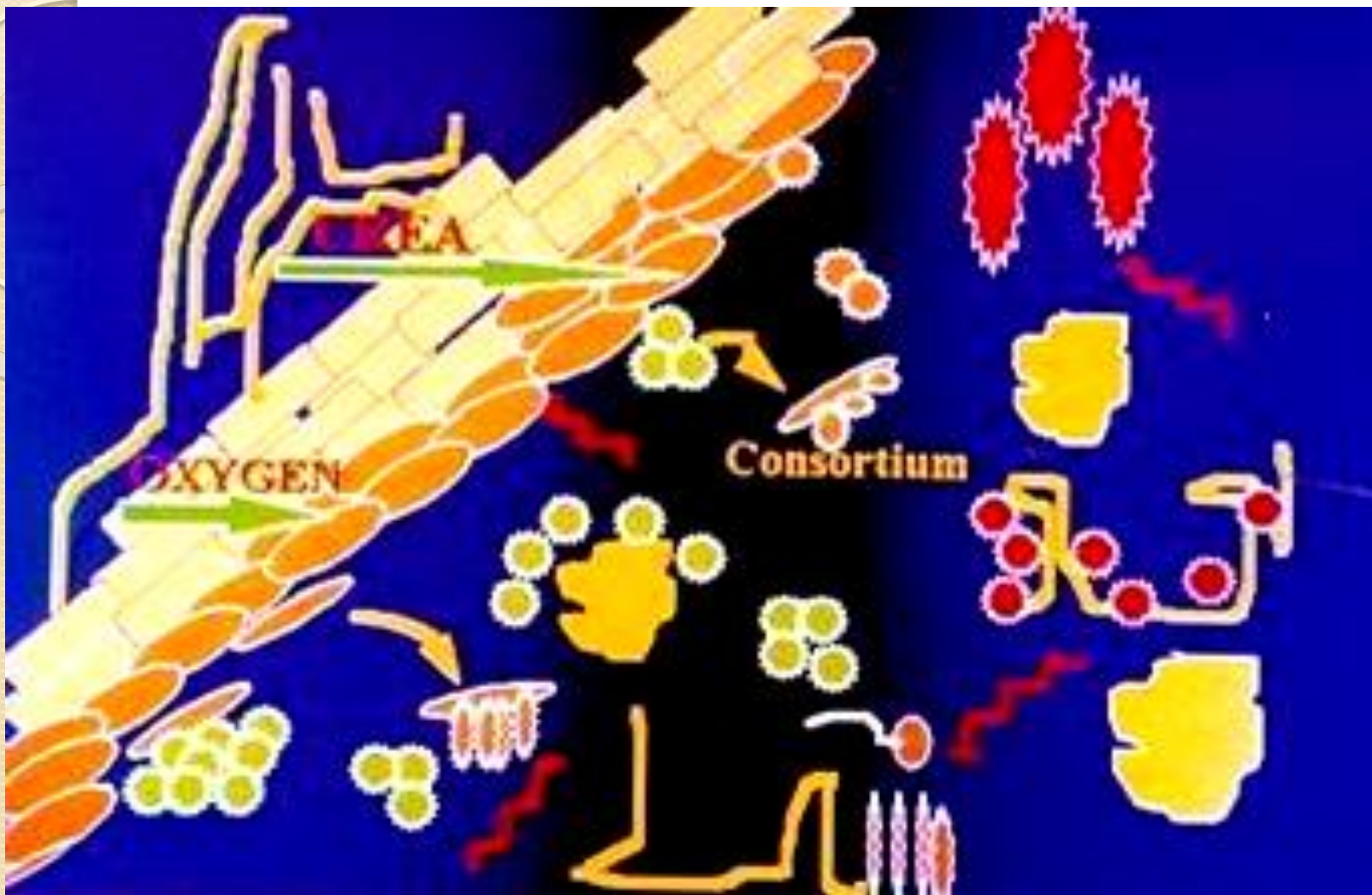
# Rumen Bacteria

- $10^{10}$  -  $10^{12}$  cells/ml rumen fluid
- Cellulolytic bacteria
- Amylolytic
- Proteolytic
- $\text{NH}_3$ -N utilizing
- etc

# **Groups of Bacteria in the Rumen**

- 1. Free-living in the liquid phase**
- 2. Loosely associated with feed particles**
- 3. Firmly adhered to feed particles**
- 4. Associated with rumen epithelium**
- 5. Attached to surface of protozoa and fungi**



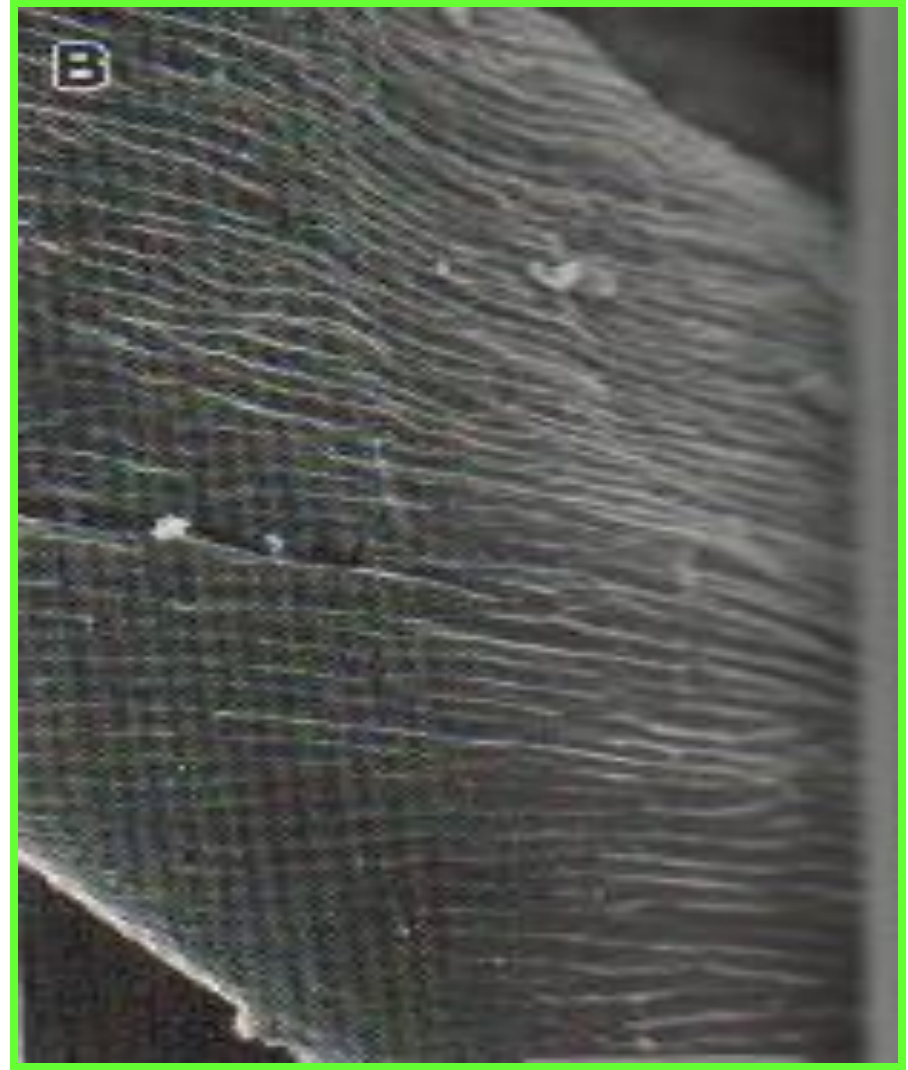


## **Distribution of rumen bacteria**

75% = **bacteria adhered to feeds**

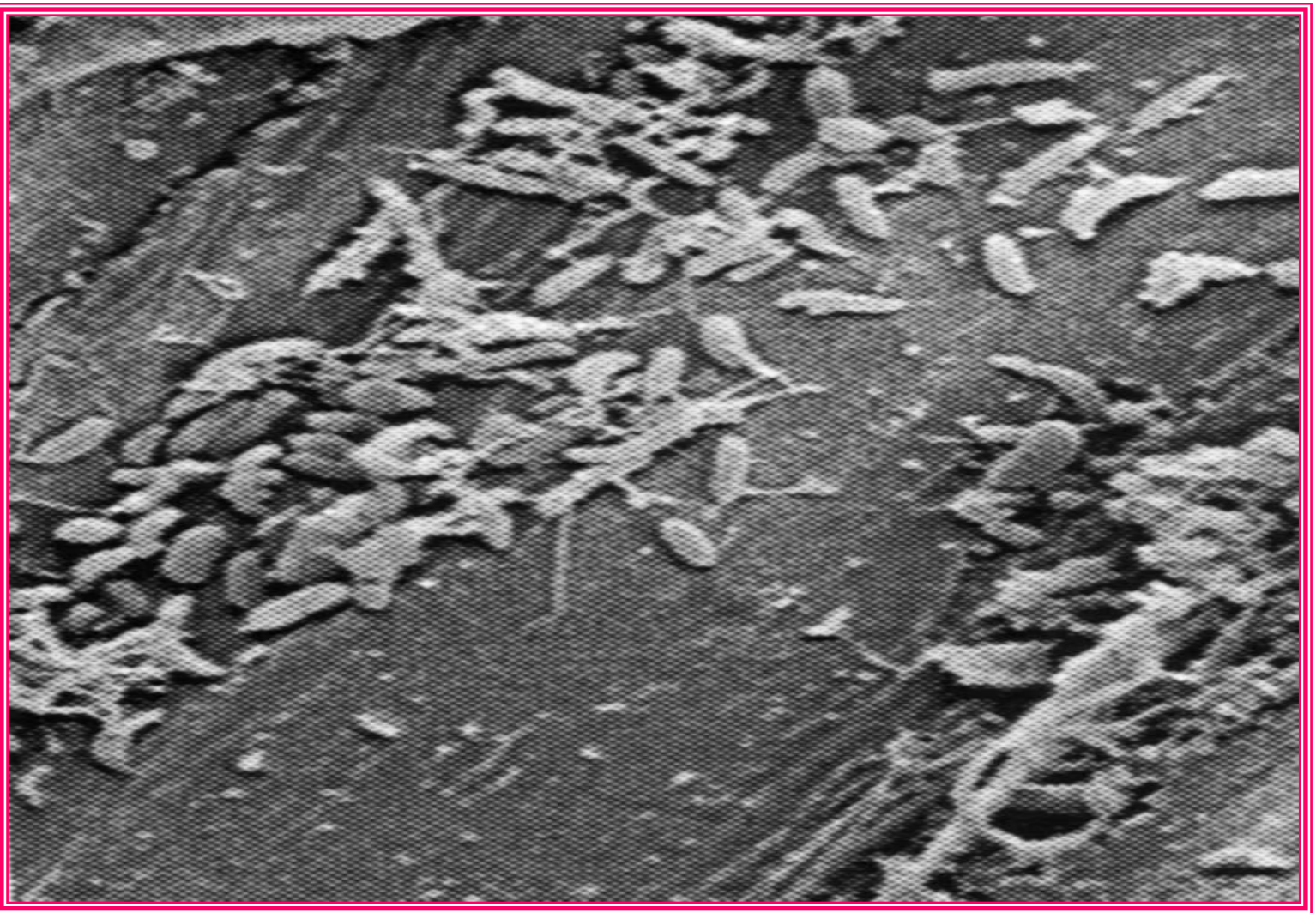
20% = **flow in rumen fluid**

5% = **adhered to rumen epithelium**



**Bacteria on feed particles**






**Attachment of rumen bacteria on rice straw  
of swamp buffalo  
(Wanapat et al., 2000b)**

# Rumen Protozoa

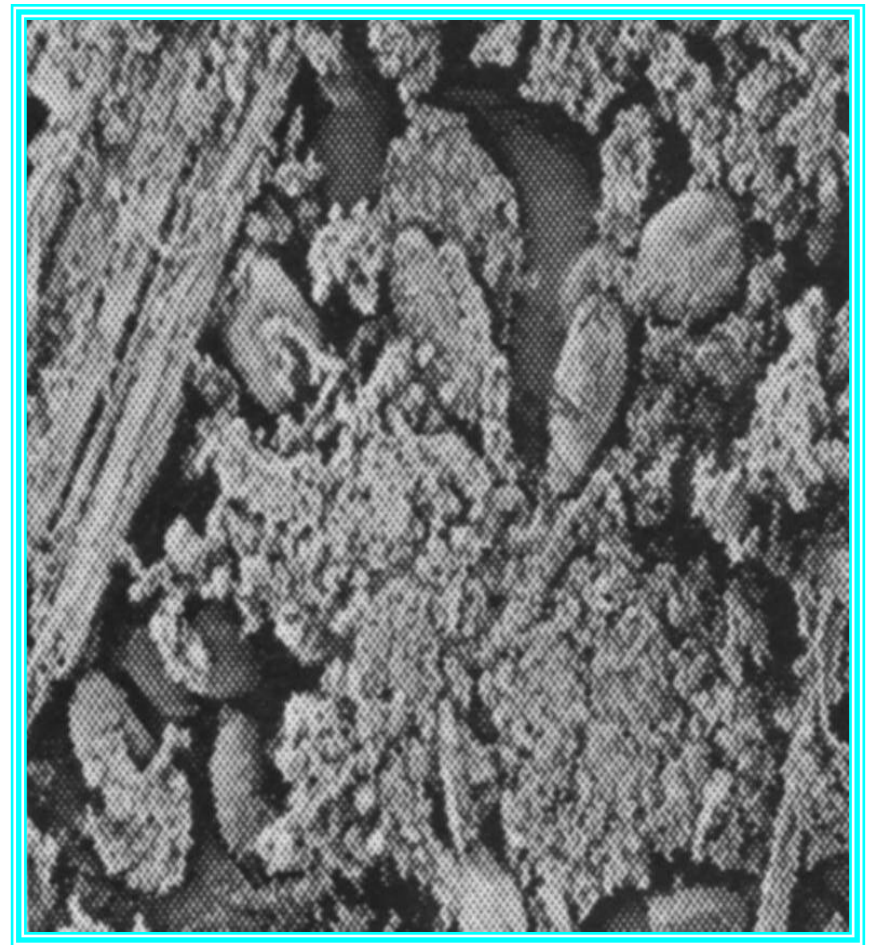
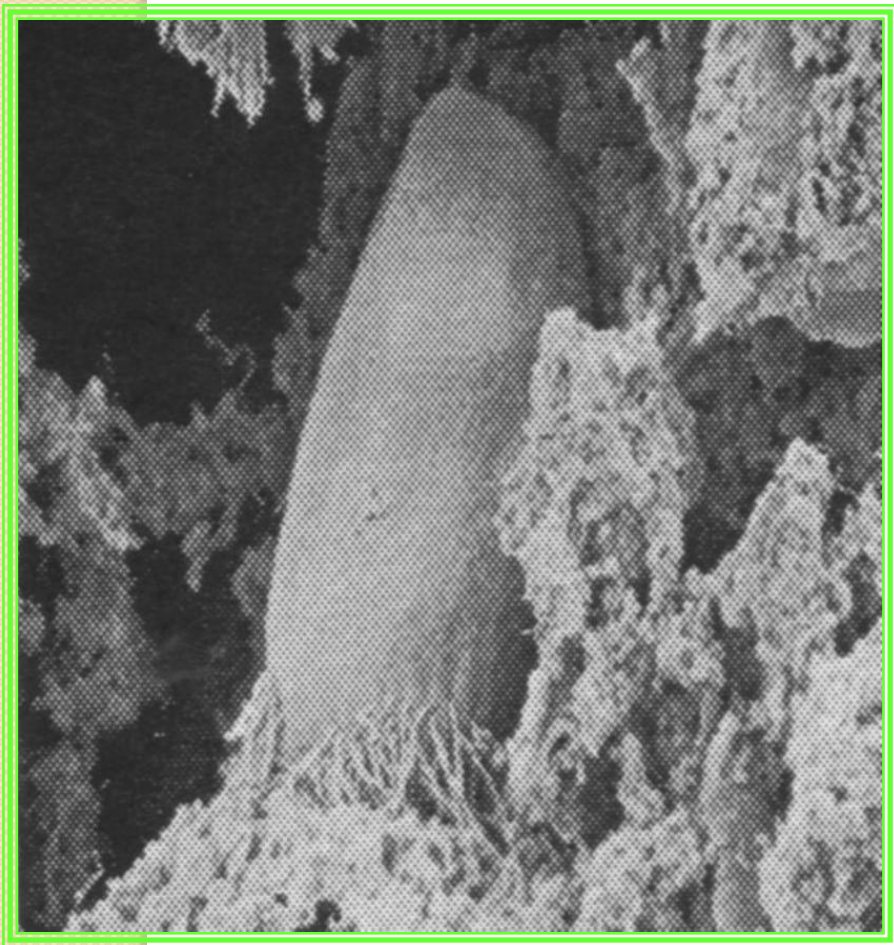
- ❖ Ciliated protozoa
- ❖  $10^4$ - $10^6$  cells/ml
- ❖ larger > bacteria
- ❖ moves rapidly



- 
- **Holotrich- Subclass**
    - **absorbs sugar**
  - **Entodinimorph (tuft)**
    - **digest starch**
  - **Stores surplus CHO**
  - **Can not use NPN**
  - **Engulf bacteria 200 cells/min**  
**1% bacteria/min**
  - **Defaunation vs Nondefaunation**

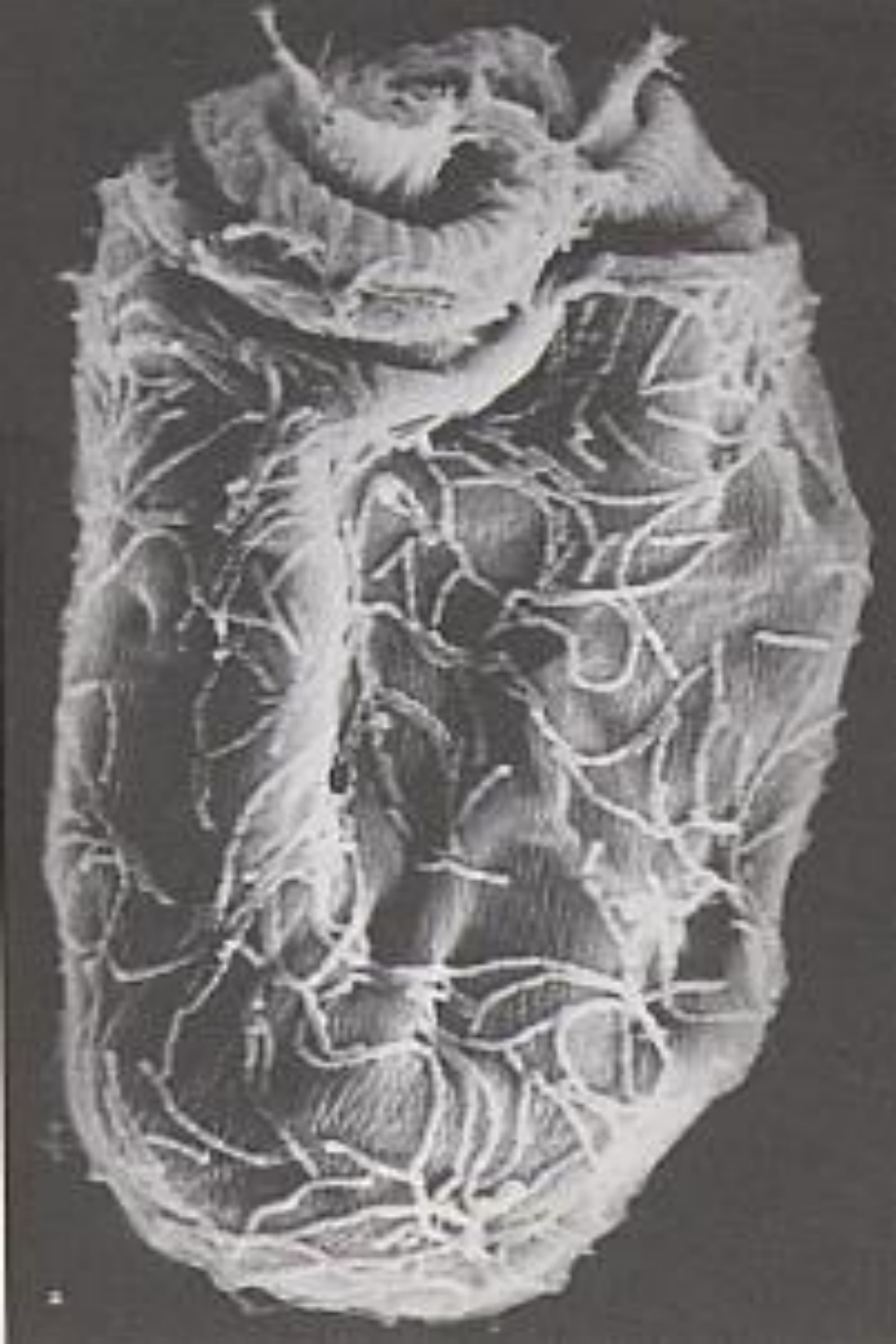


**Rumen protozoa,  
*Holotrich* sp.  
(Hungate, 1966)**



**Rumen protozoa, *Entodiniomorph* sp. of swamp buffalo (Wanapat et al., 2000b)**





**Entodiniomorph**  
***Diplodinium* with**  
**adherent**  
**methanogenic**  
**bacteria**

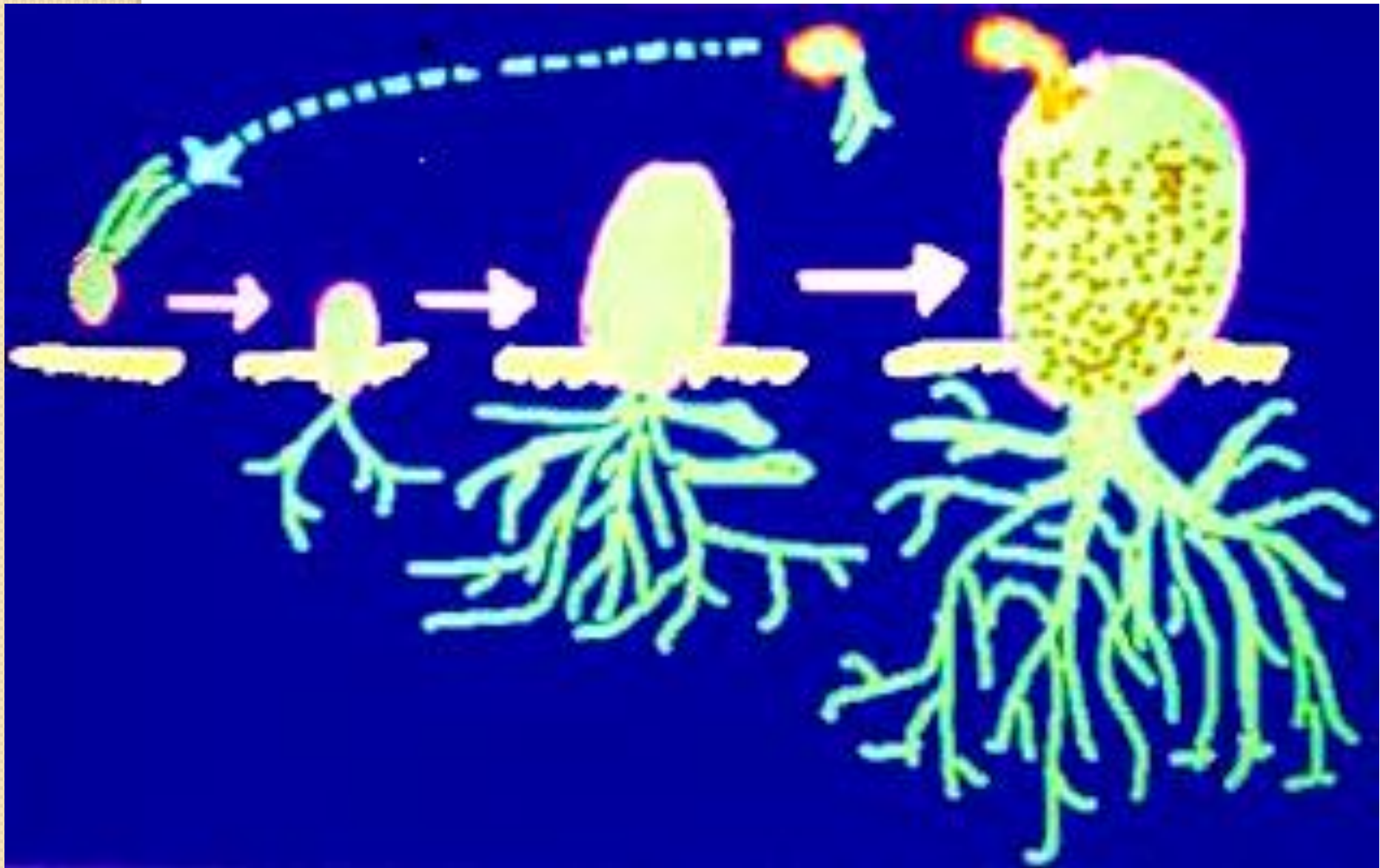


**Symbiosis of bacteria protozoa and fungal zoospores**

# Rumen Fungi

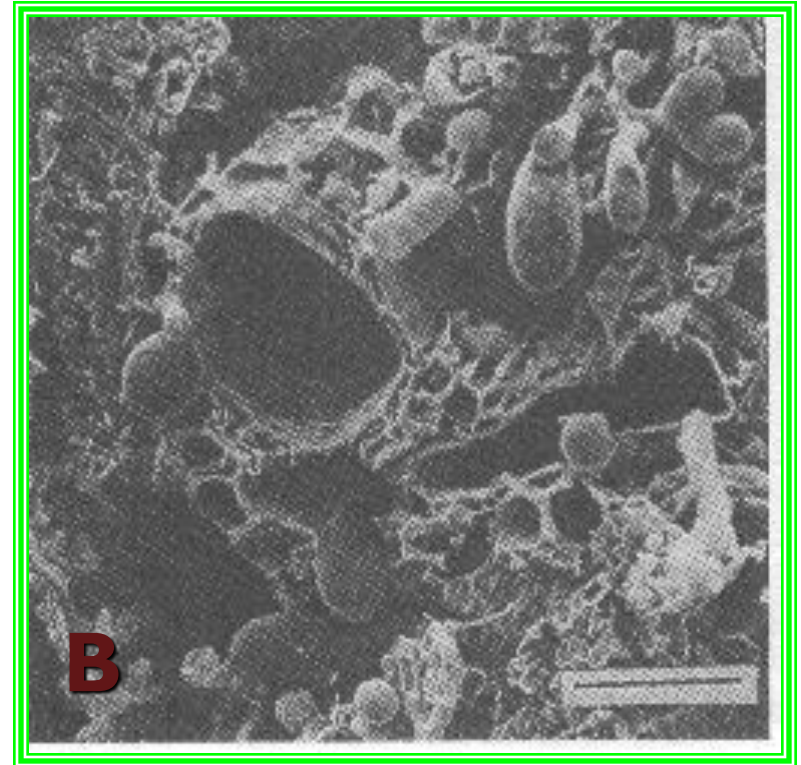
- ~ 8% of total rumen microbes
- ~ 20 genera
- low in number
- digest fiber with bacteria





**Life cycle of rumen fungi**

# Rumen fungi on fiber digestion



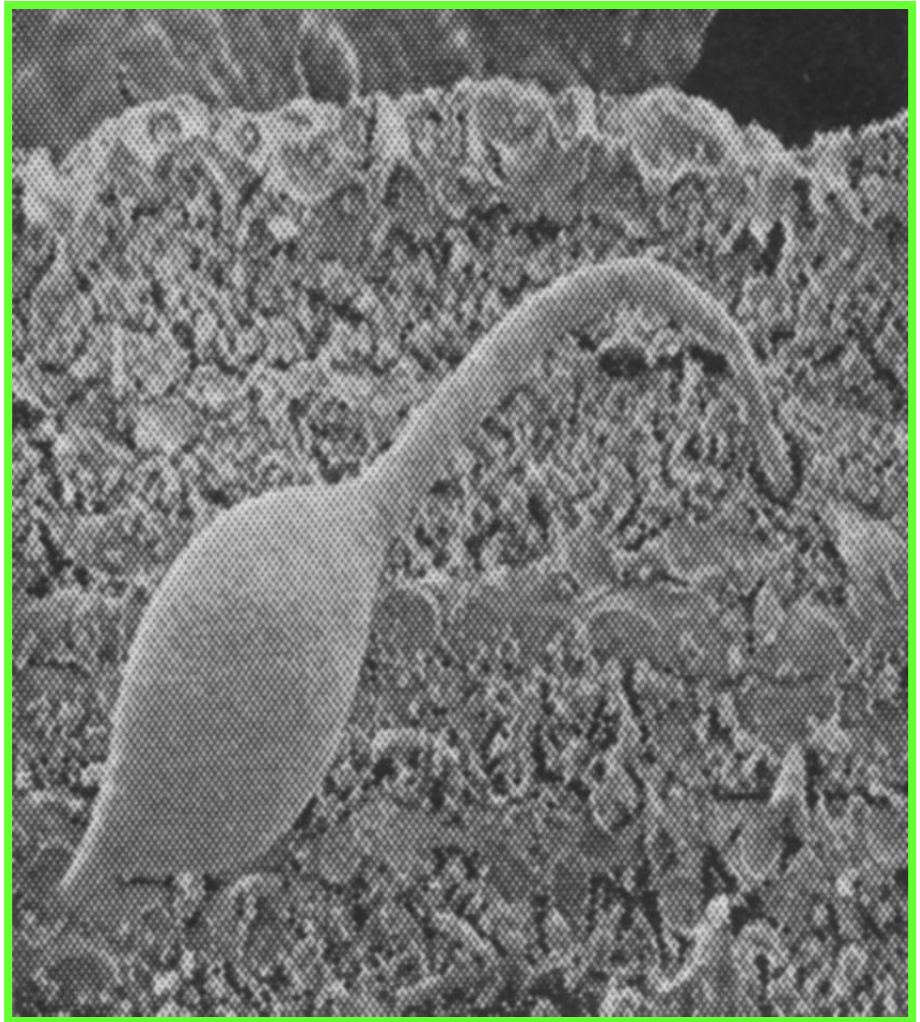
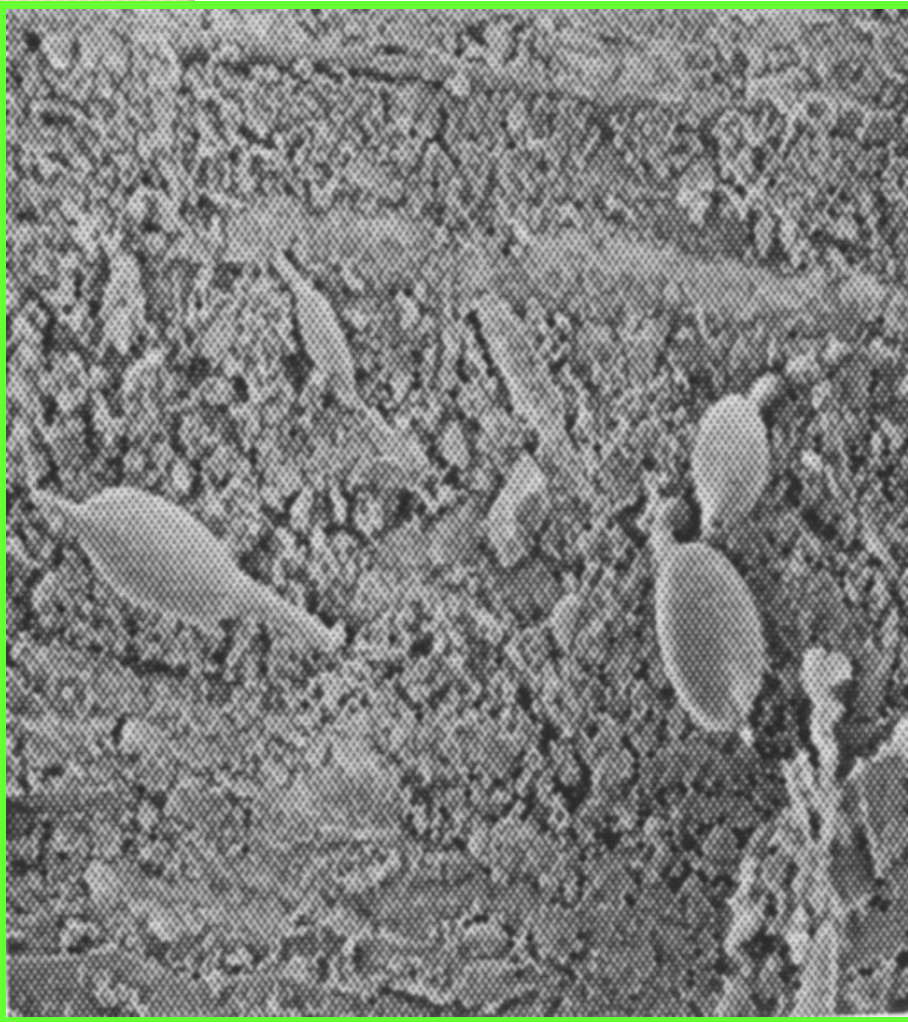
**A germinated zoospore in a stoma of guinea grass from rumen of buffaloes**

**A = 30 min after incubation (Bar = 5 *micron*)**

**B = 24 hr after incubation (Bar = 25 *micron*)**

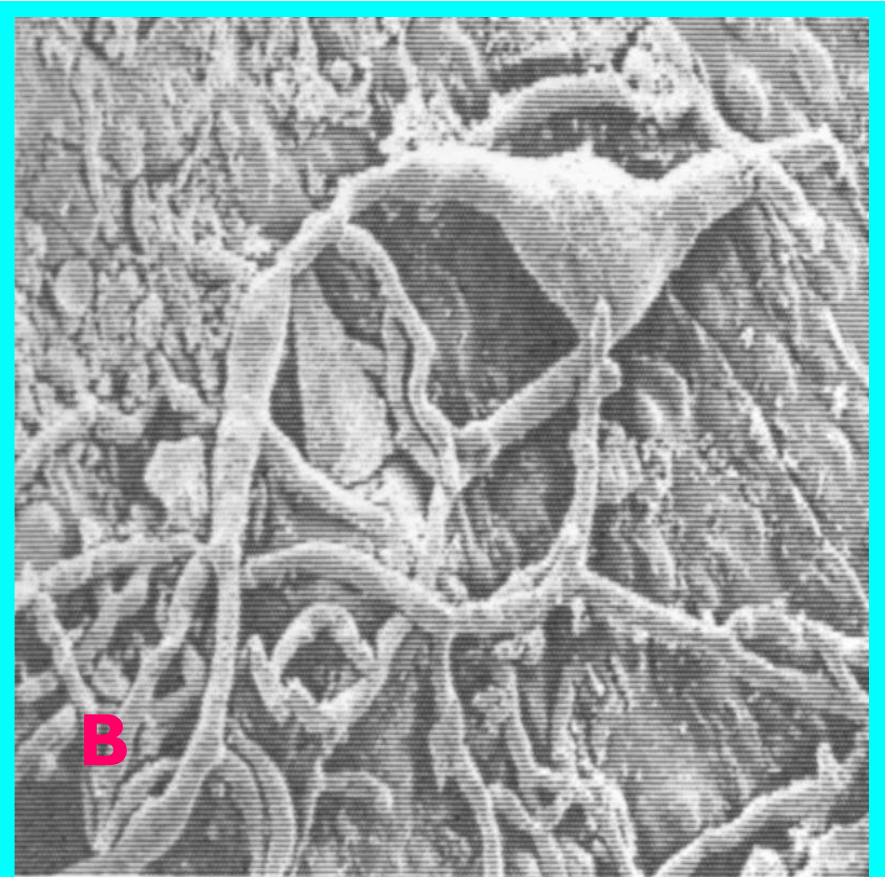
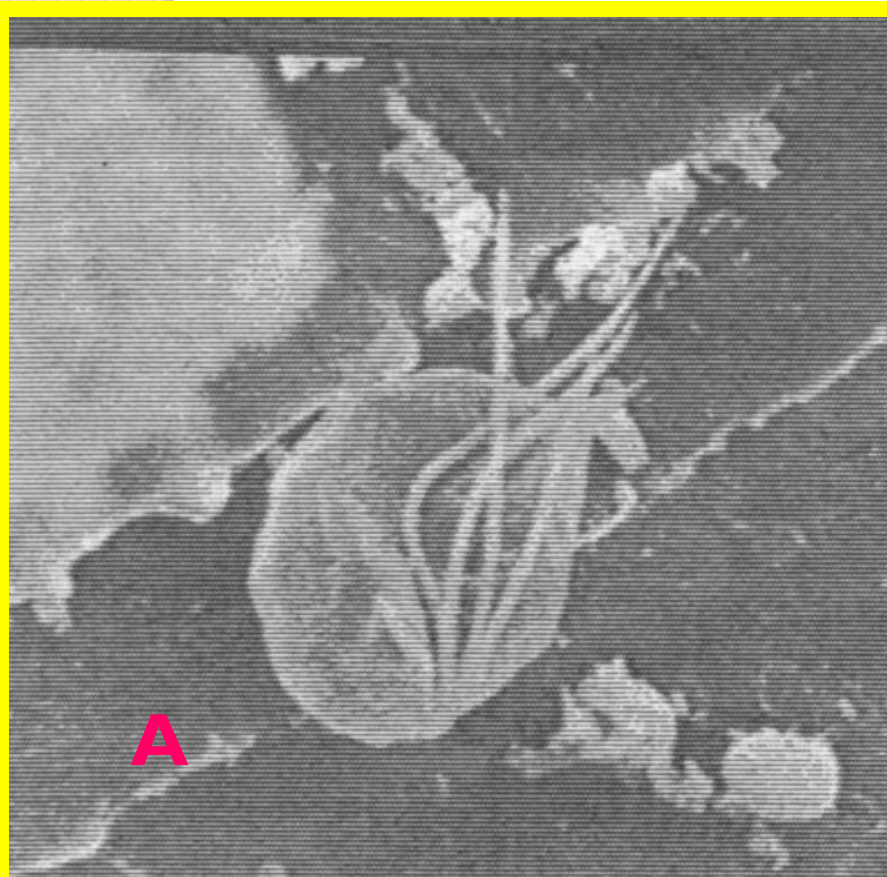
**Source : Ho et al. (1988)**





**Rumen fungus of swamp buffalo,  
*Anaeromyces* sp. with acuminate apex  
(Wanapat et al., 2000b)**

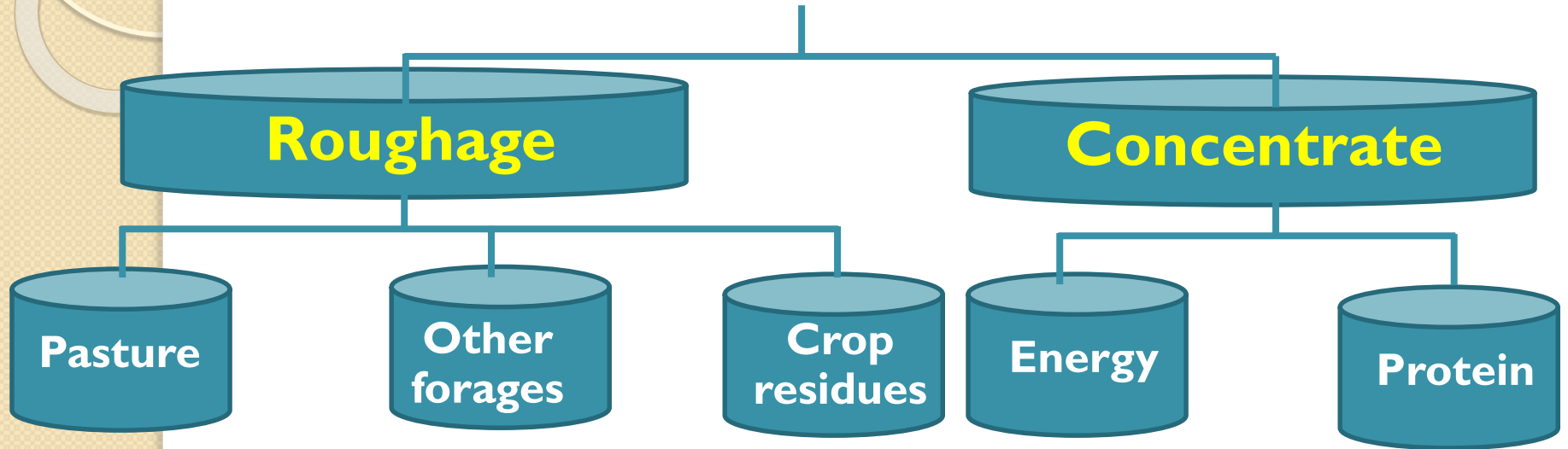




**A = Rumen fungal sporangium with flagellae**  
**B = Rumen fungal rhizoid with penetrated appressorium of swamp buffalo**  
**(Wanapat et al., 2000b)**

# Feeds and feed utilization

# Feeds for Beef Cattle





# Fermentation by-products

Carbohydrate	Protein
<ul style="list-style-type: none"><li>▪ <b>Volatile fatty acids</b><ul style="list-style-type: none"><li>-Acetate (C2)</li><li>-Propionate (C3)</li><li>-Butyrate (C4)</li></ul></li></ul>	<ul style="list-style-type: none"><li>▪ <b>Microbial protein</b></li></ul>
<ul style="list-style-type: none"><li>▪ <math>\text{CO}_2</math>, <math>\text{CH}_4</math></li></ul>	<ul style="list-style-type: none"><li>▪ <math>\text{NH}_3</math></li></ul>
<ul style="list-style-type: none"><li>▪ Microbial cell</li></ul>	<ul style="list-style-type: none"><li>▪ <math>\text{CO}_2</math>, <math>\text{CH}_4</math></li></ul>
<ul style="list-style-type: none"><li>▪ Starch</li></ul>	<ul style="list-style-type: none"><li>▪ Amino acid/protein</li></ul>

# **Energy Supply to Ruminants**

**Contribution of the microbes to the symbiotic relationship:**

**VFA 70%**

**Microbial cells 10%**

**Digestible unfermented feed 20%**

**Concentration of VFA in the rumen 50 to 125 uM/ml**

# **Amino Acid Supply to Ruminants**

## **Contribution of the microbes to the symbiotic relationship**

**Protein in microbial mass** **65%**

**Undegraded feed proteins** **30%**

**Recycled endogenous proteins** **5%**

**Amino acid balance of microbial mass is superior to that from undegraded feed proteins when corn-based diets are fed.**



# Interaction between microbes on SC digestion

**Cellulolytic  
bacteria**

**Entodiniomorphs**  
\*Polyplastron,  
\*Eudiplodinium

\*Neocallimastic  
\*Piromyces  
\*Opinomyces  
\*Anaeromyces  
\*Caecomyces

exo-1,4-B-glucanase/  
cellulase

endo-1,4-B-glucanase/  
exo -1,4-B-glucanase

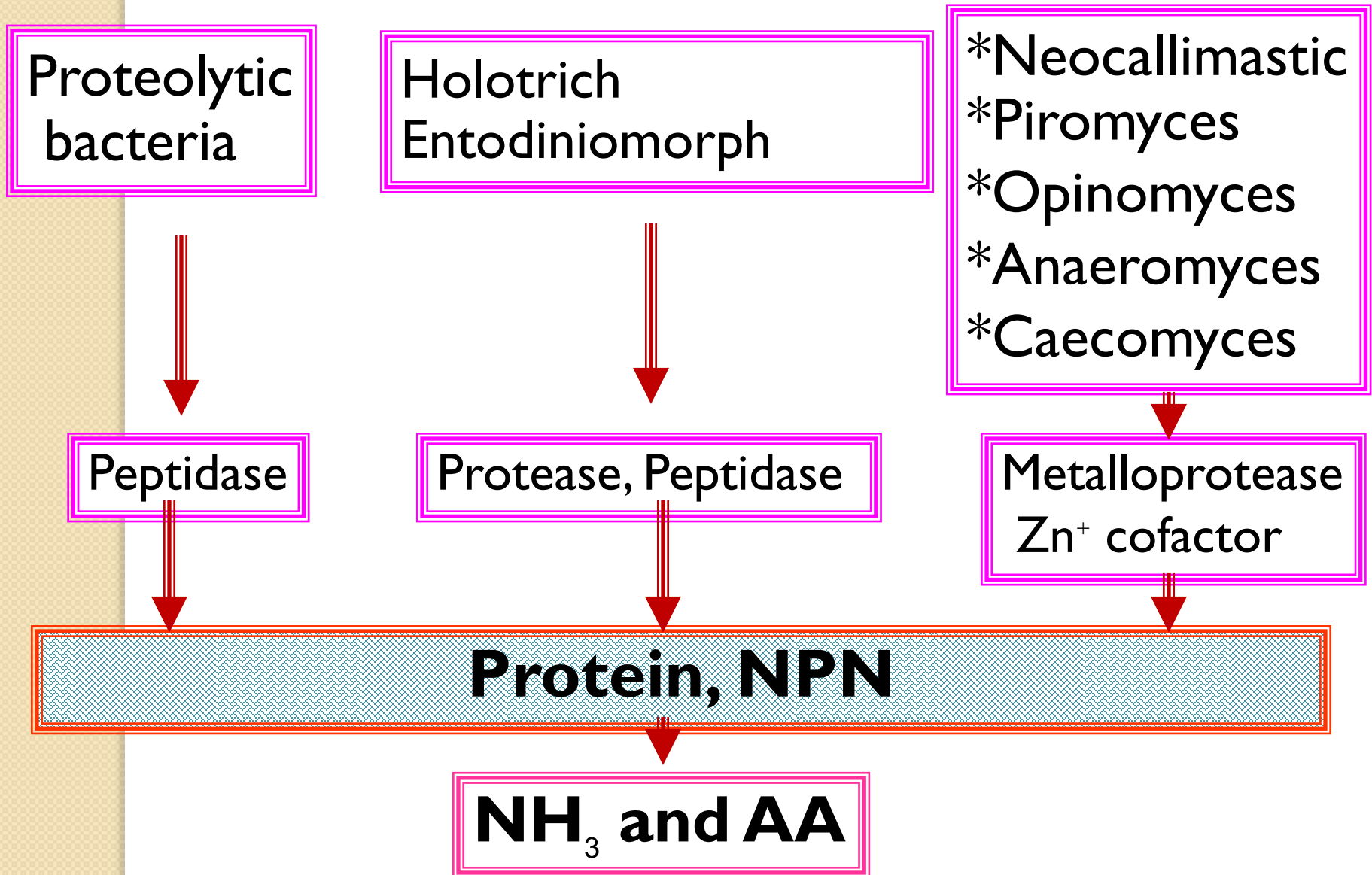
endo-1,4-B-D-glucanase/  
exo-1,4-B-D-glucanase

**Structural carbohydrate**

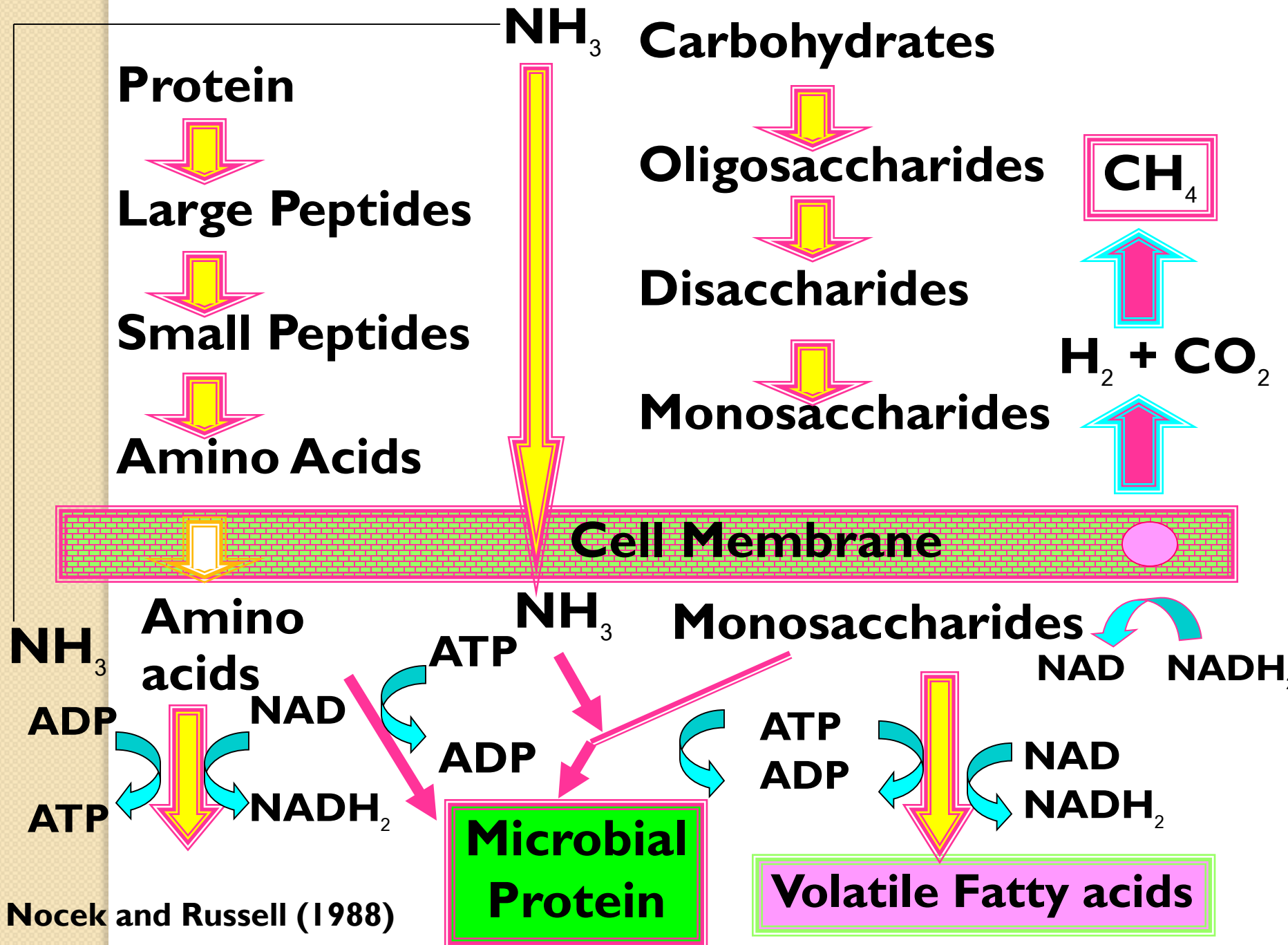
**VFA**

(Hungate, 1996; Ushida and Jouanu, 1994; Ho and Abdullah, 1999)

# Interaction between microbes on Protein digestion



(Hungate, 1996; Ushida and Jouanu, 1994; Ho and Abdullah, 1999)

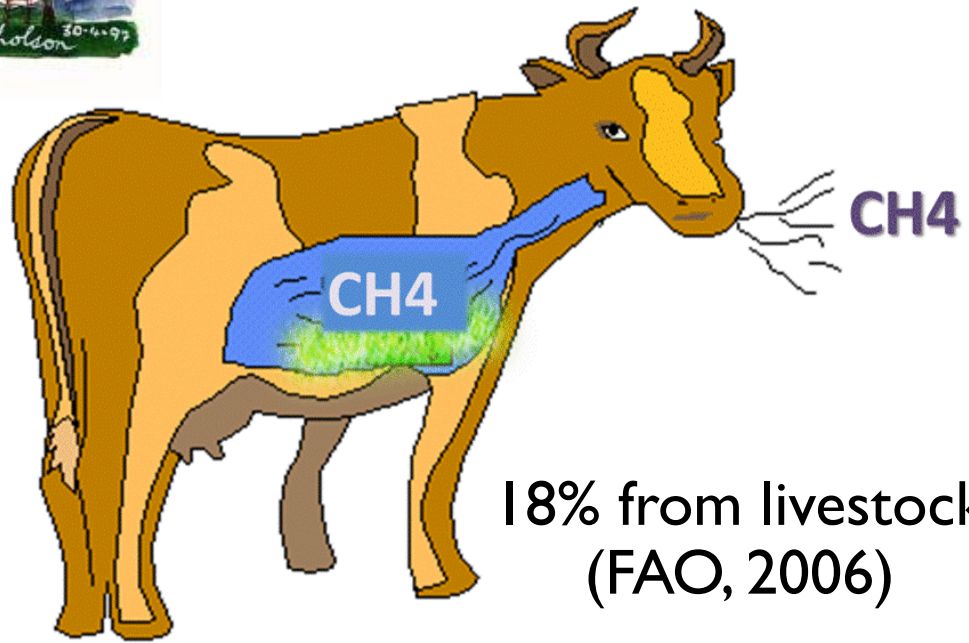
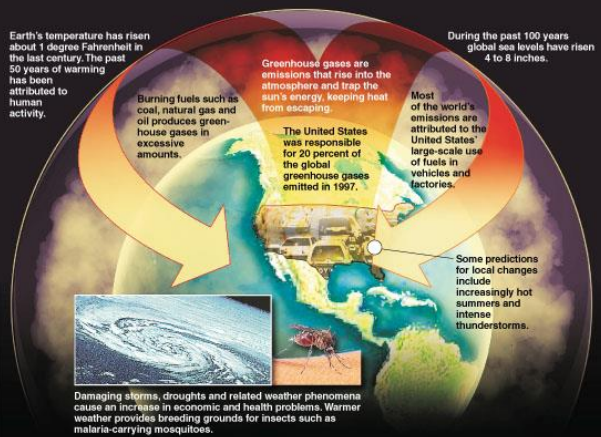




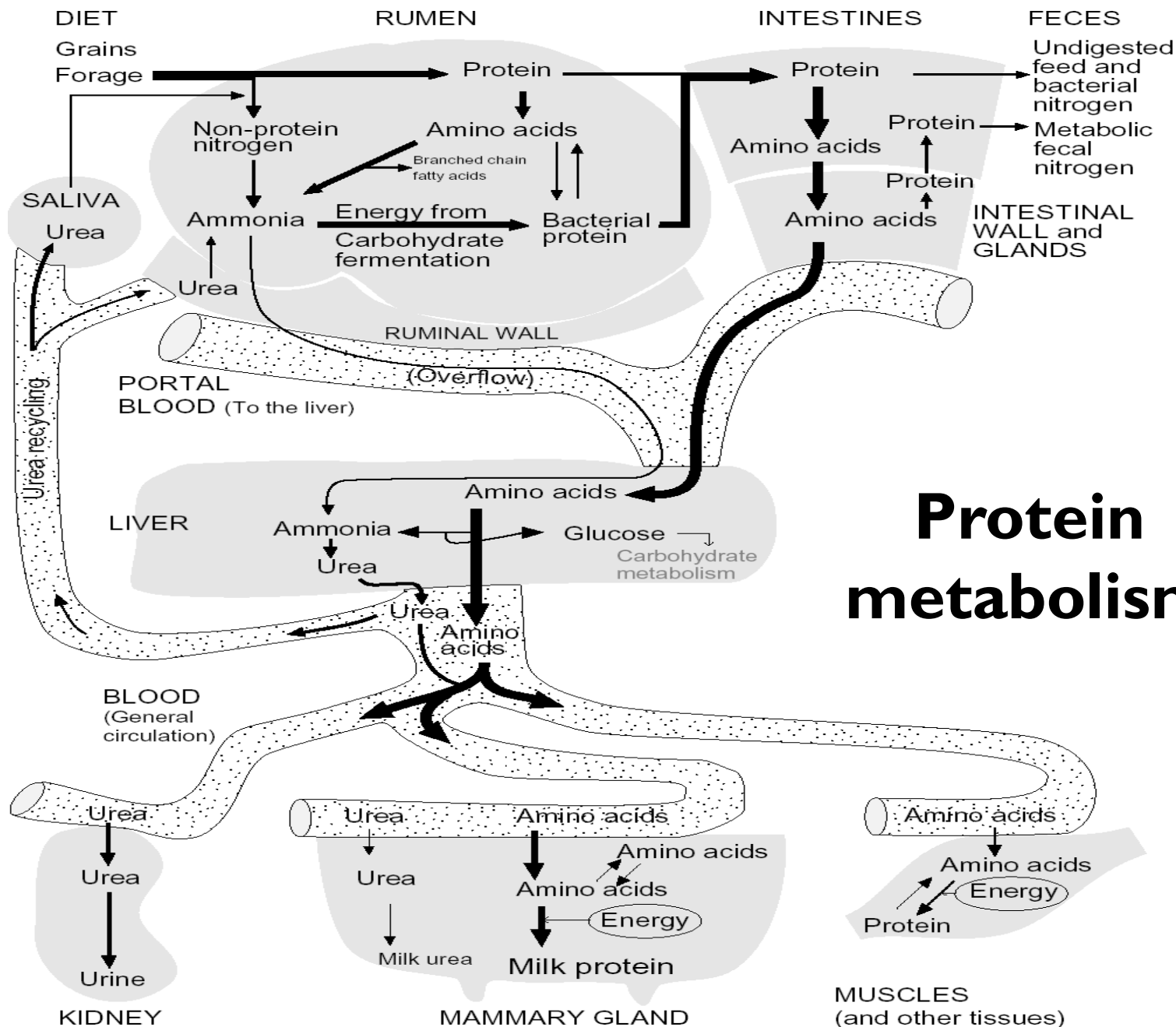
# Ruminal CH<sub>4</sub> Production

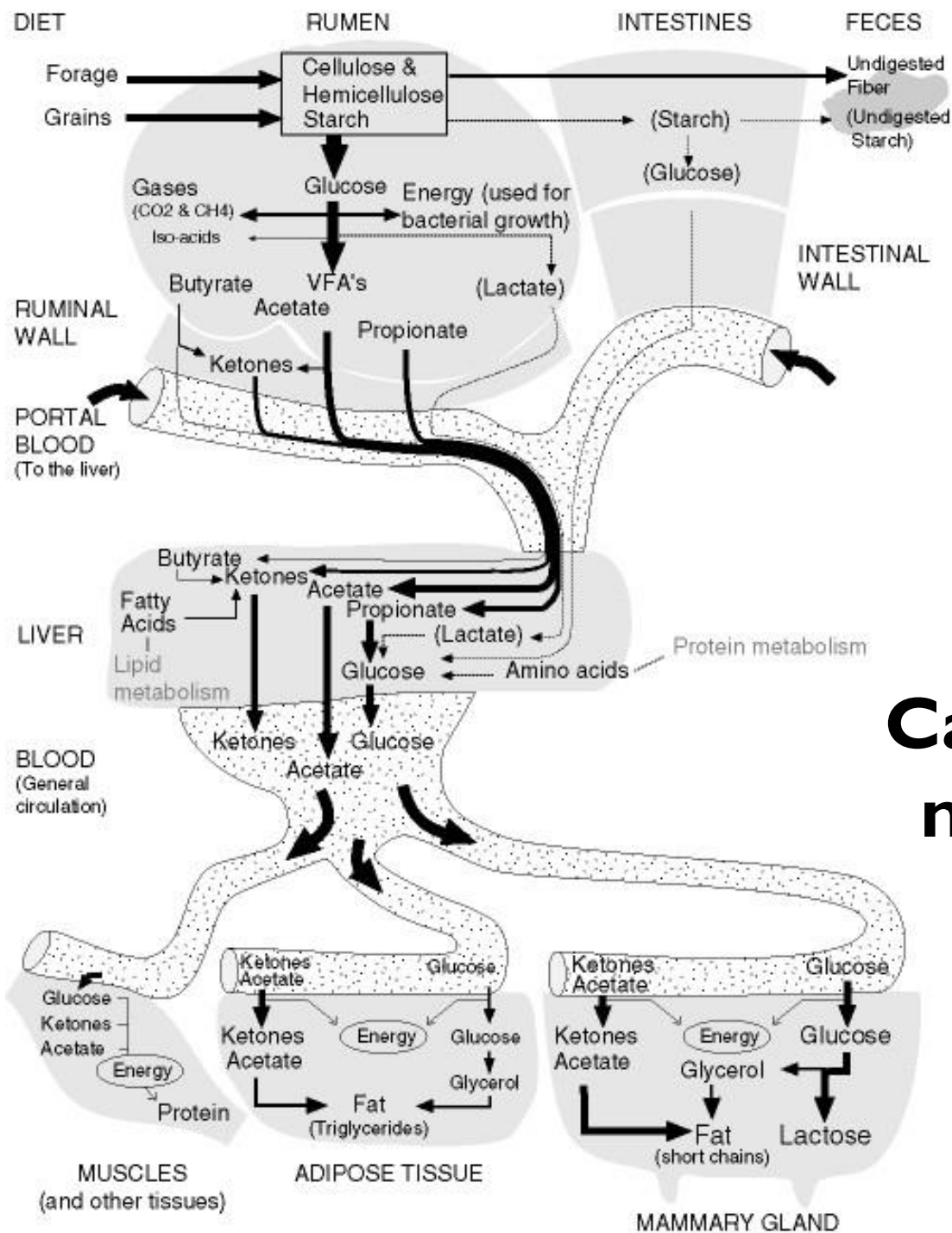


## Global warming: Causes and effects



18% from livestock  
(FAO, 2006)





# Carbohydrate metabolism



A photograph of three brown cows in a stall, eating hay. The cows are positioned behind metal bars. The cow on the right has a yellow ear tag with the number 15328. The cow in the middle has a yellow ear tag with the number 15318. The text "Thank you very much" is overlaid in large, green, bold letters across the center of the image.

**Thank you  
very much**