

Gut Health and High Grain Diets: Consequences of Ruminal and Hindgut Acidosis and Systemic Inflammation



Gut Health in Cattle Fed High Grain Diets

- **Outline:**
 - **Gut Microbial Ecosystems: Rumen vs Hindgut**
 - **Gut Acidosis: Ruminal and Hindgut**
 - **Gut Wall: Protective Barrier Function**

GI Tract of Cattle: Microbes

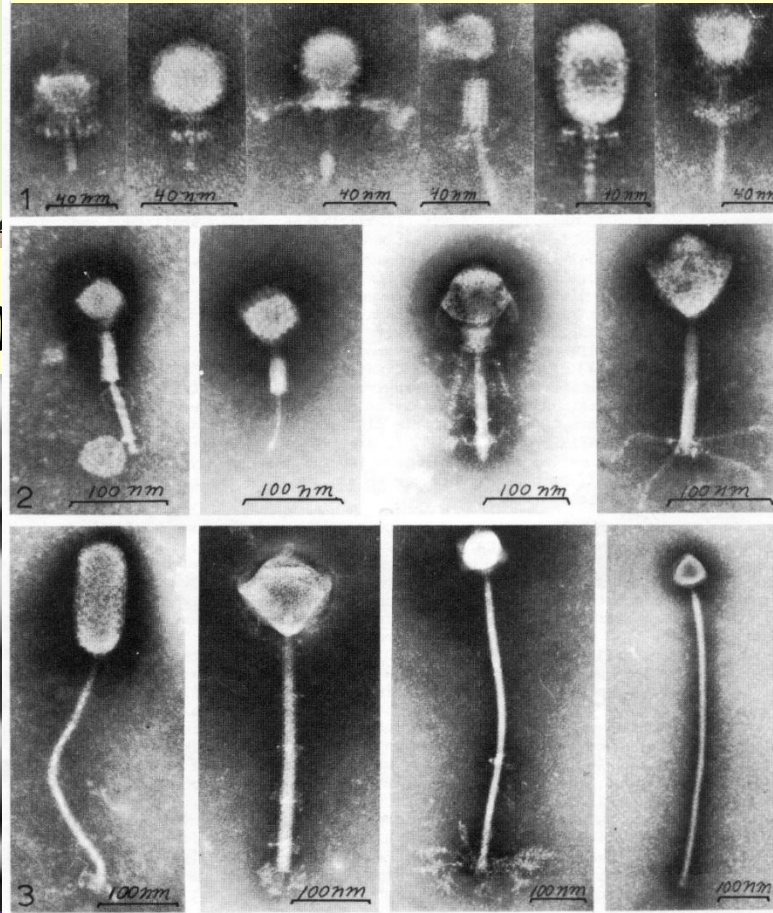
Bacteria



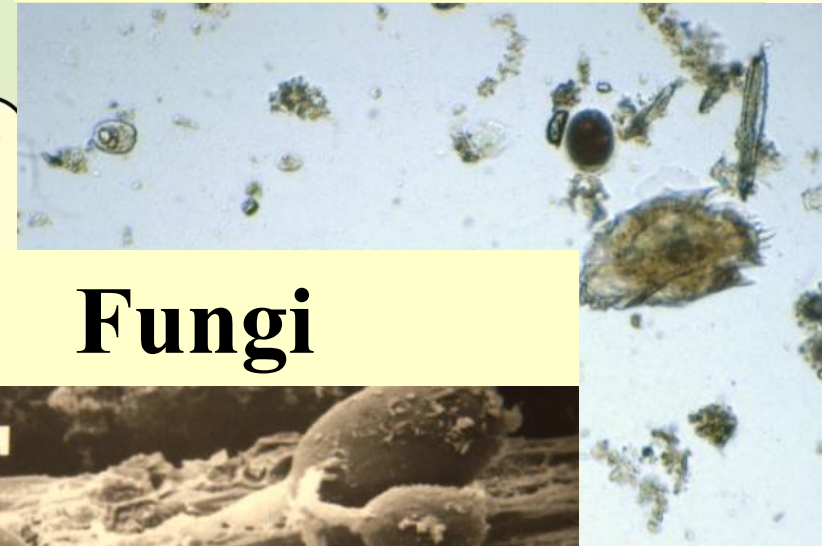
Methano



Bacterial Viruses



Ciliated Protozoa



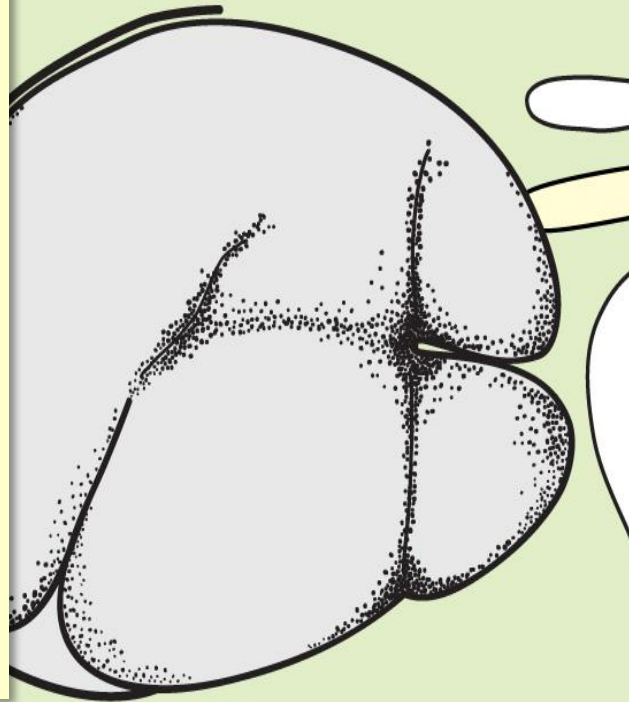
Fungi



GI Tract of Cattle: Microbial Ecosystems

Rumen

- Bacteria
- Methanogens
- Protozoa
 - Flagellated
 - Ciliated
- Fungi
- Viruses



Cecum and Colon

- Bacteria
- Methanogens
- Fungi
- Viruses

Bovine Gut Microbial Ecosystem: Contributions

Rumen

- **Major source of energy (90 to 95%)**
- **Major source of protein**
- **Nitrogen recycling**
- **Protective barrier function**



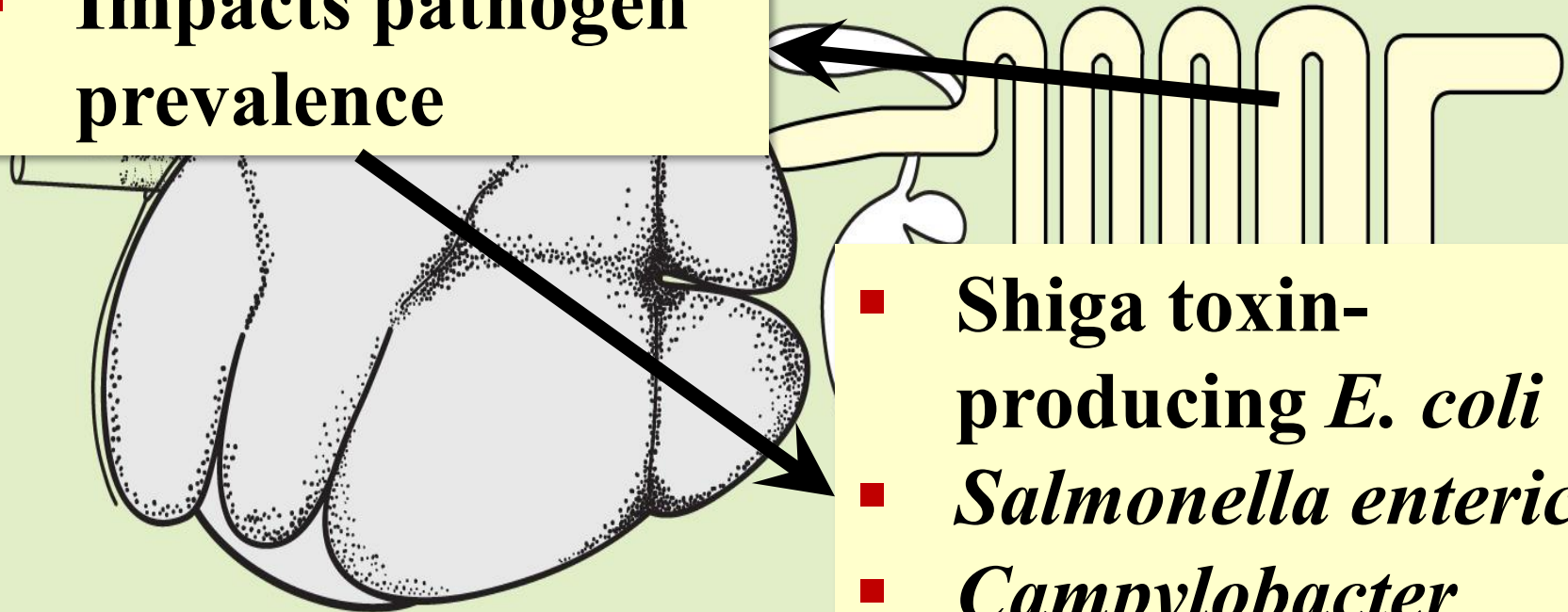
Cecum and Colon

- **Minor source of energy (5 to 10%)**
- **Protein is not available to the host**
- **Nitrogen recycling**
- **Protective barrier function**

Bovine Hindgut: Functions

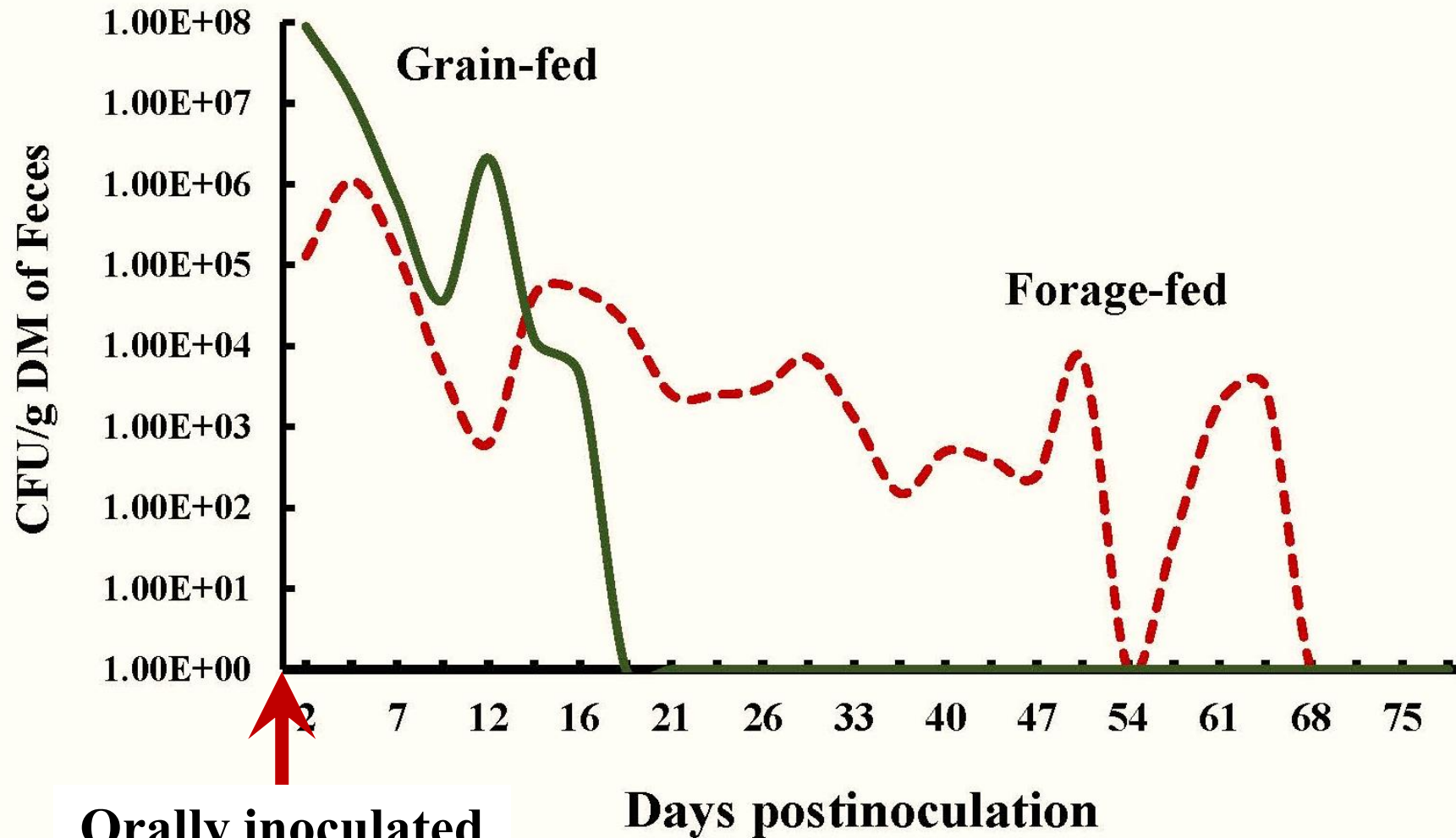


- Impacts pathogen prevalence



- Shiga toxin-producing *E. coli*
- *Salmonella enterica*
- *Campylobacter jejuni, coli*

Fecal Shedding of *E. coli* O157 in Cattle: Roughage vs. Grain

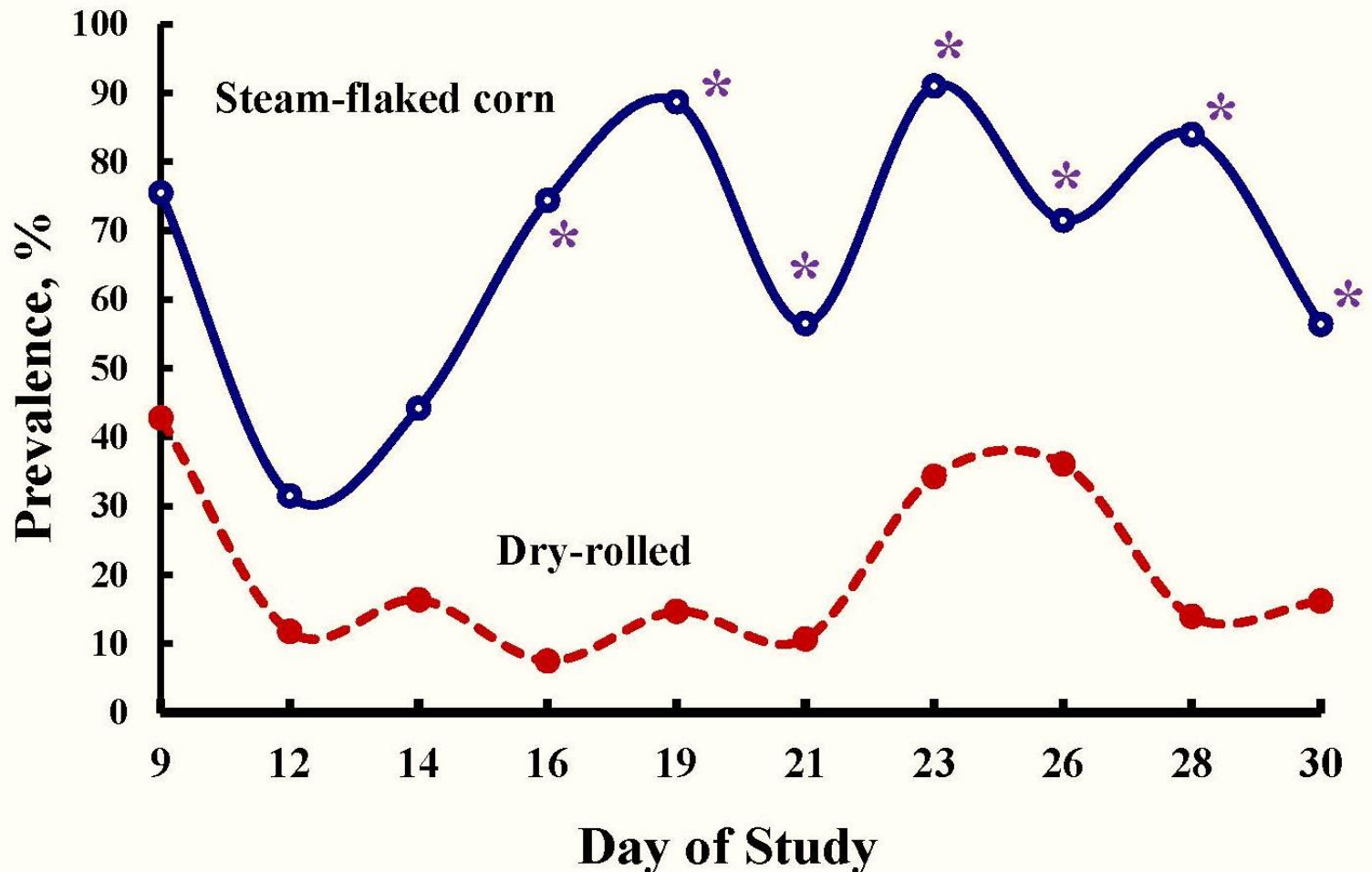


Orally inoculated
with *E. coli* O157

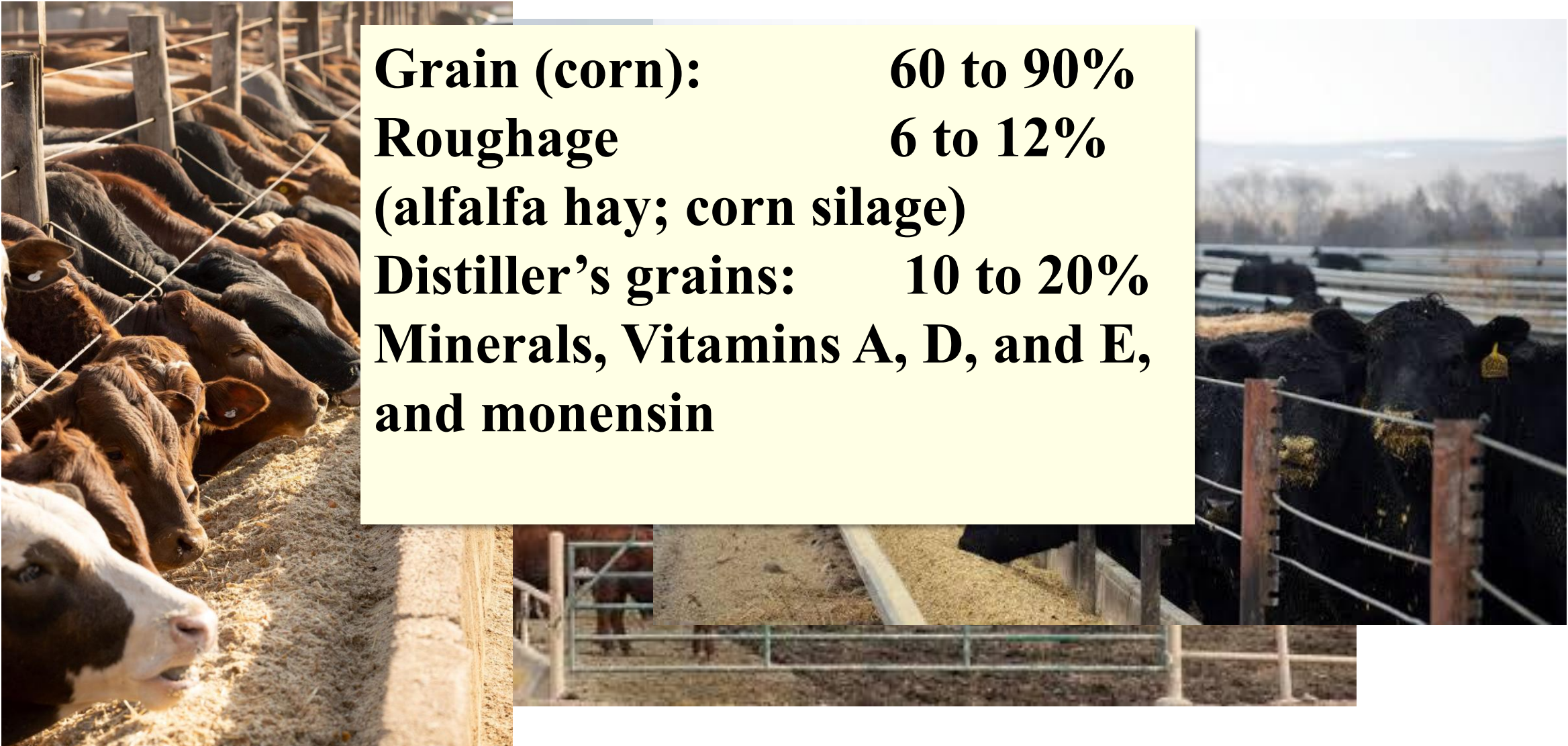
Days postinoculation

Fecal Shedding of *E. coli* O157:H7: Steam-flaked vs. Dry-rolled corn

- Cattle fed diets containing either:
 - Steam-flaked corn
 - Dry-rolled corn
- Fecal samples were tested for *E. coli* O157:H7 by culture method.

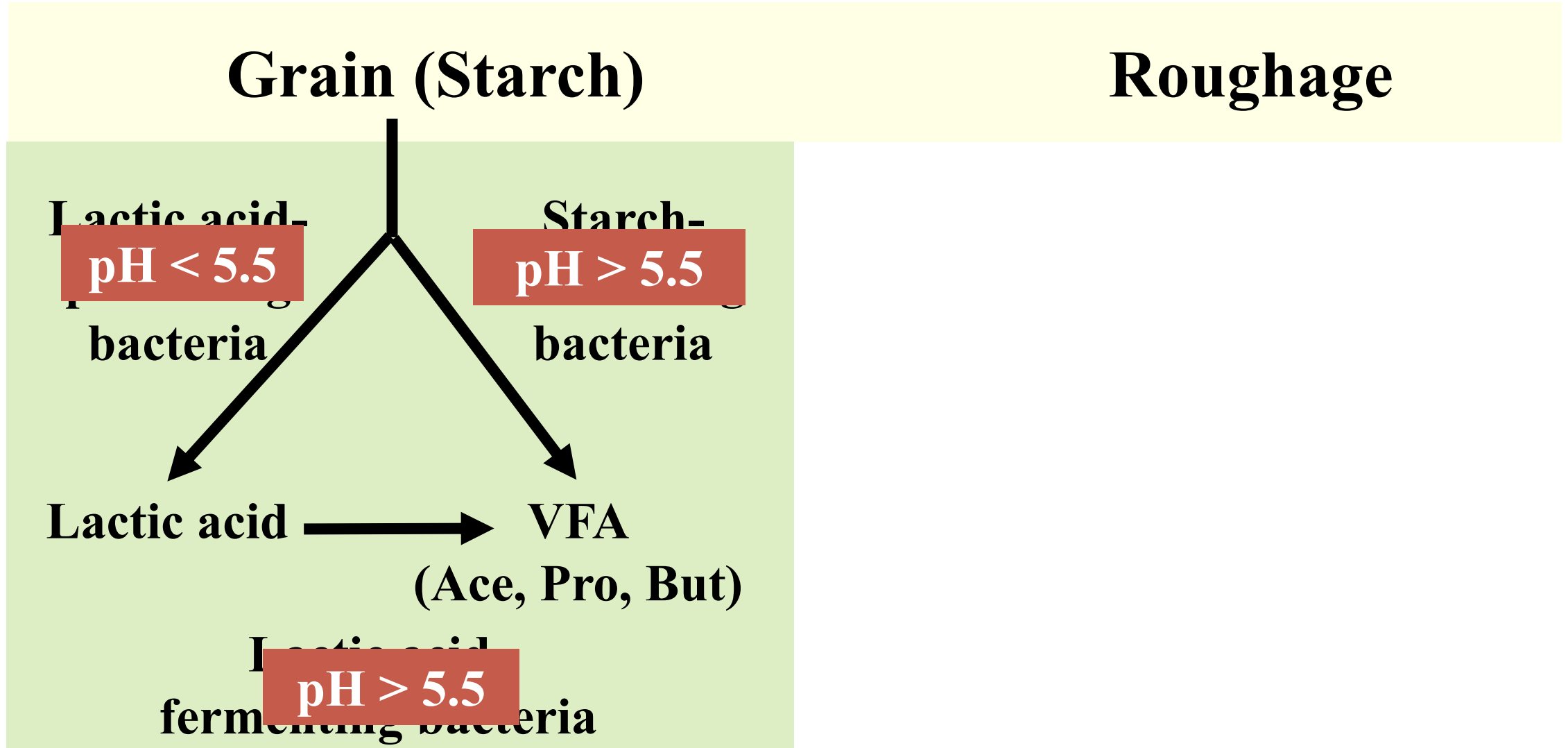


Typical Feedlot Diets in the US

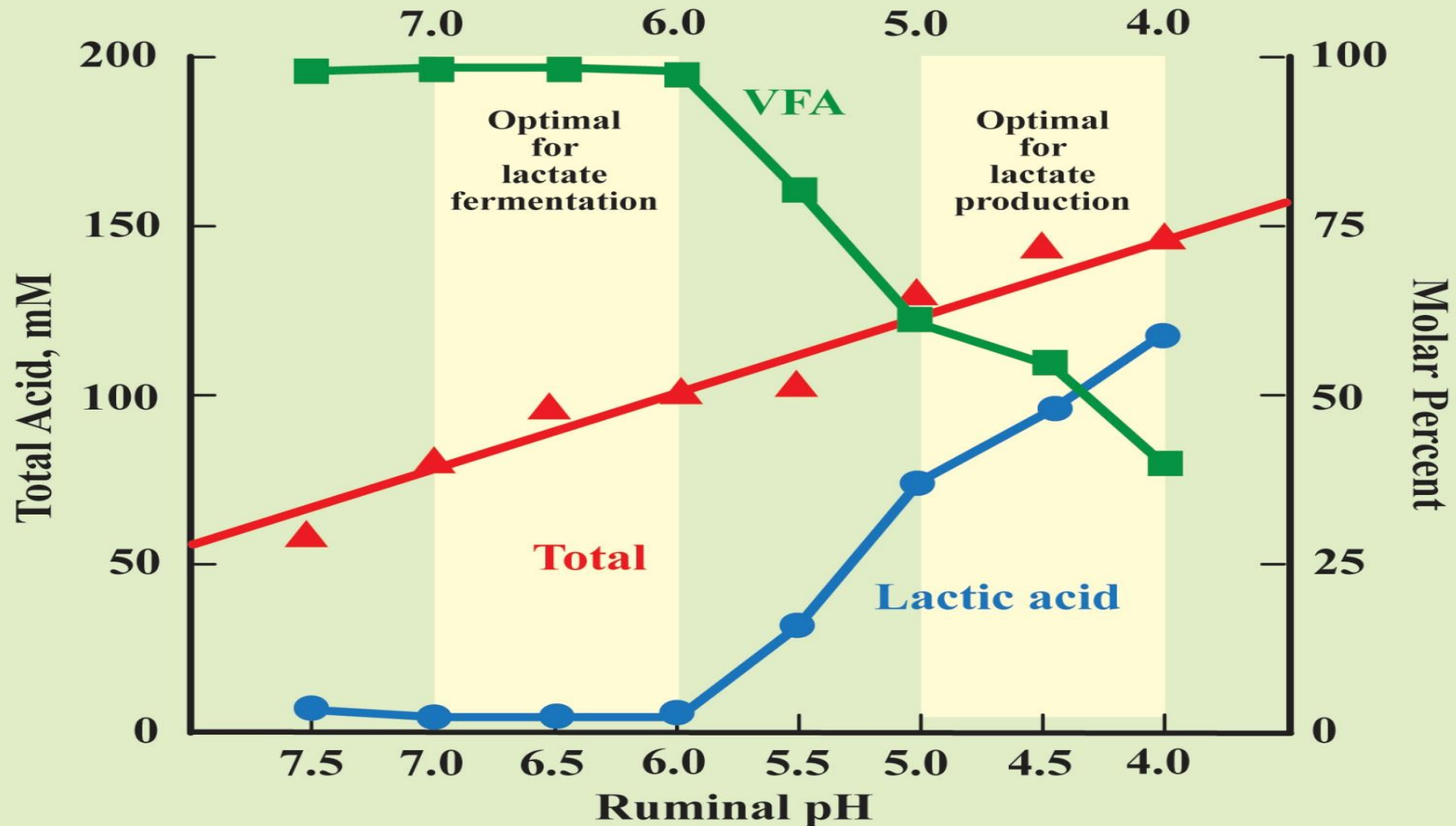


Grain (corn): 60 to 90%
Roughage 6 to 12%
(alfalfa hay; corn silage)
Distiller's grains: 10 to 20%
Minerals, Vitamins A, D, and E, and monensin

Feedlot Cattle: High-Grain Diets



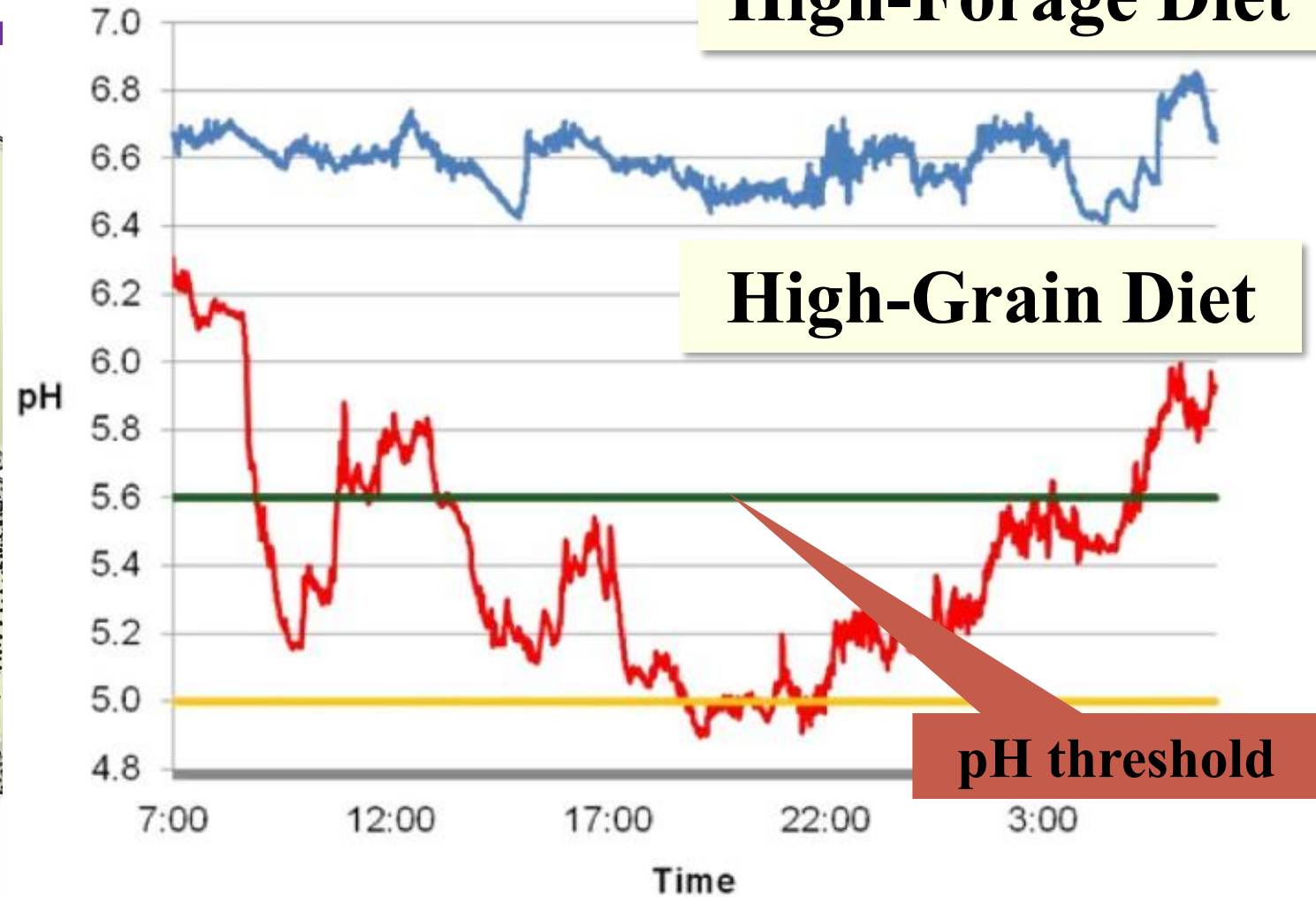
Relationship Between Ruminal pH and VFA and Lactate



Ruminal pH and High Grain Diet

High-Forage Diet

High-Grain Diet



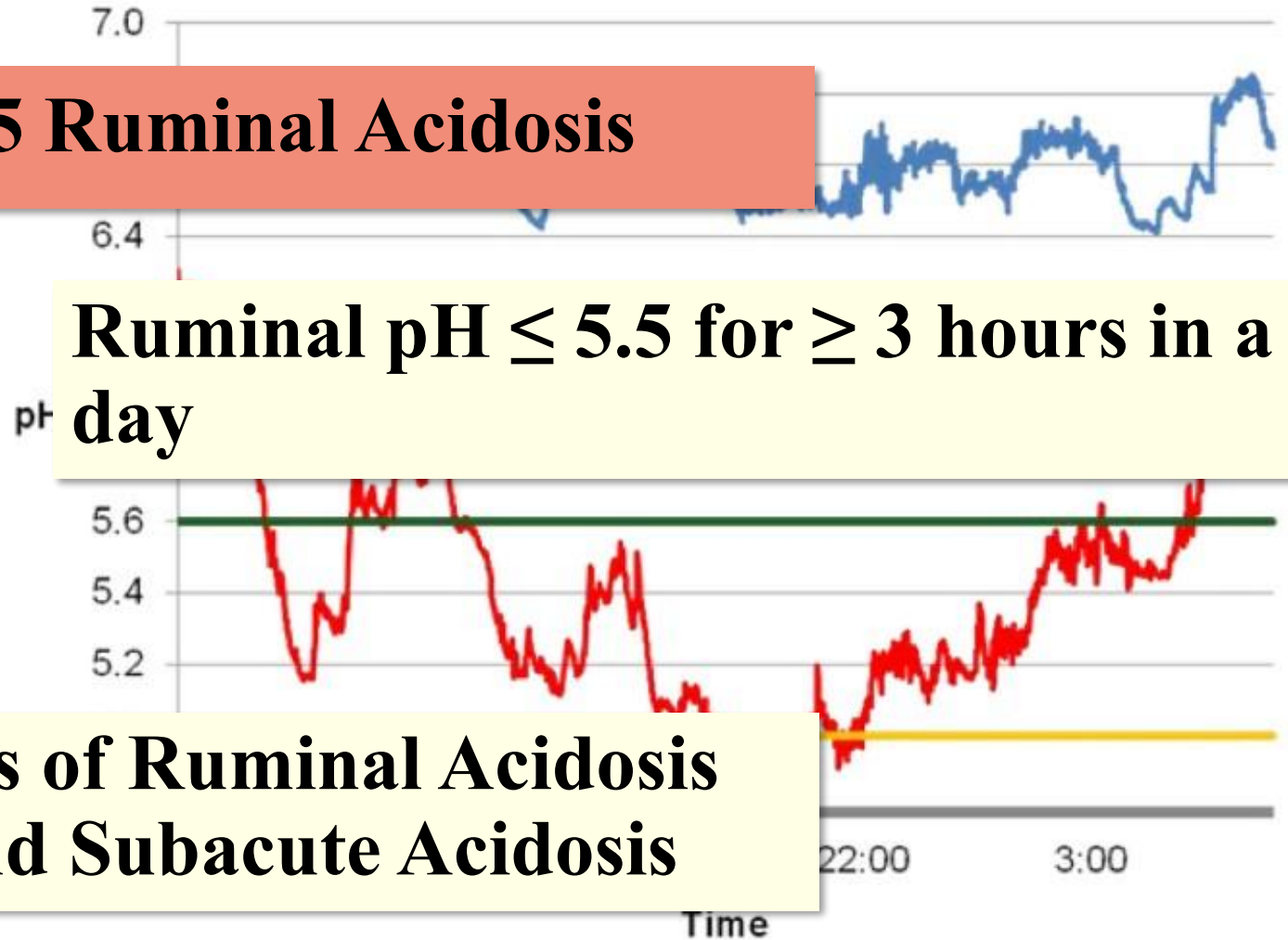
pH threshold

Ruminal pH and High Grain Diet

$\text{pH} \leq 5.5$ Ruminant Acidosis

Ruminal $\text{pH} \leq 5.5$ for ≥ 3 hours in a day

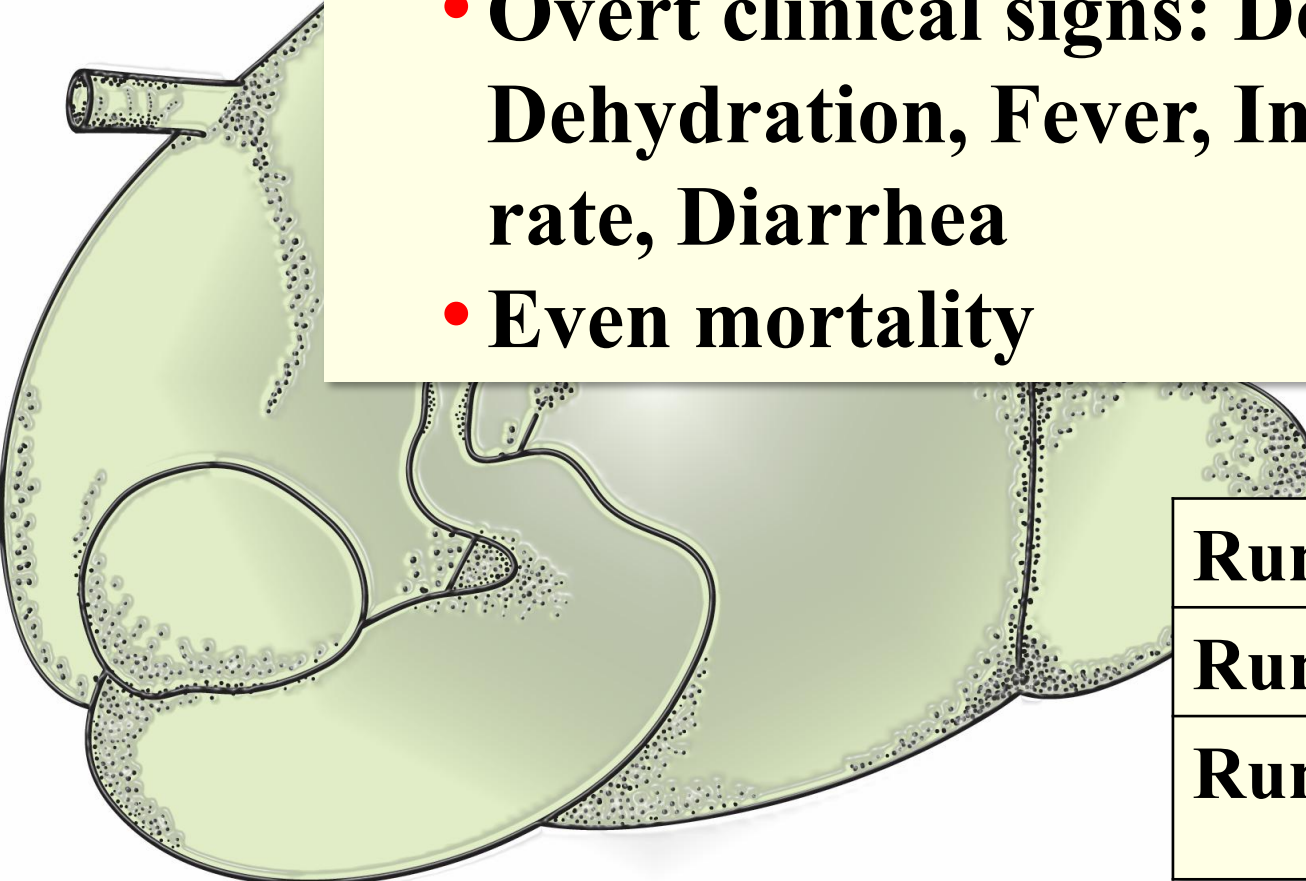
**Two Types of Ruminant Acidosis
Acute and Subacute Acidosis**



Acute Ruminal Acidosis

- **Characteristics:**

- **Overt clinical signs: Depressed, Anorexia, Dehydration, Fever, Increased respiratory rate, Diarrhea**
- **Even mortality**

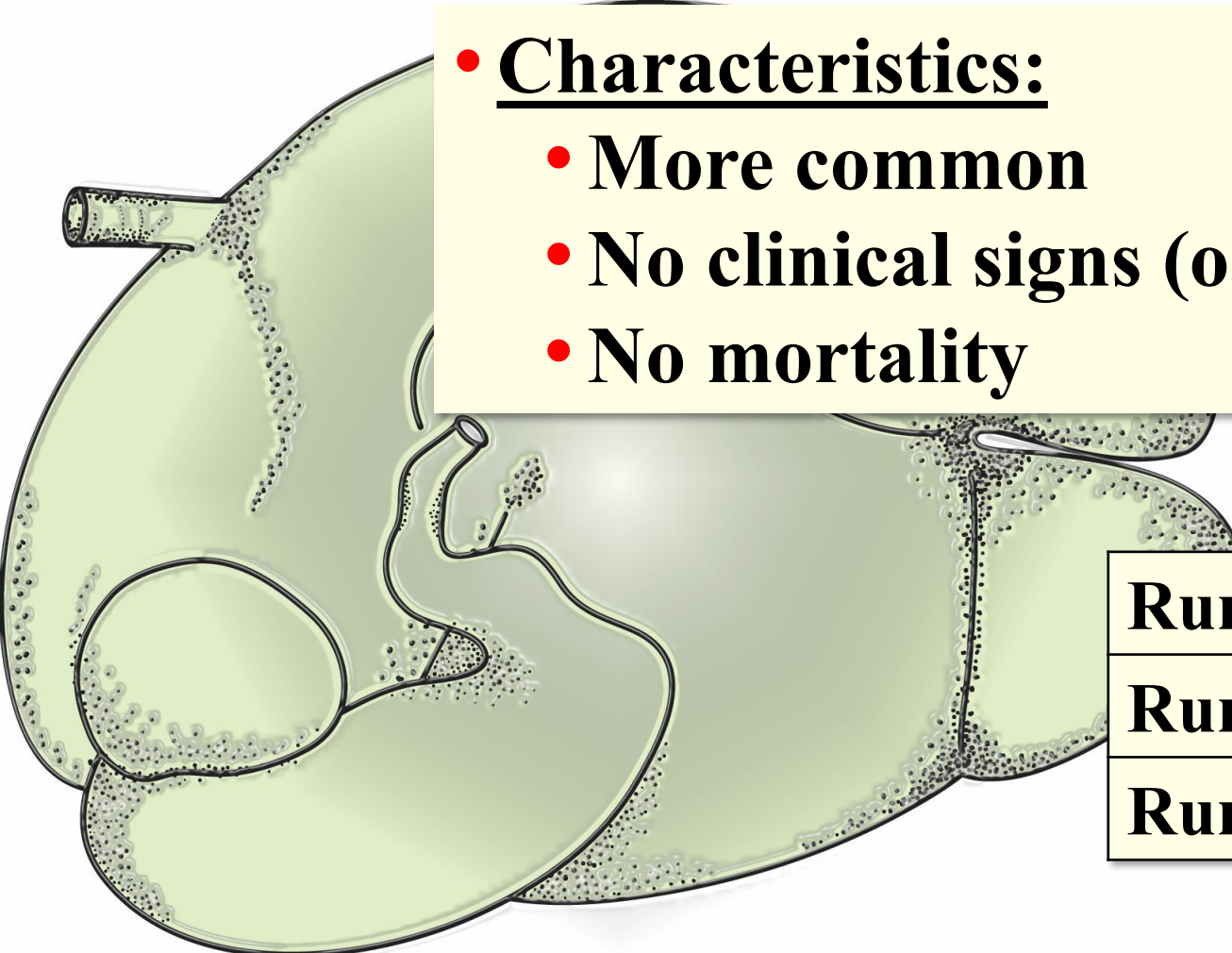


Ruminal pH	4.0 to 5.0
Ruminal lactate	100 to 120 mM
Ruminal VFA	Normal or decreased

Subacute Ruminal Acidosis (SARA)

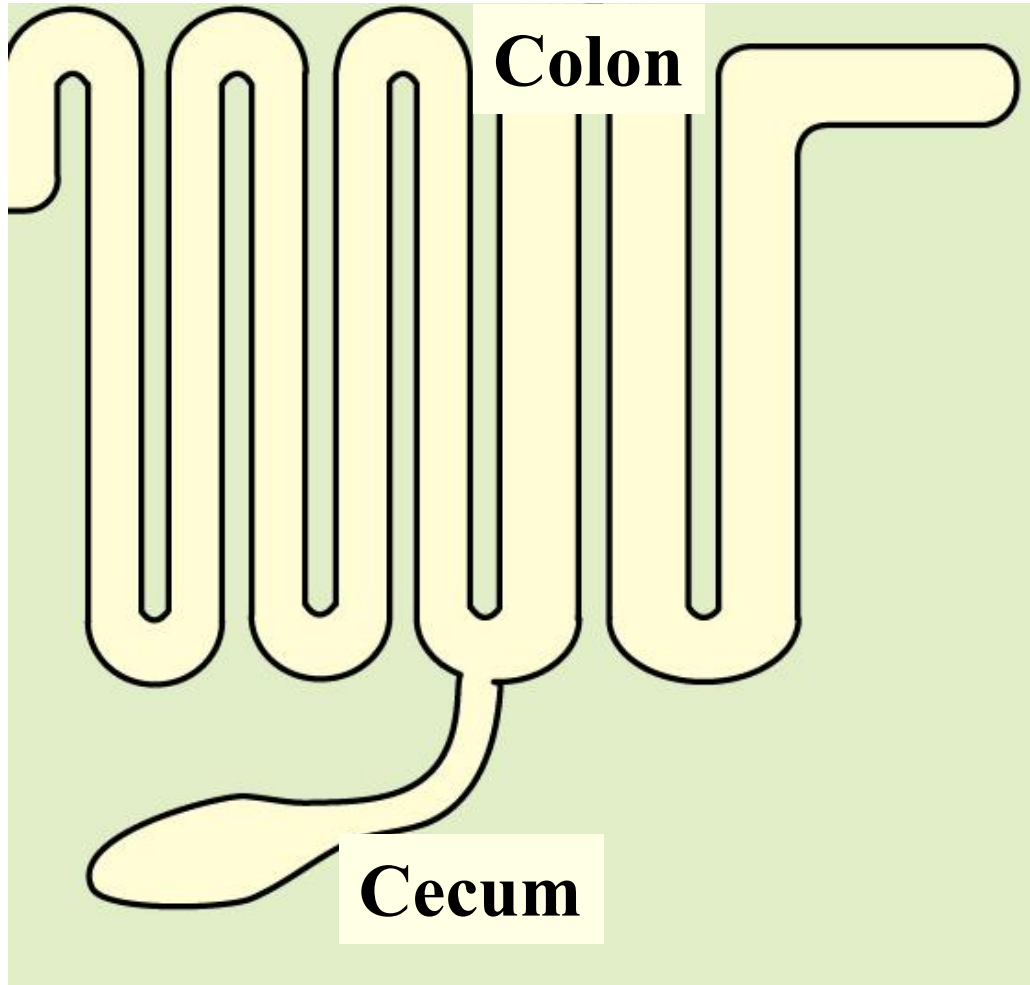
- **Characteristics:**

- **More common**
- **No clinical signs (off-feed!)**
- **No mortality**



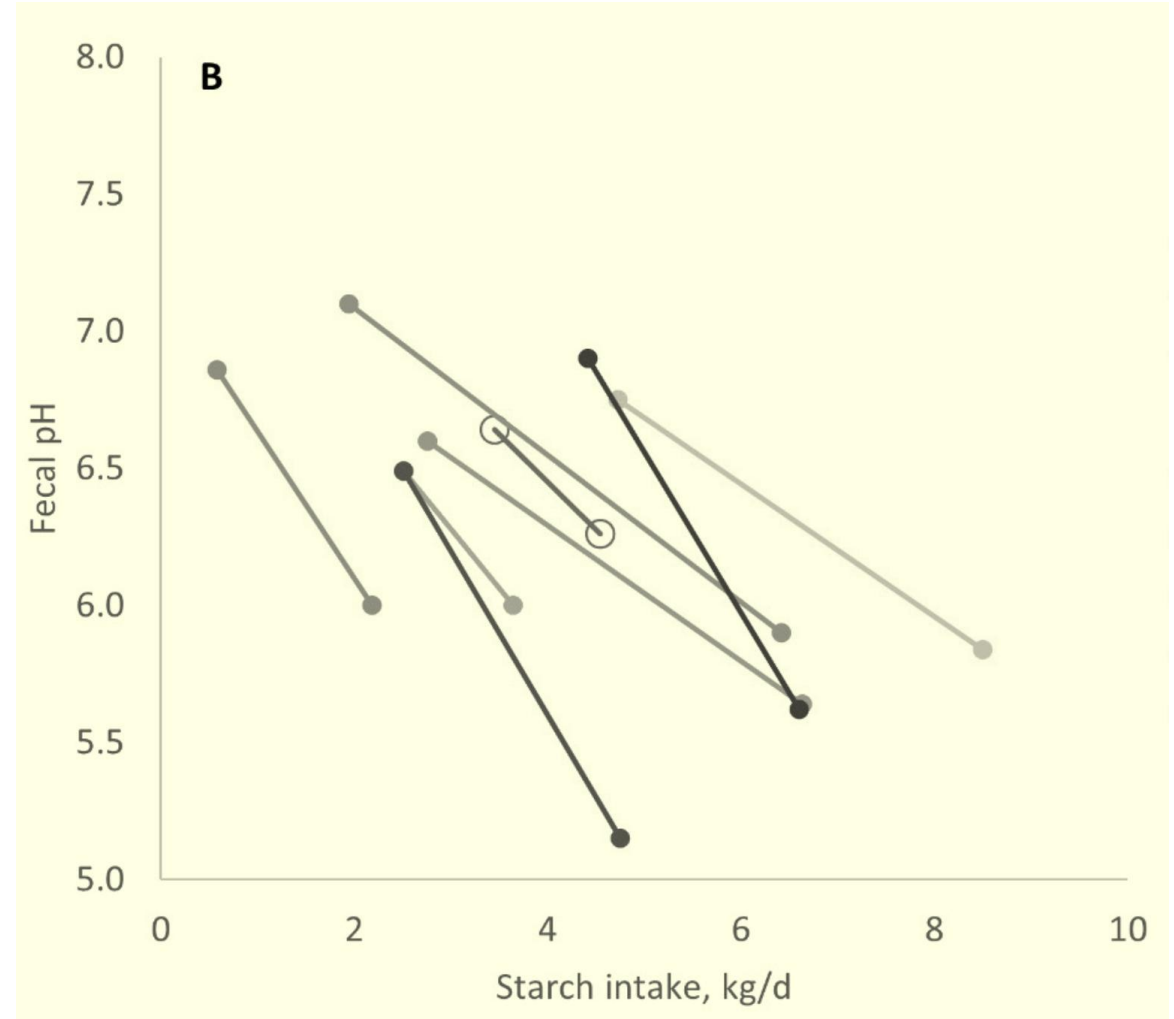
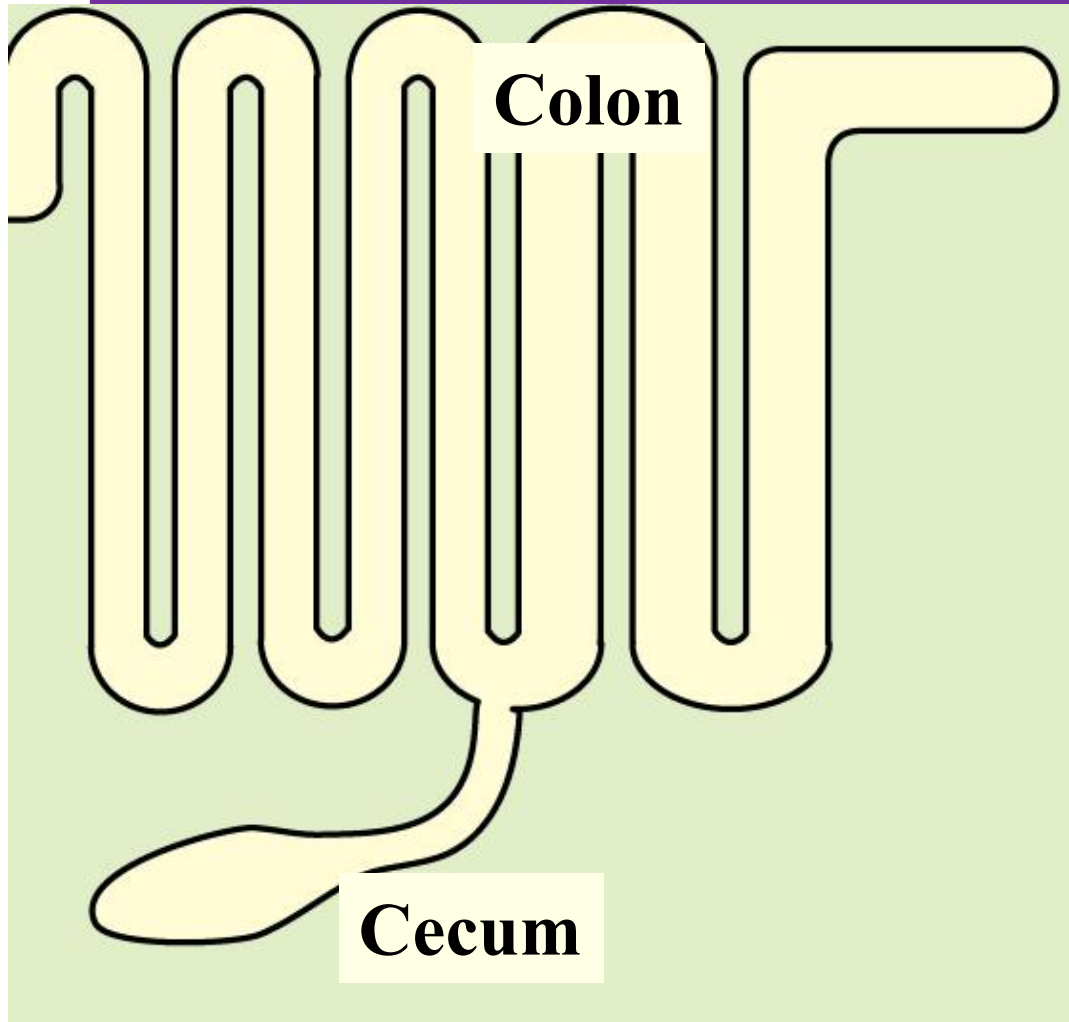
Ruminal pH	5.0 to 5.5
Ruminal lactate	0 to 5 mM
Ruminal VFA	>175 mM

Hind Gut Acidosis

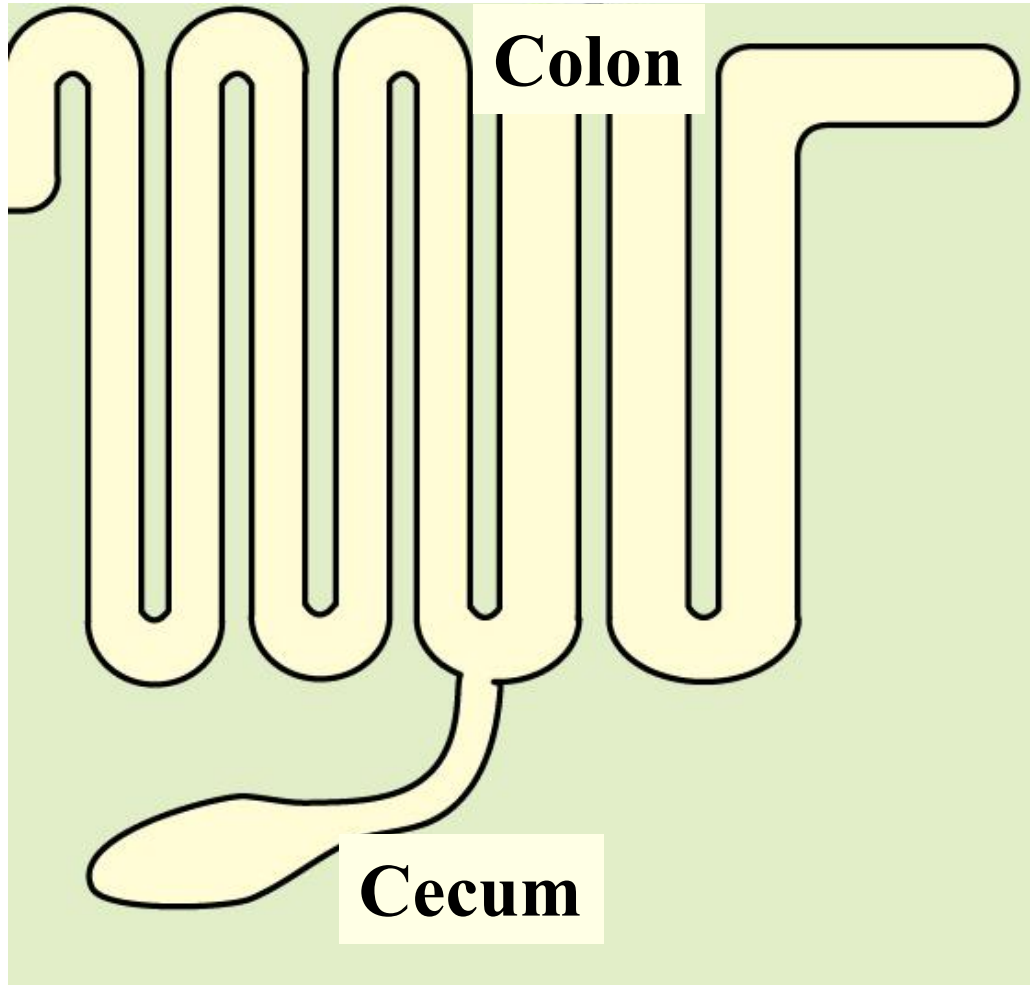


- Increased starch intake leads to increased flow of starch into the hindgut

Hind Gut Acidosis



Hind Gut Acidosis

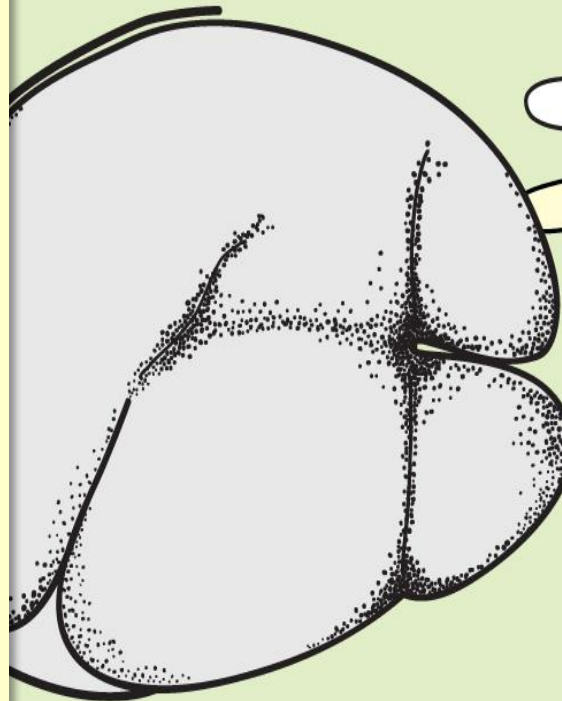


- Hindgut is more susceptible to acidosis than the rumen

Rumen vs. Hindgut Microbial Ecosystem: Physiology

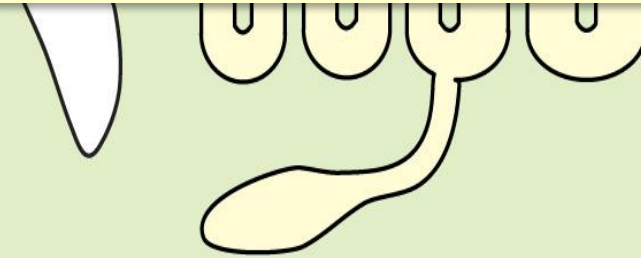
Rumen

- **Good buffering systems**
 - **Saliva**
- **More absorptive surface**
- **Protozoa contribute to buffering system**



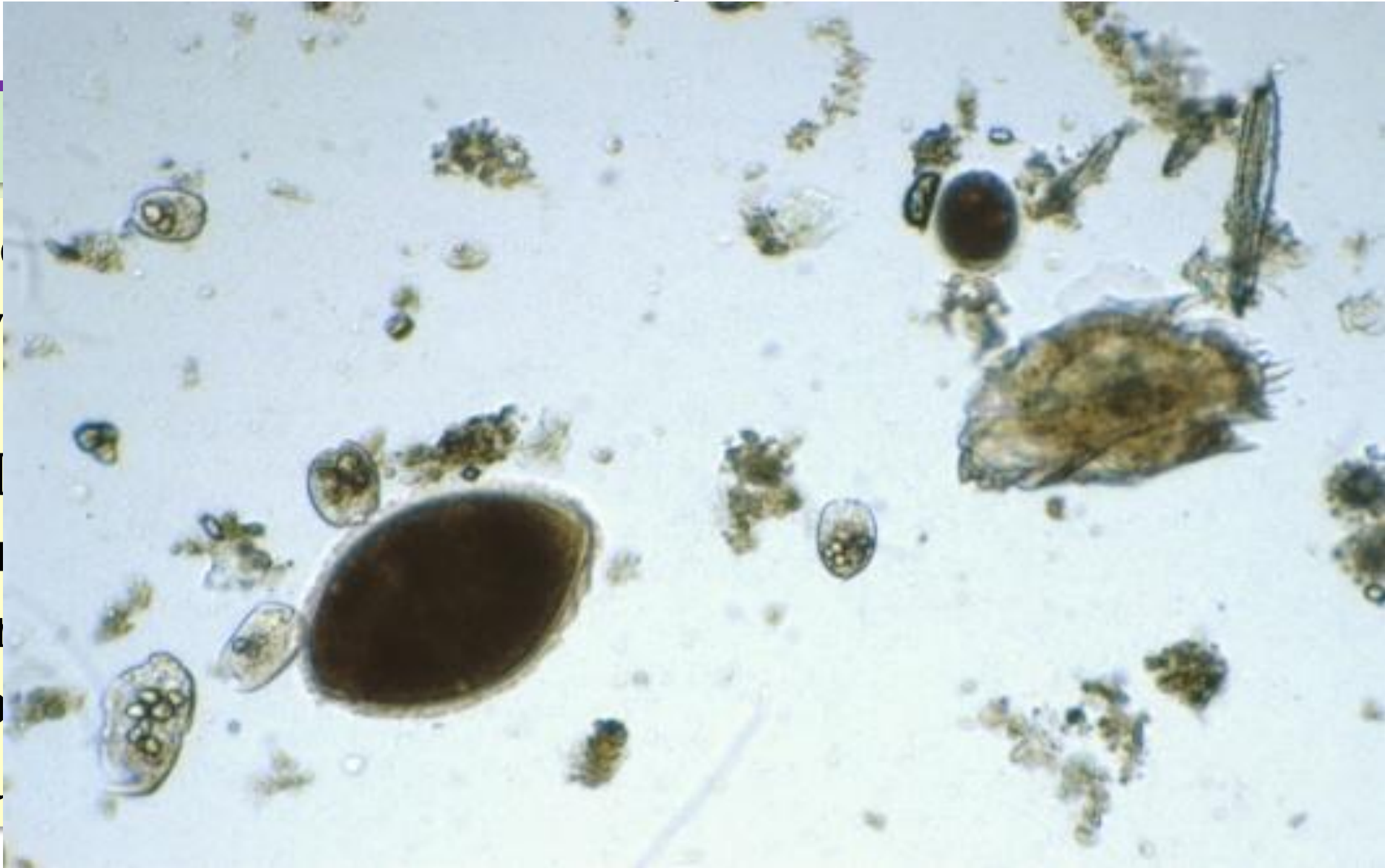
Cecum and Colon

- **Poor buffering systems**
- **Less absorptive surface**
- **No protozoa**



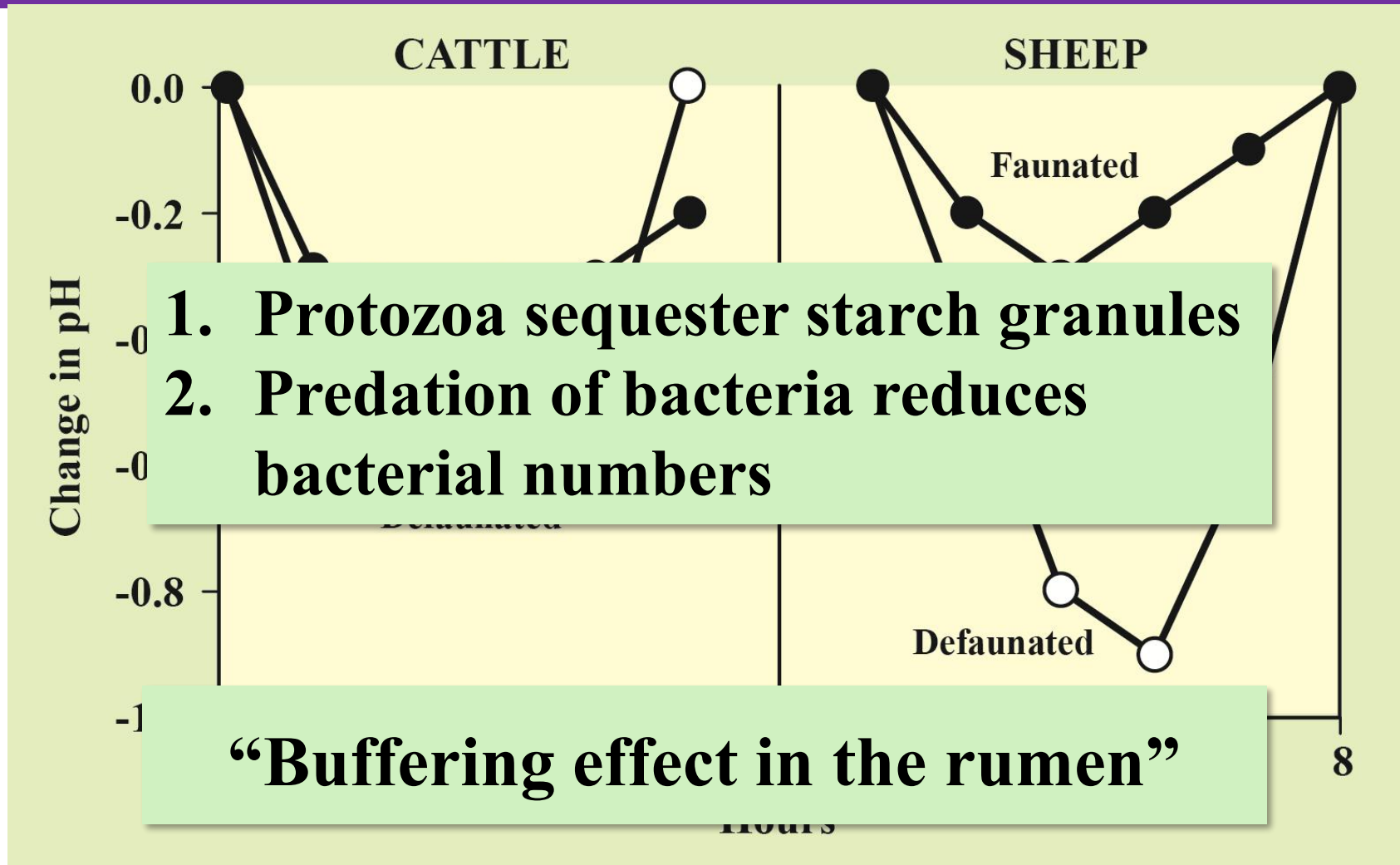
Rumen vs. Hindgut Microbial Ecosystem:

- G
- sy
-
- M
- su
- Pr
- co
- bu

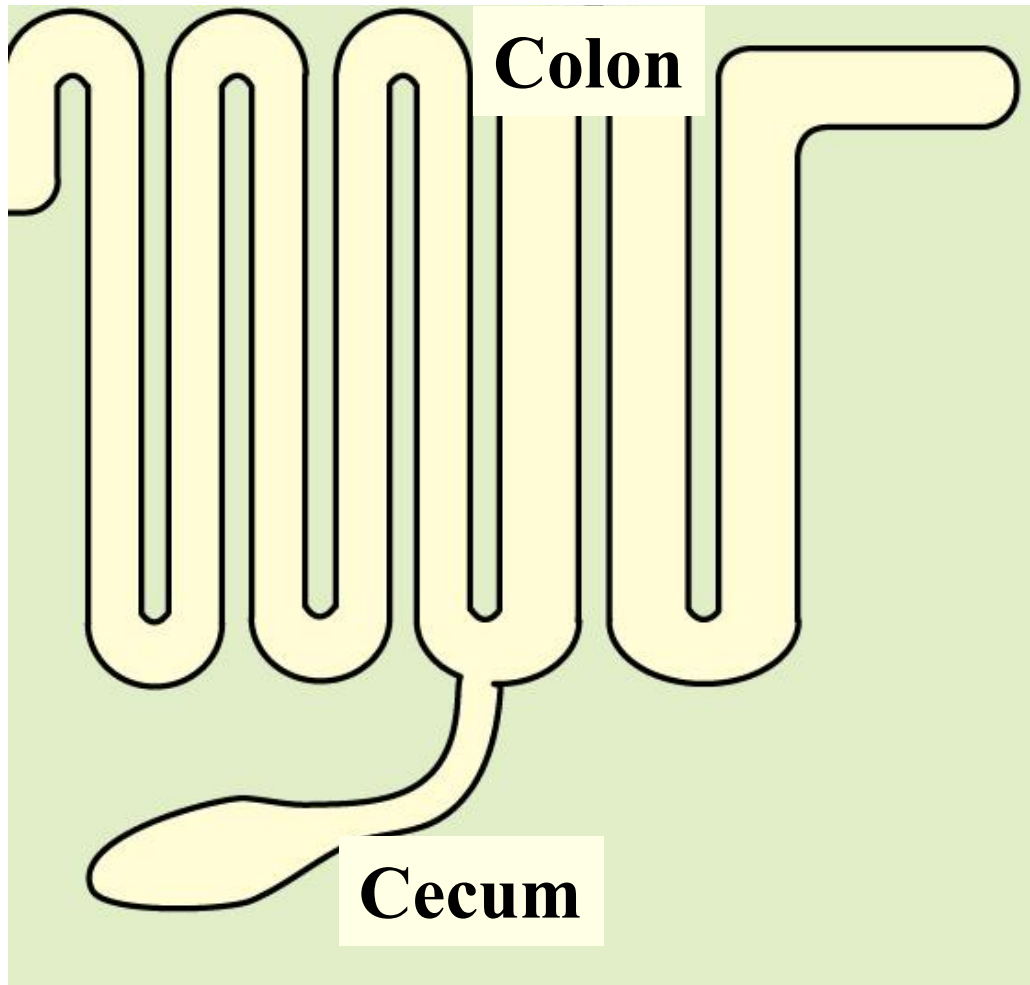


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Post Feeding Ruminal pH Change



Hind Gut Acidosis

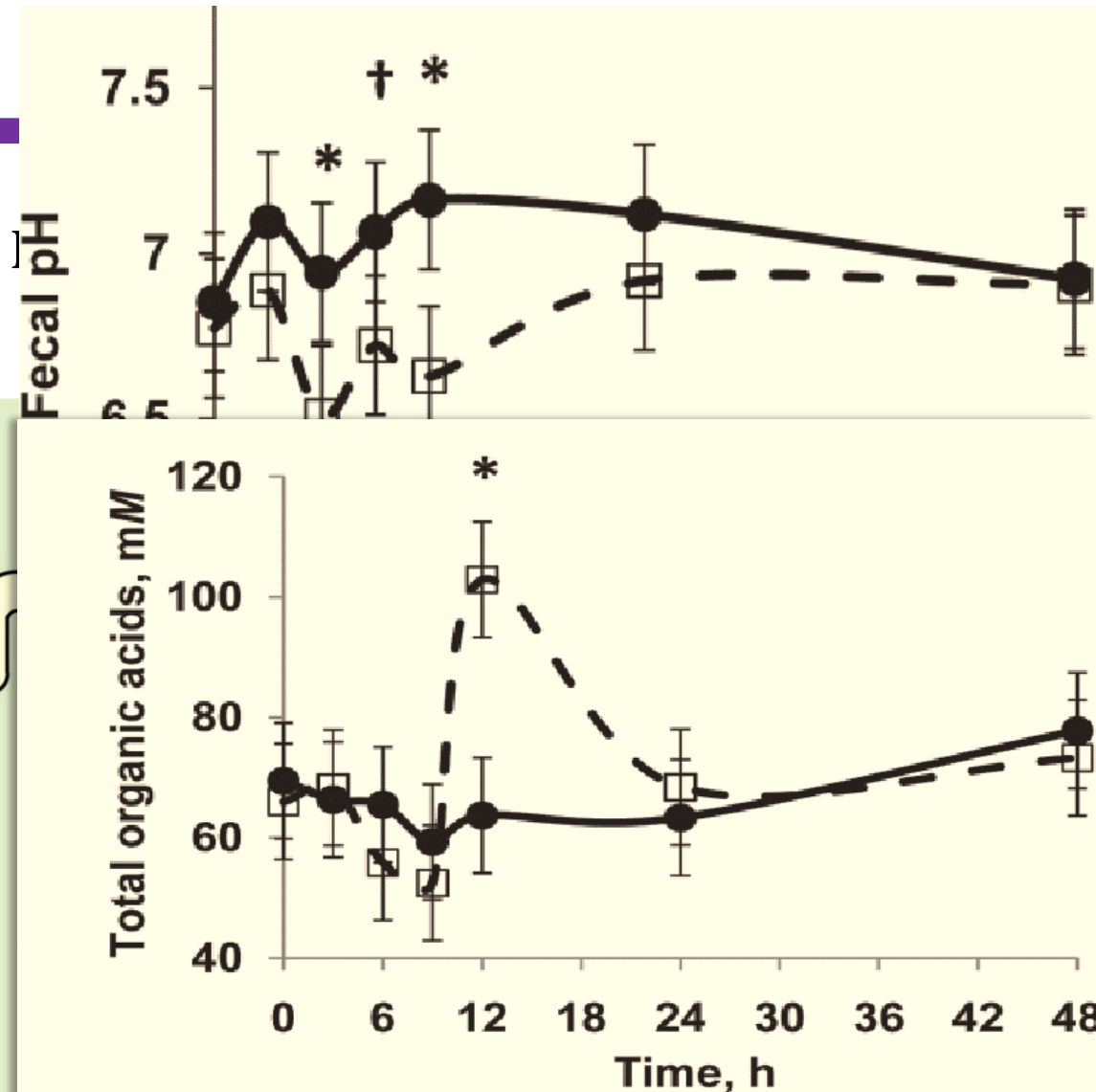
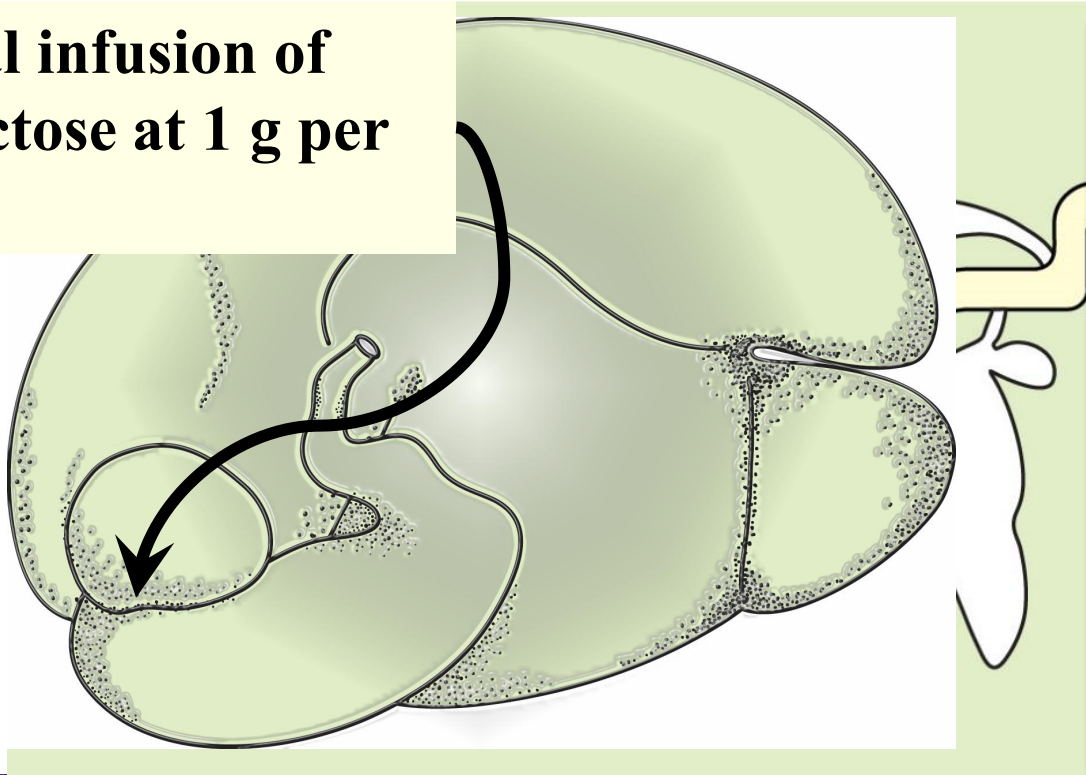


- **Clinical Signs:**
 - **Soupy feces**
 - **Mucin cast in the feces**
 - **Reduced fecal pH**
 - **pH threshold?**
- **Hindgut is always associated with ruminal acidosis**

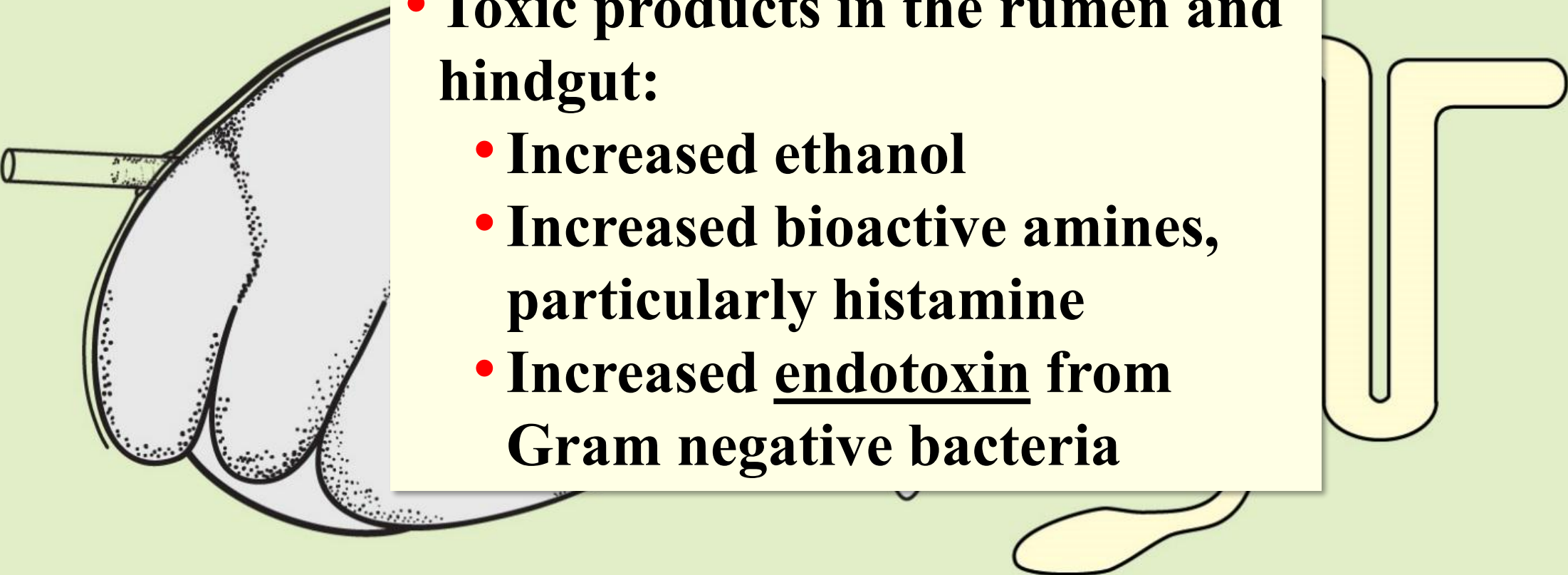
Induction of Hindgut Acidosis

- Hindgut acidosis independent of fecal pH

Abomasal infusion of Oligofructose at 1 g per Kg BW

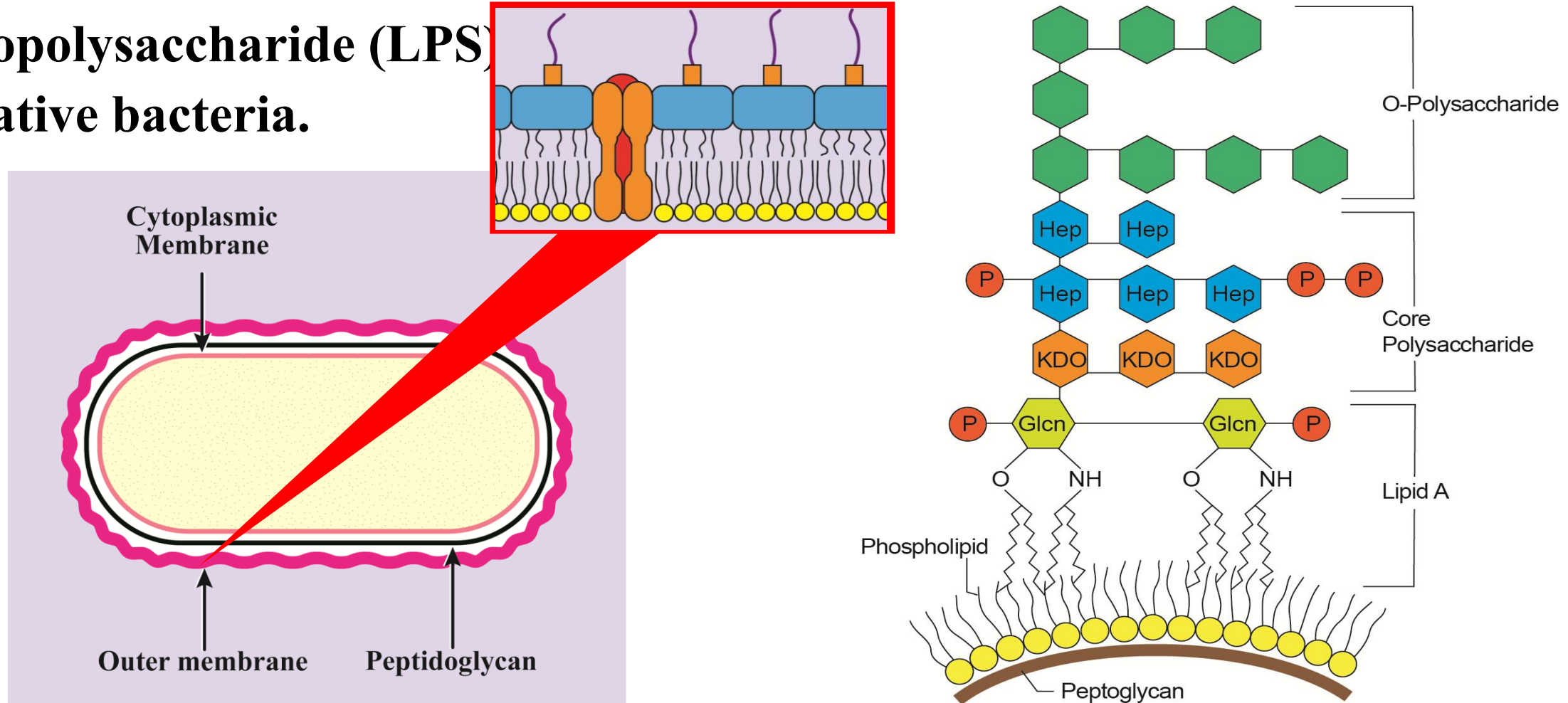


Ruminal and Hindgut Acidosis: Disruption of the Protective Barrier

- 
- Toxic products in the rumen and hindgut:
 - Increased ethanol
 - Increased bioactive amines, particularly histamine
 - Increased endotoxin from Gram negative bacteria

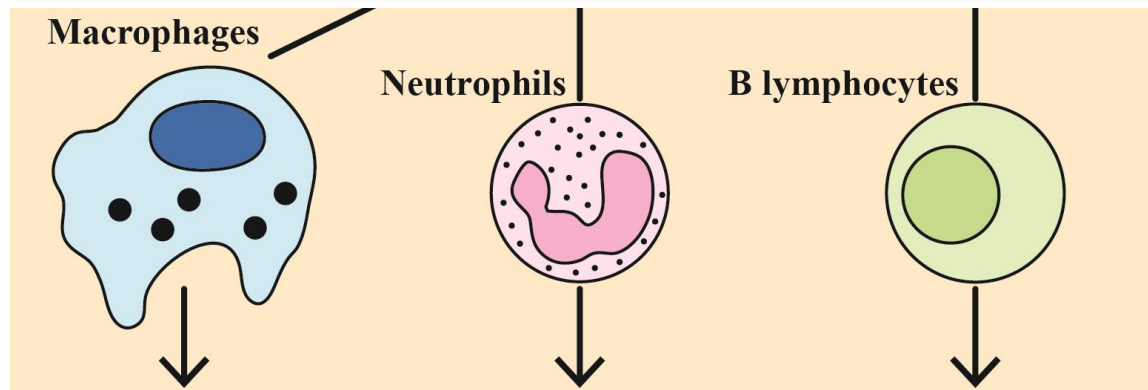
Ruminal Endotoxin

- **Lipopolysaccharide (LPS)** negative bacteria.



Systemic Effects of Endotoxin

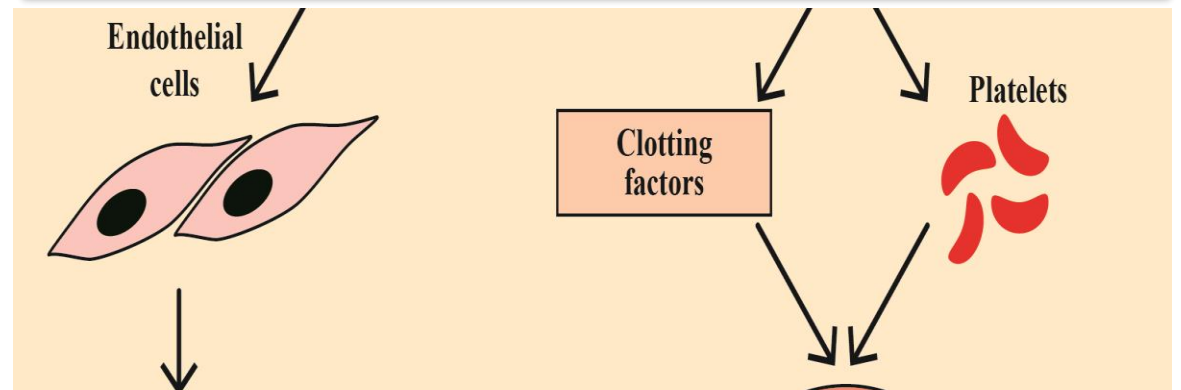
Low Concentration of Endotoxin



Inflammatory Cytokines

Fever, Inflammation

High Concentration of Endotoxin



**Vasodilation,
Shock and Death**

**Disseminated
Intravascular
Coagulation (DIC)**

Endotoxin and Gut Acidosis

Subacute acidosis	Control	Subacute acidosis
Ruminal LPS, EU/mL	10,405	168,391*
Cecal LPS, EU/mL	16,508	118,522*
Plasma LPS, EU/mL	0	0

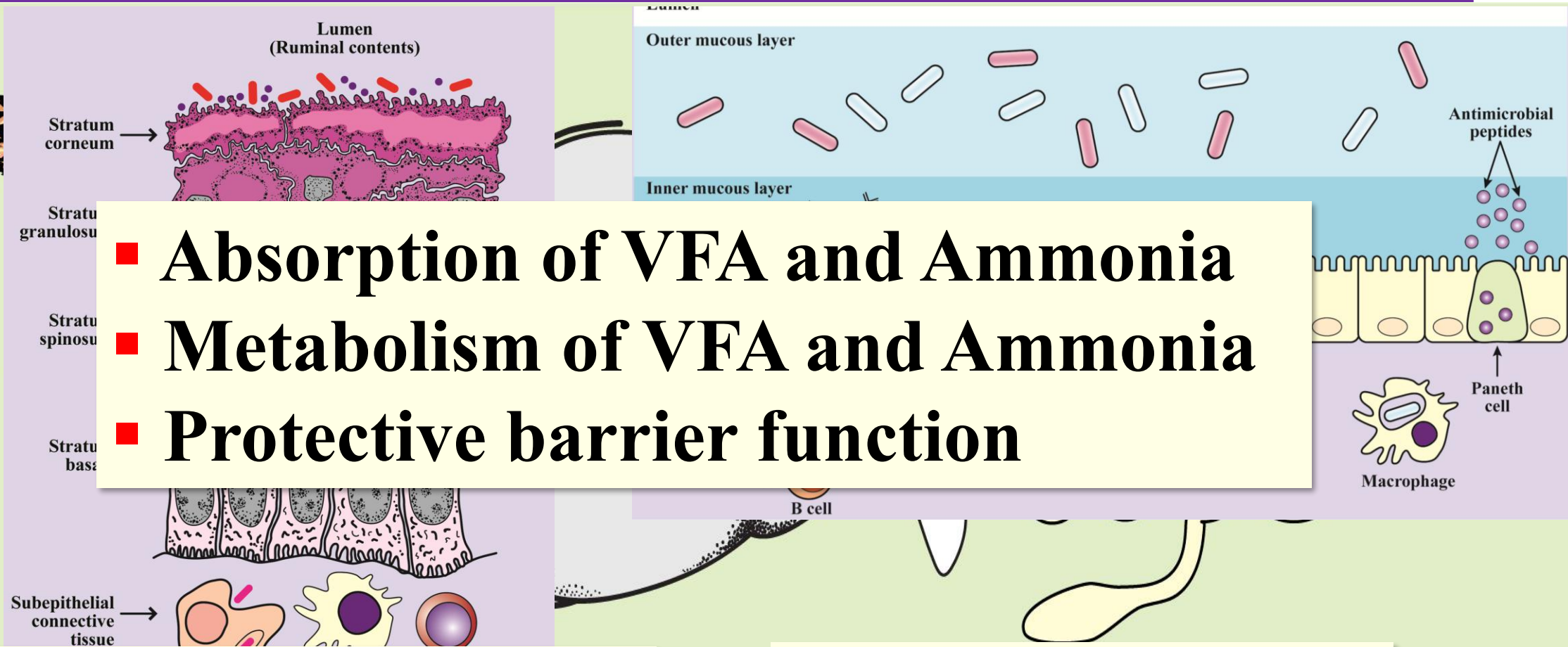
* Different from control ($P < 0.05$)

Acute Phase Proteins and Subacute Acidosis

Acute phase proteins	Control	Subacute acidosis
Serum amyloid A, $\mu\text{g/mL}$	164.4	446.7*
Serum haptoglobin, $\mu\text{g/mL}$	ND	484*
LPS binding protein, $\mu\text{g/L}$	18.2	53.1*

* Different from control ($P < 0.05$)

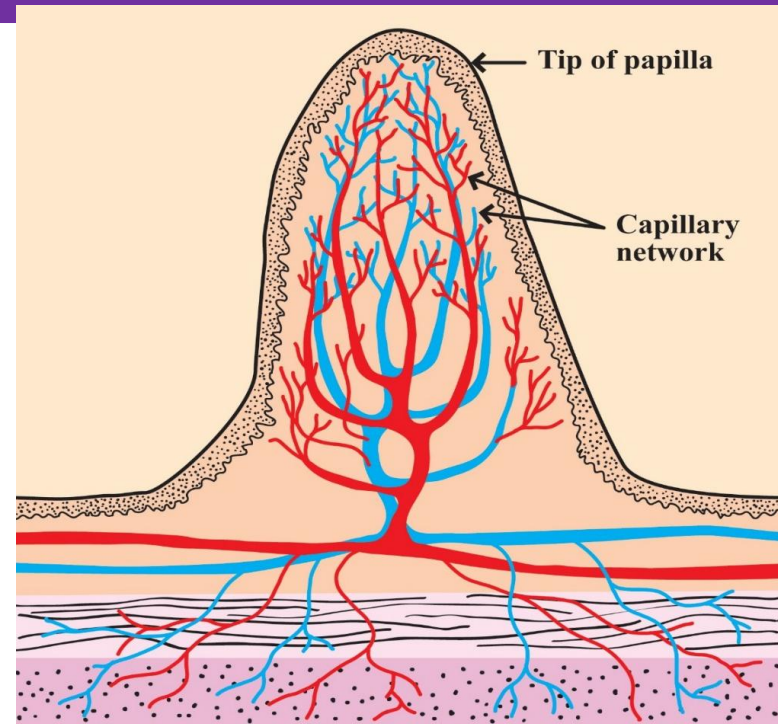
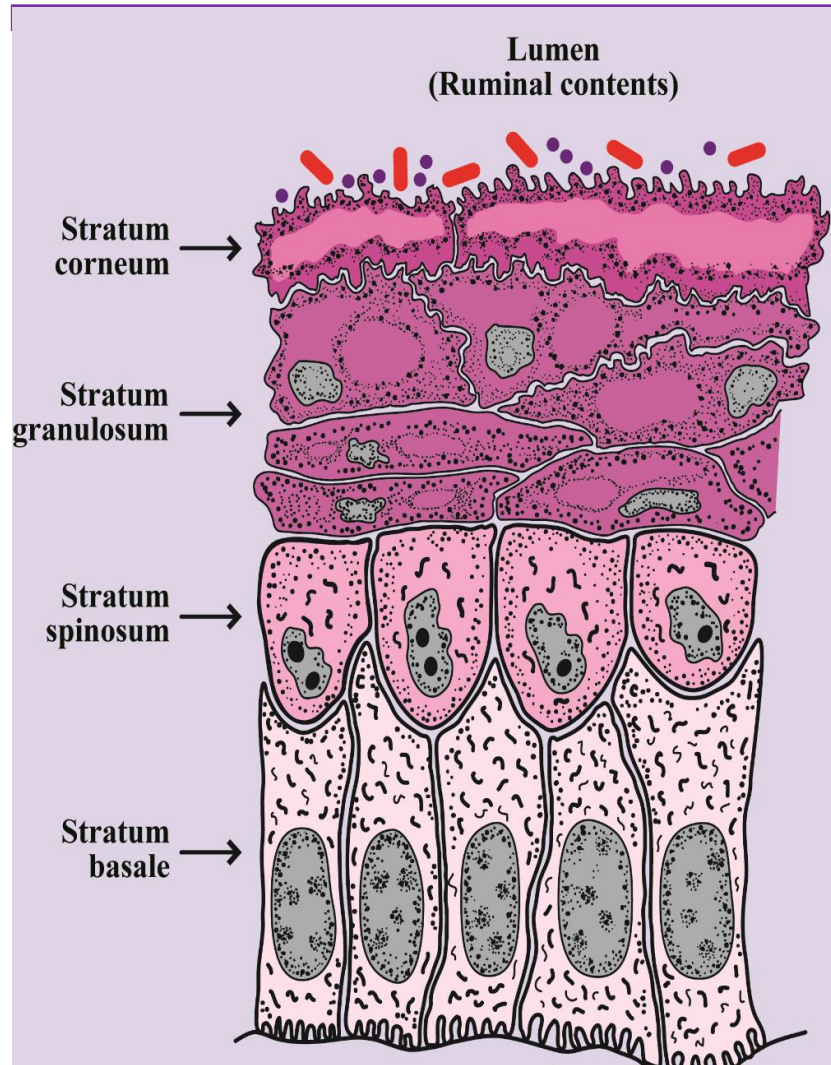
Gut Epithelium Functions



Stratified Squamous Cells

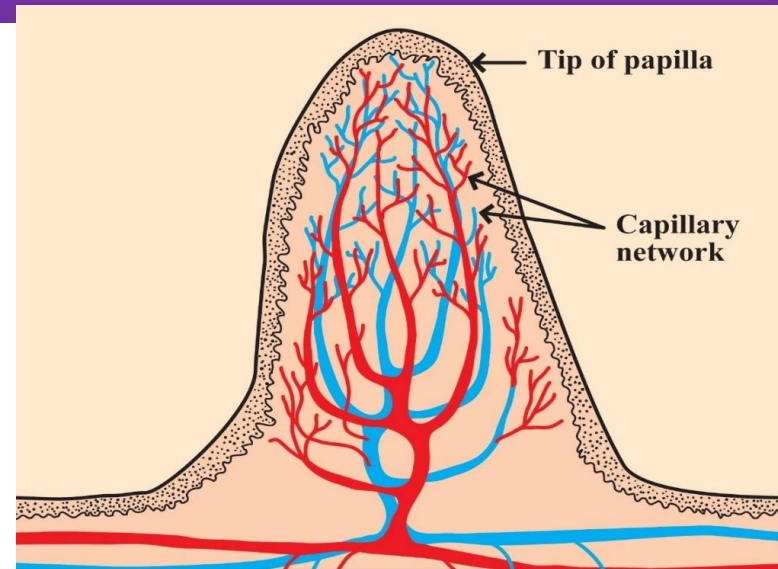
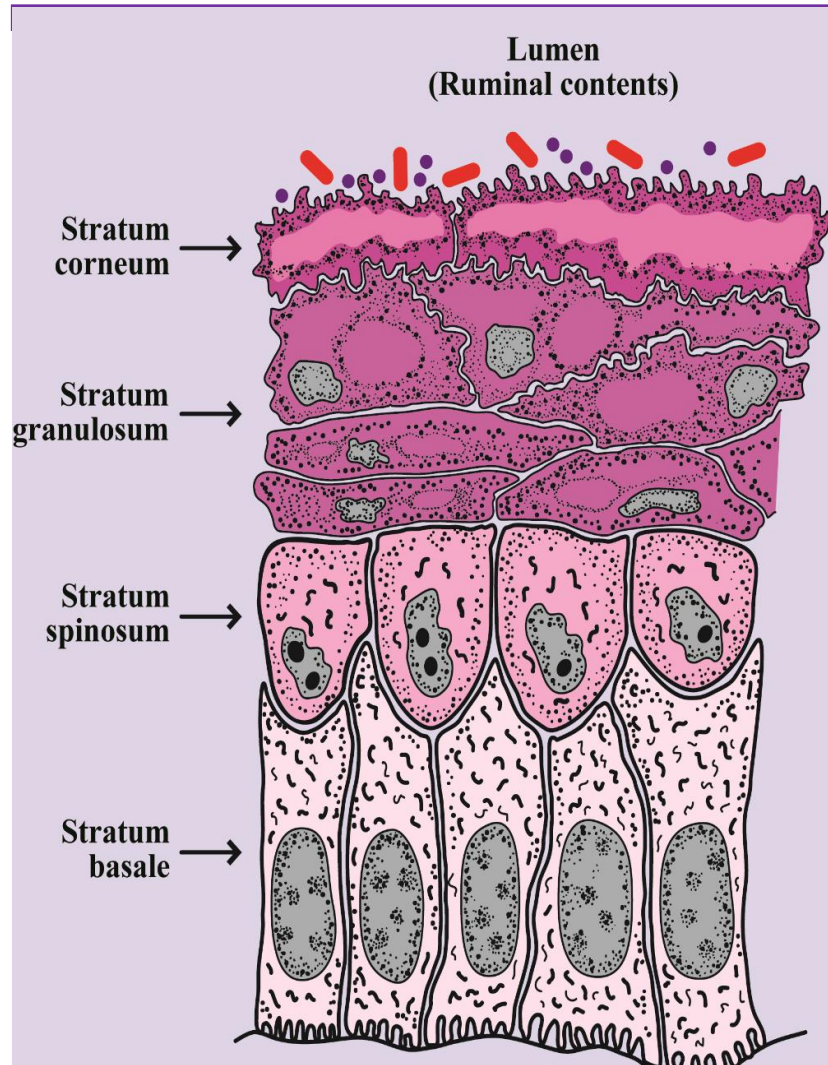
Columnar Cells

Ruminal Epithelium and Papillae



- **Healthy papillae are critical for optimal absorption**

Ruminal Epithelium and Papillae



- Diet has major impact on the papillae. Diet provides:
 - Physical stimulation
 - Chemical stimulation

Feedlot Cattle: High-Grain Diets

Starch

Roughage (6 to 12%)

Digestibility?

**Physical
effectiveness!**

Feedlot Cattle: High-Grain Diets

Starch

Fiber

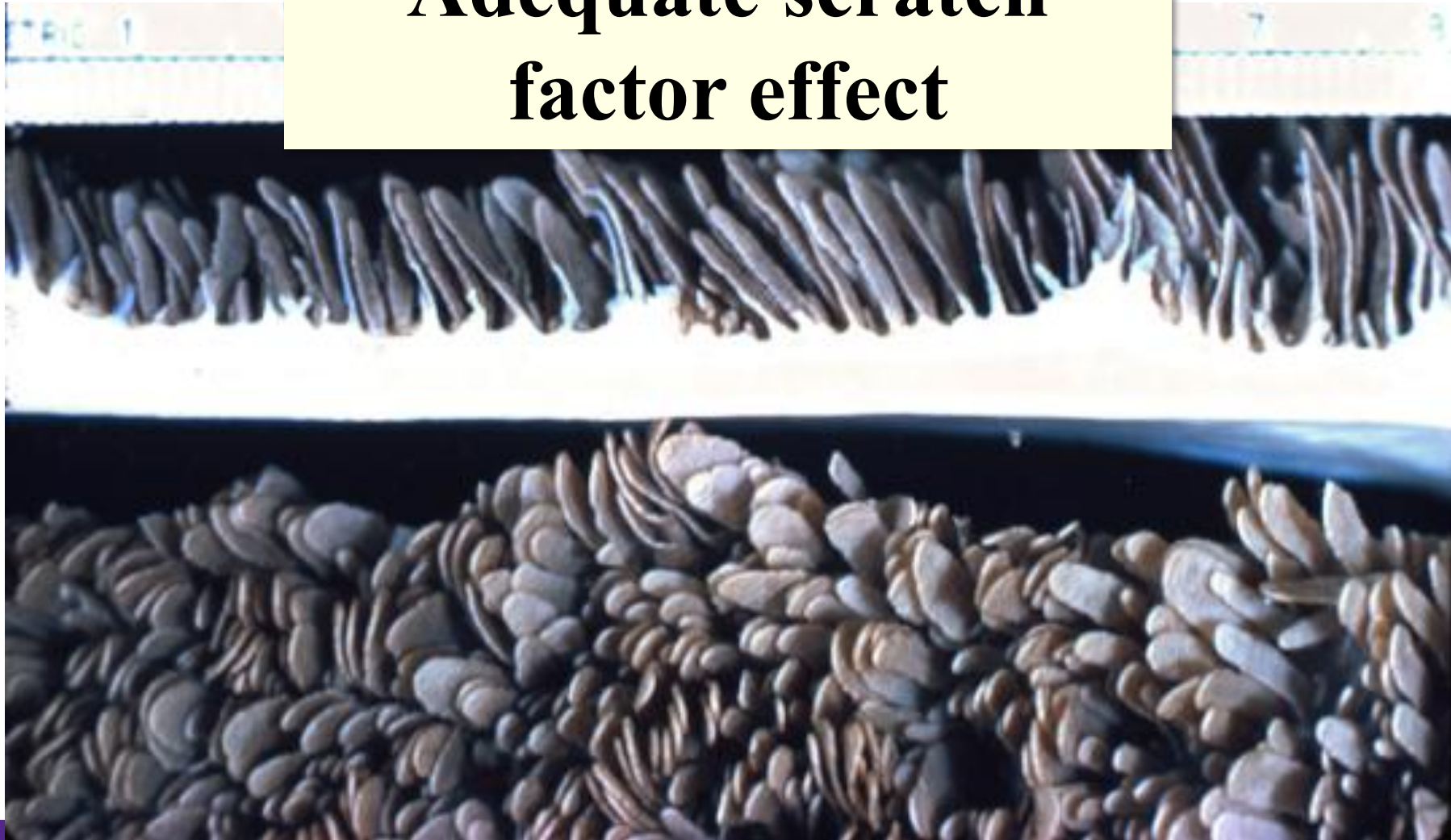
Salivation

Motility

**Scratch Factor
Effect**

Forage-Fed Cattle

**Adequate scratch
factor effect**

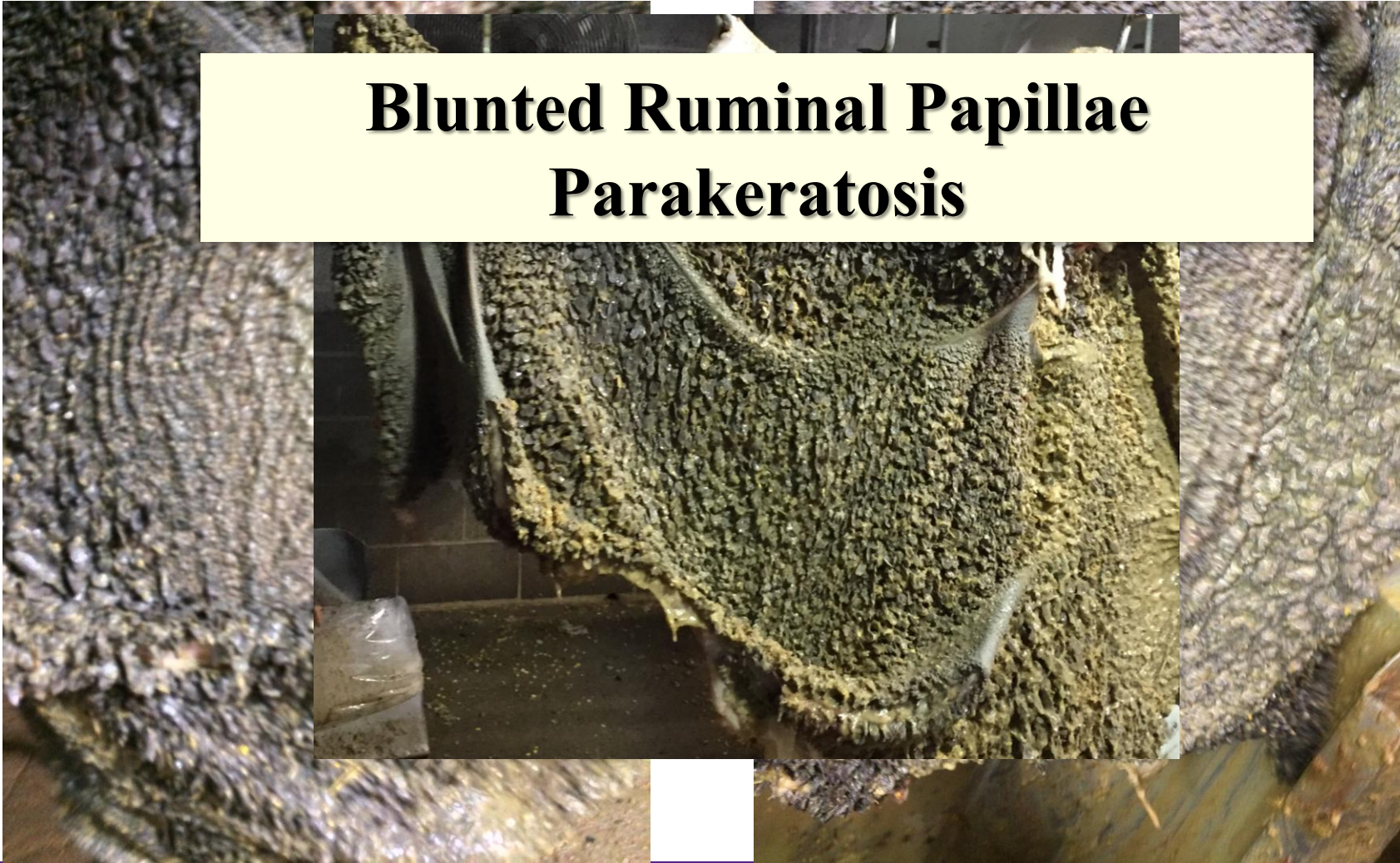


High-Grain Fed cattle

Lack of scratch factor effect



Ruminal Papillae and High-Grain Diets



Blunted Ruminal Papillae Parakeratosis

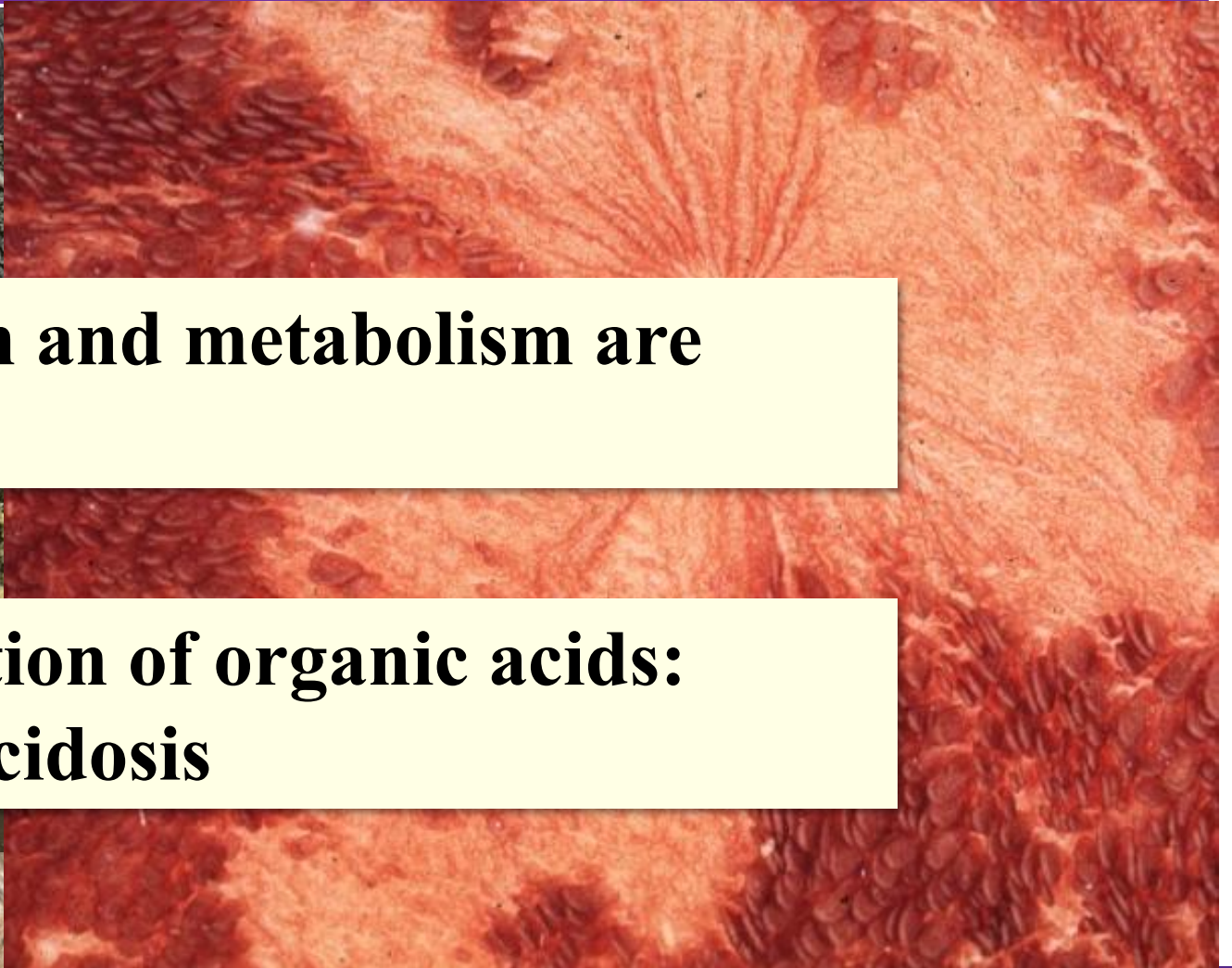
Ruminal Papillae and High-Grain Diets



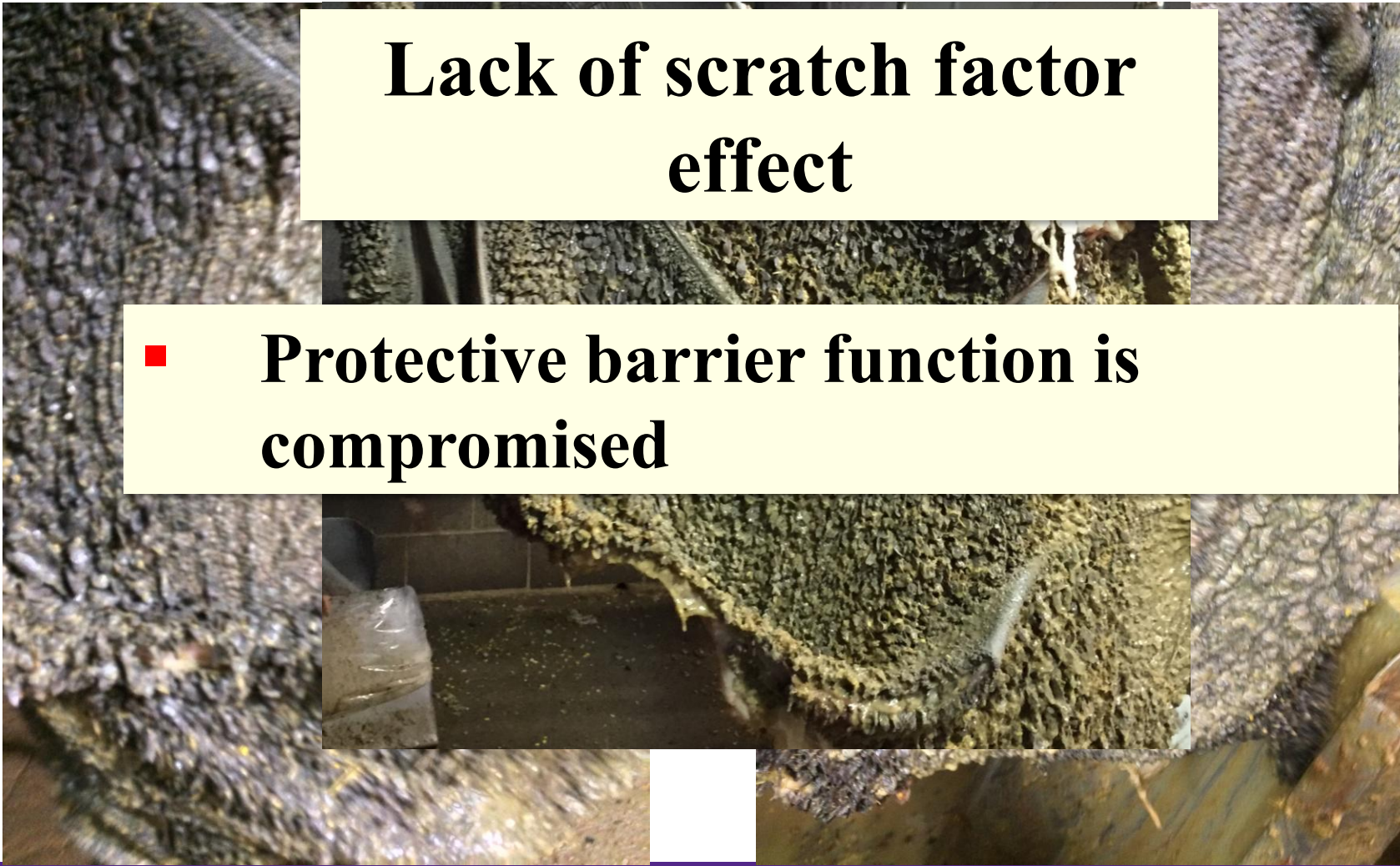
- Absorption and metabolism are impaired



- Accumulation of organic acids:
Ruminal acidosis



Ruminal Papillae and High-Grain Diets

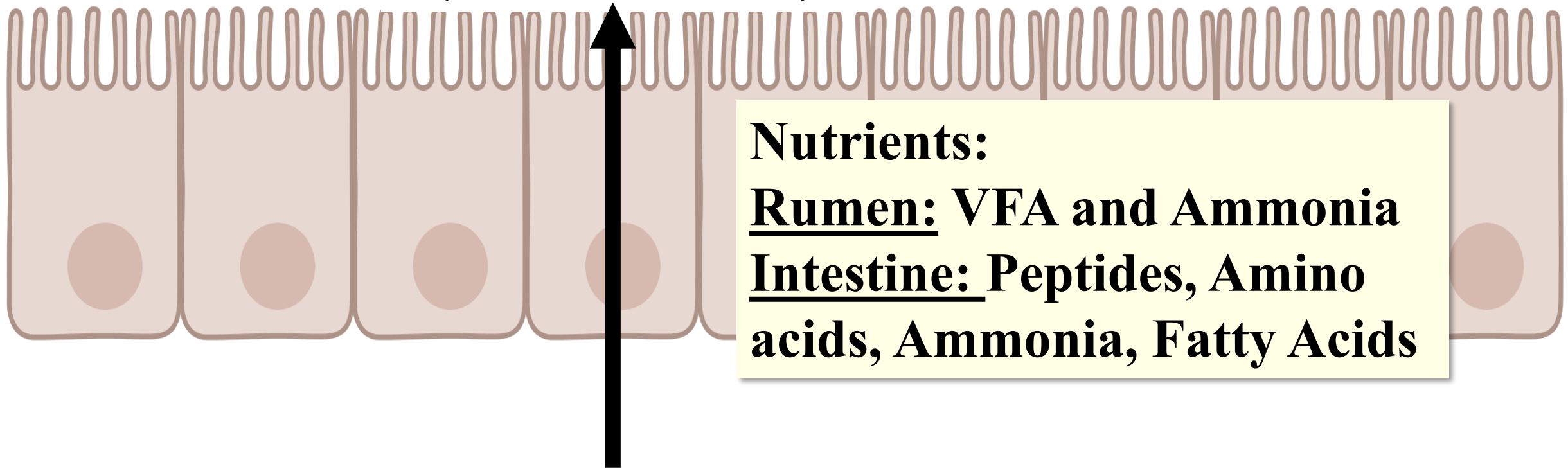


Lack of scratch factor effect

- **Protective barrier function is compromised**

Gut Permeability

**Through the cells
(Transcellular)**



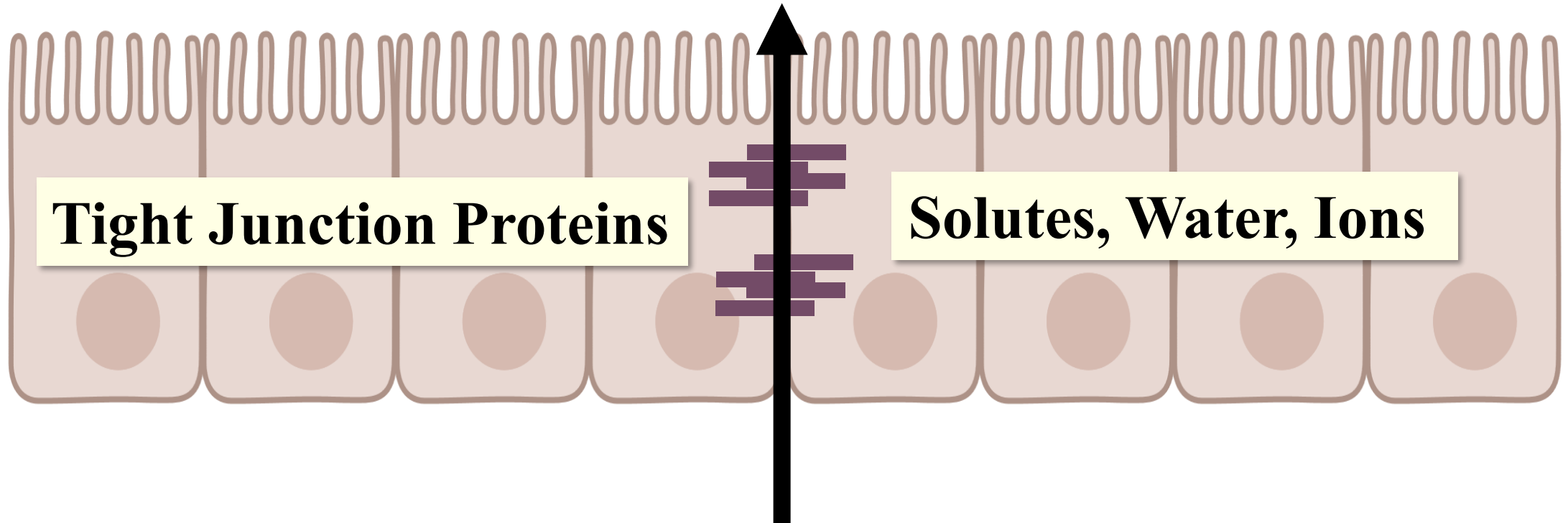
Nutrients:

Rumen: VFA and Ammonia

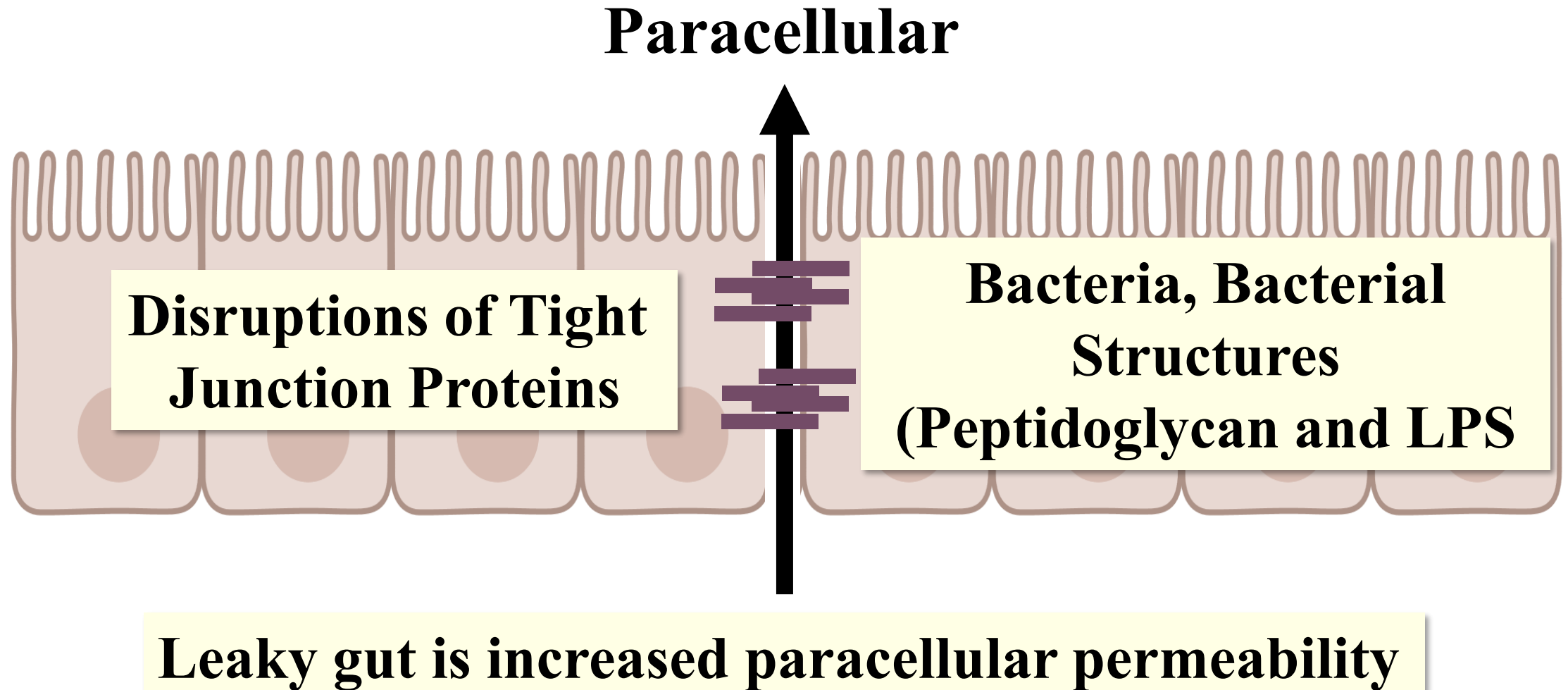
Intestine: Peptides, Amino acids, Ammonia, Fatty Acids

Gut Permeability

In between the cells
Paracellular



Gut Permeability

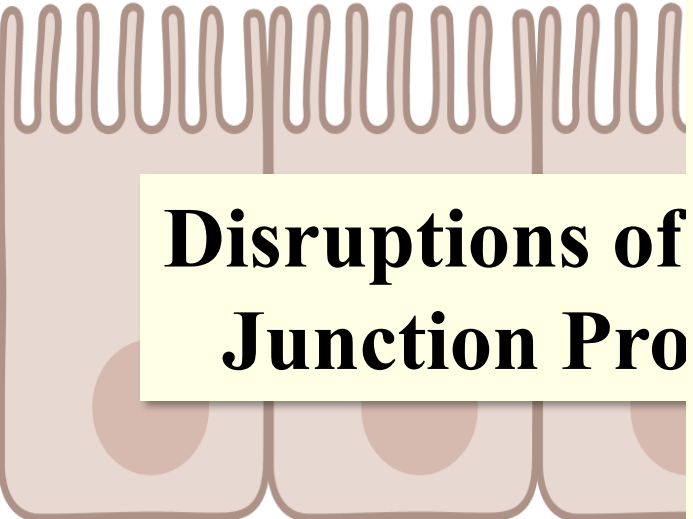


Gut Permeability

Paracellular

Short-term stressors: Weaning, comingling, transportation, fasting, overcrowding, heat, acute acidosis, and diseases

Long-term stressors: Subacute and Chronic acidosis

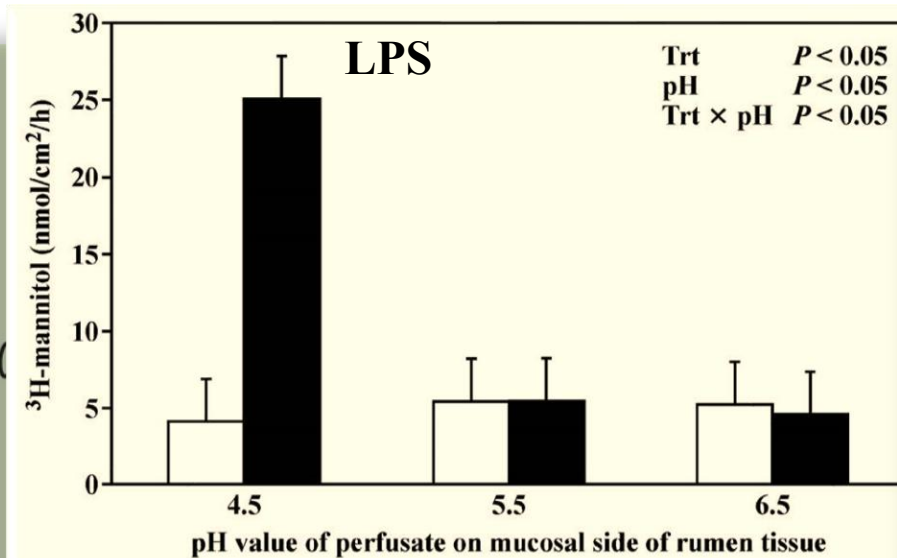


Disruptions of Junction Pro

Leaky gut is increased paracellular permeability

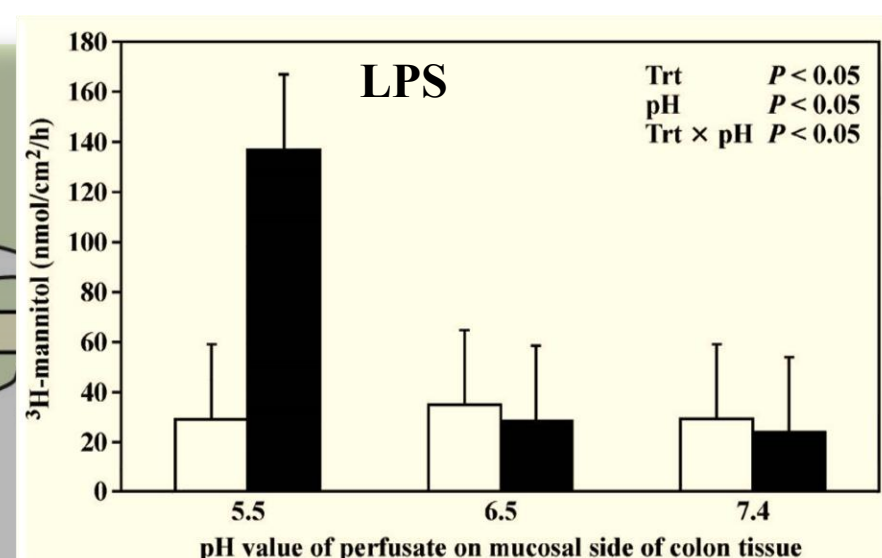
Acidosis and LPS on Gut Epithelial Permeability

Rumen



Ruminal Acidosis

Colon

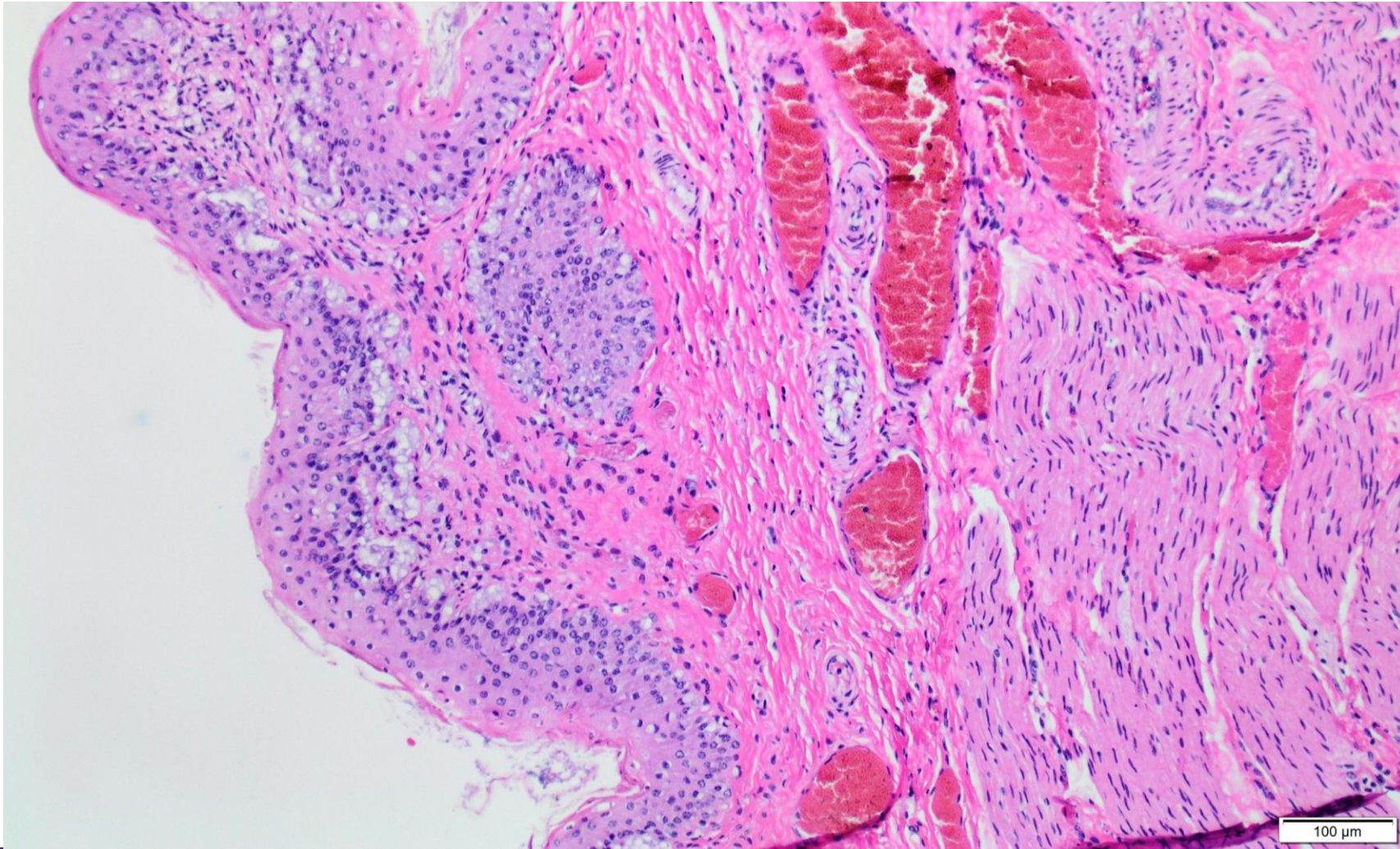


Hindgut Acidosis

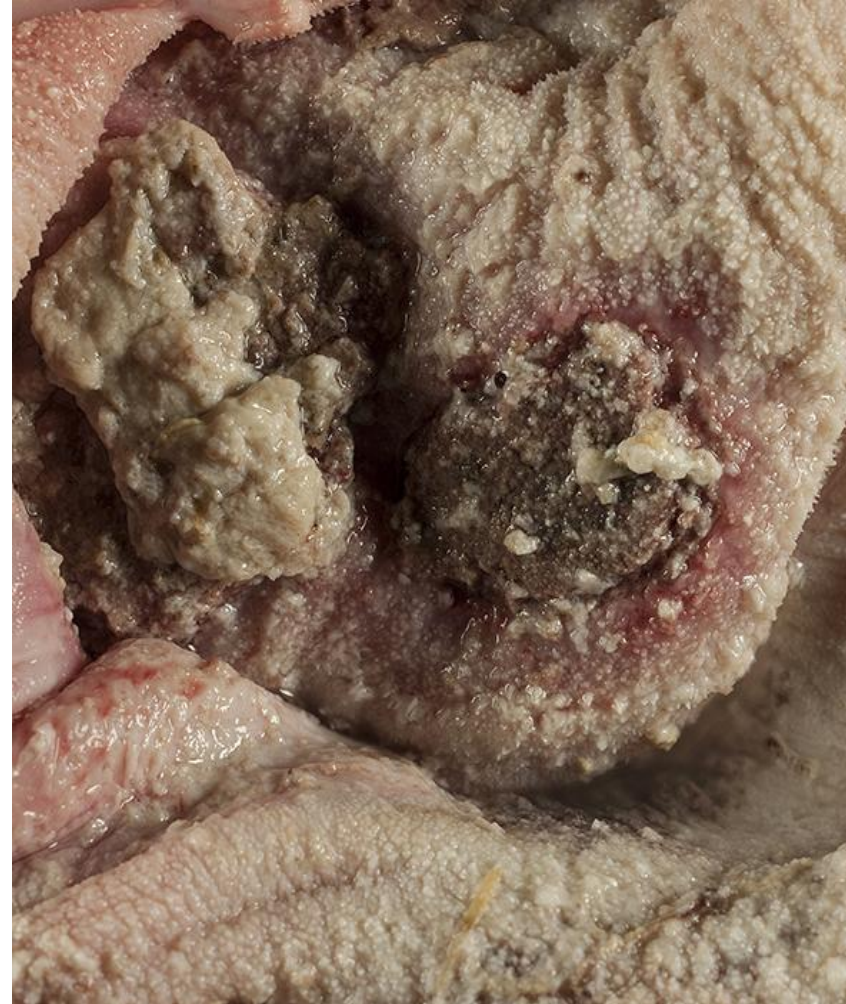
Rumenitis



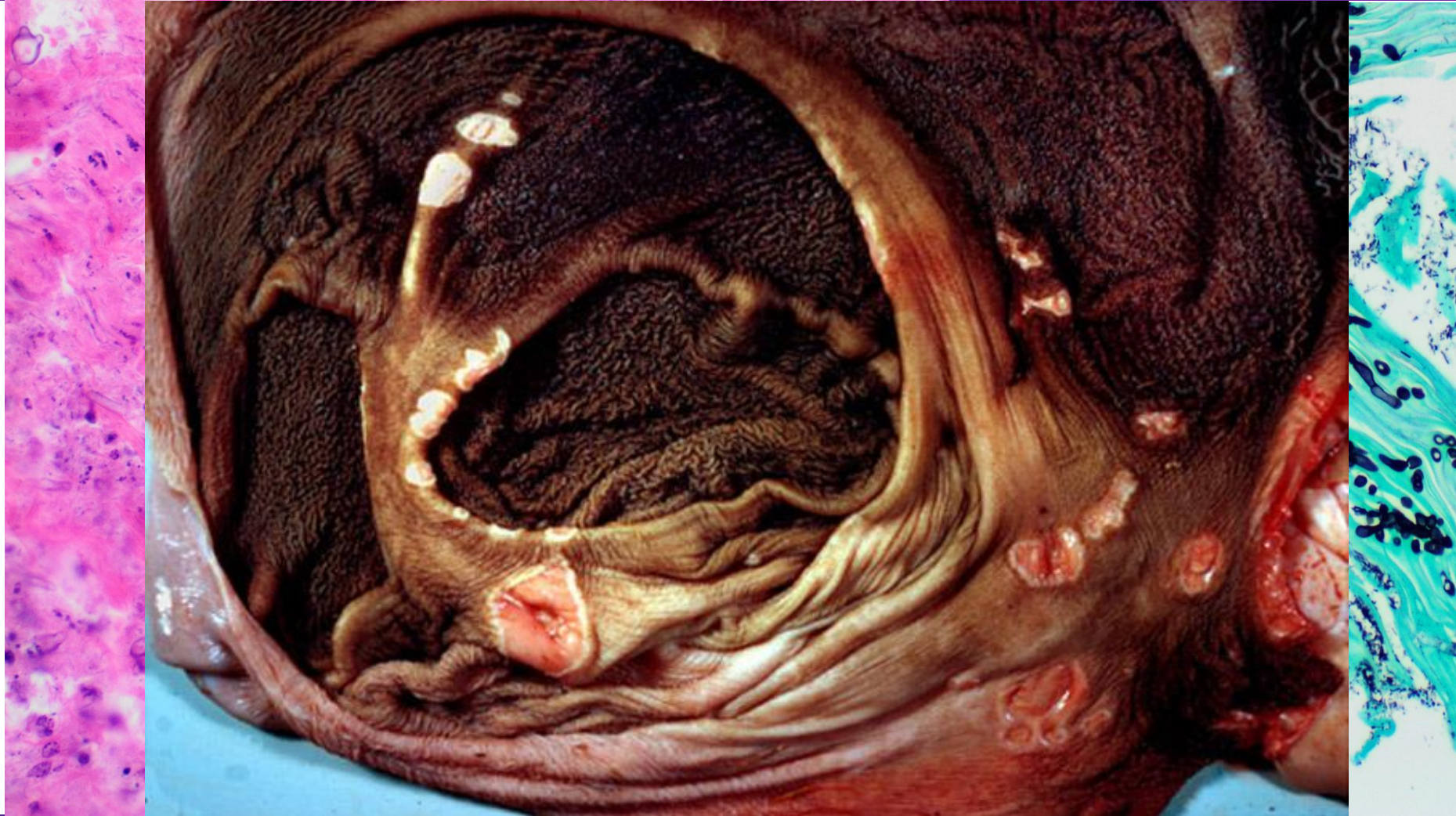
Congestion and Edema



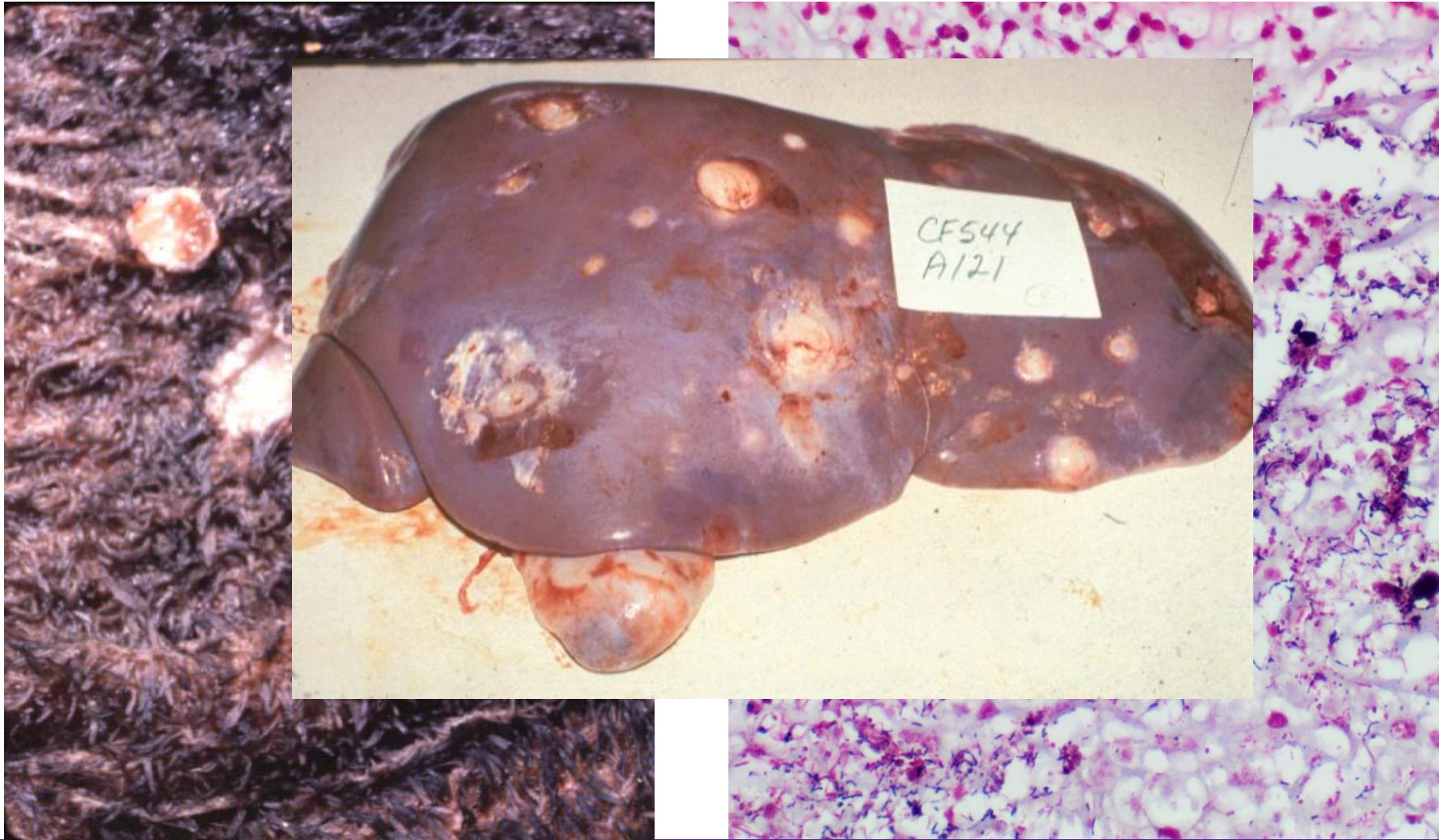
Mycotic Rumenitis



Mycotic Rumenitis

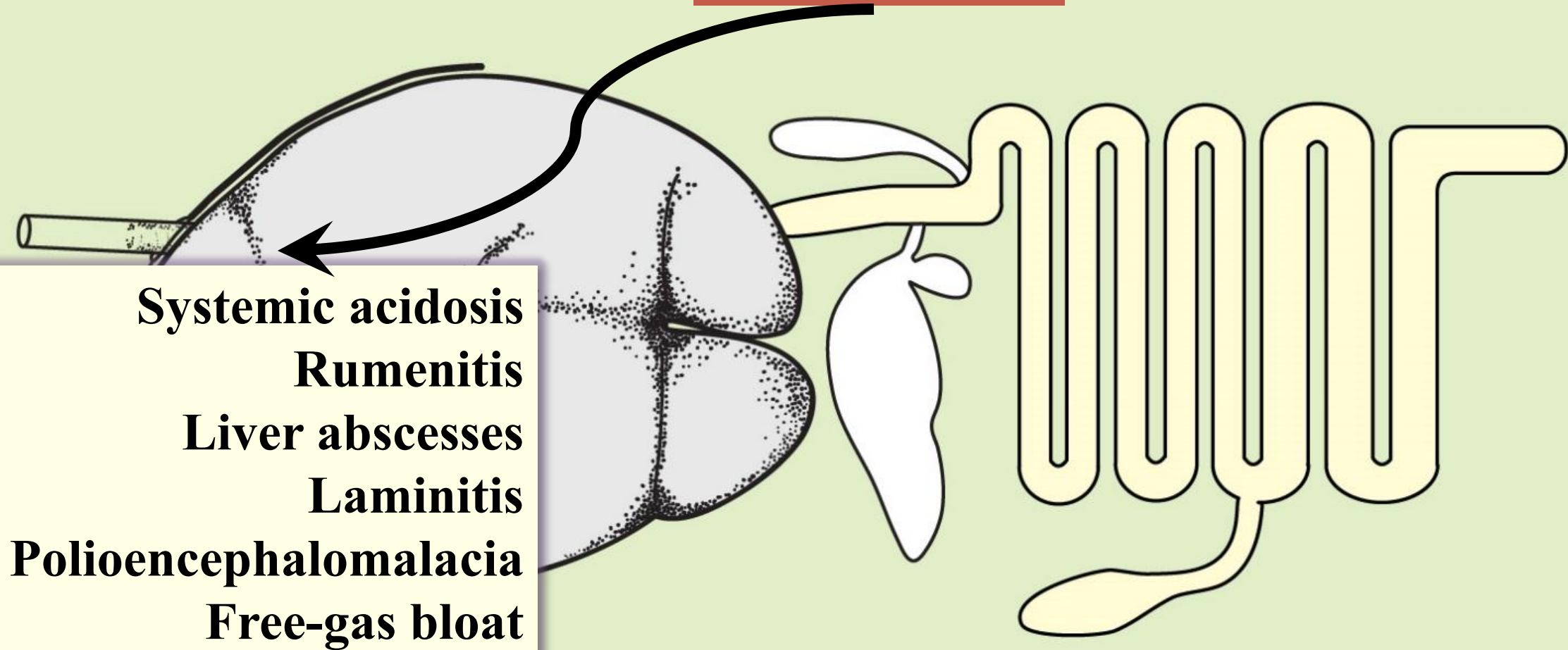


Bacterial Rumenitis



Ruminal and Hindgut Acidosis: Sequelae

Gut Acidosis



Obrigado pela sua atenção!