COURSE TITLE: Animal Production

SECTION: Principles of Animal Nutrition

COURSE CODE: VETM1111

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Lecture 3

6. Course Objectives

List of Topics

Part 1: Principles of Animal Nutrition

- 1.1 The Animal and its Food
- 1.2 Comparison of the Digestive Systems in Farm Animals and their practical implications in the feeding of Animals and the Balancing of Rations
- 1.3 What is a Feed?
- 1.4 Components of Feeds/ Feed Nutrients
    - 1.4.1 Lipids/Fats
    - 1.4.2 Carbohydrates [Soluble (Sugars), Starches, Structural (Fibre)]
    - 1.4.3 Proteins
        - 1.4.3.1 Animal Acids
        - 1.4.3.2 True Proteins
        - 1.4.3.3 Non Protein Nitrogen
    - 1.4.4 Vitamins
        - 1.4.4.1 Fat Soluble Vitamins
        - 1.4.4.2 Water Soluble Vitamins
    - 1.4.5 Minerals
        - 1.4.5.1 Macro Minerals
        - 1.4.5.2 Micro Minerals
    - 1.4.6 Water
- 1.5 Classification of Feeds and Feedstuffs with particular reference to the Caribbean Region
- 1.6 Feed Additives
    - 1.6.1 Probiotics
    - 1.6.2 Essential Amino Acids
- 1.7 Ideal Protein Concept
- 1.8 Anti Nutritional Factors
- 1.9 What is a Ration?
- 1.10 Evaluation of Foods and Feeds:
    - 1.10.1 Chemical Composition
    - 1.10.2 Digestibility
    - 1.10.3 Energy Content
    - 1.10.4 Partitioning of Feed Energy within the Animal
    - 1.10.5 Systems of expressing the Energy Value of Feeds
    - 1.10.6 Feed Protein
- 1.11 Feed Intake
    - 1.11.1 As Fed
    - 1.11.2 Dry Matter
    - 1.11.3 Voluntary Feed Intake
- 1.12 Feeding Standards
- 1.13 Ration Formulation
    - 1.12.1 Monogastrics
    - 1.12.2 Ruminants
- 1.14 Feed Conversion Ratio
- 1.15 Feed Conversion Efficiency
- 1.16 Economics of Feeding Animals

1.5 Classification of Feeds and Feedstuffs with particular reference to the Caribbean Region

NRC classification of Feedstuffs

- Pasture, green forages and range plants
- Dry roughages and forages (hay, straw, hulls)
- Silages (corn, legume, grass)
- Energy or basal feeds (cereals grains, mill by products, roots)
- Protein supplements (animal, marine, avian, plant)
- Mineral supplements
- Vitamin supplements
- Nonnutritive additives (antibiotics, colors, flavors, hormones)
- Complete Feeds

When describing feedstuffs consider ……..

- origin
- species
- part utilized
- stage of maturity
- processes/treatment
- cutting or crop
- grade/quality
- classification

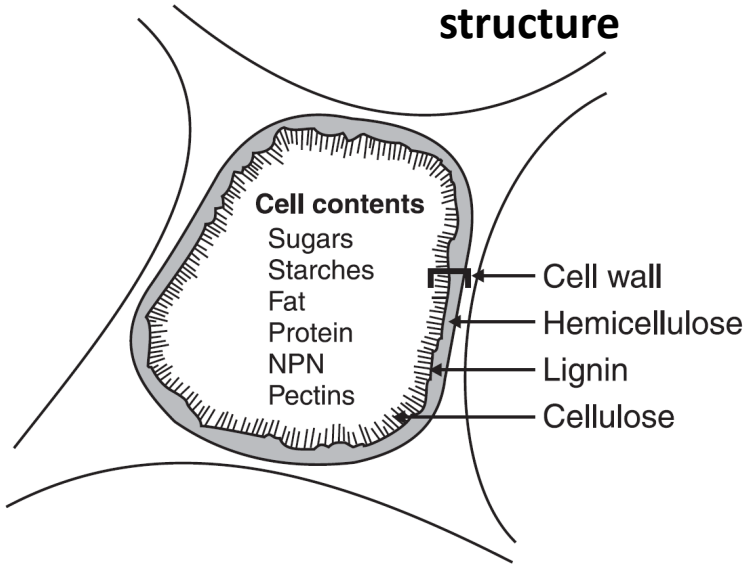
Forages

- fed fresh, dried or ensiled
- provided energy and >18% crude fibre
- ⬇ digestibility; due to lignin
- Minerals - Ca, K and some trace minerals
- variable protein/fat content
- high vs low quality
- range vs zero grazing
- included in all balanced rations

✦ *Bracharia arrecta* (tanner grass)

✦ Bracharia sp. (mulato)

Plant cell showing cell wall structure



Schroeder, JW. 2010. Forage Nutrition for Ruminants. North Dakota State University Extension Service

Classification of forage fractions using the Van Soest method

Fraction	Components included	Nutritional Availability	
		Ruminant	Non-ruminant
Cell contents	• sugars, starch, pectin	complete	complete
	• soluble carbohydrates	complete	complete
	• protein, non-protein N	high	high
	• lipids (fats)	high	high
	• other solubles	high	high
Cell Wall (NDF)	• hemicellulose	partial	low
	• cellulose	partial	low
	• heat damaged protein	indigestible	indigestible
	• lignin	indigestible	indigestible
	• silica	indigestible	indigestible

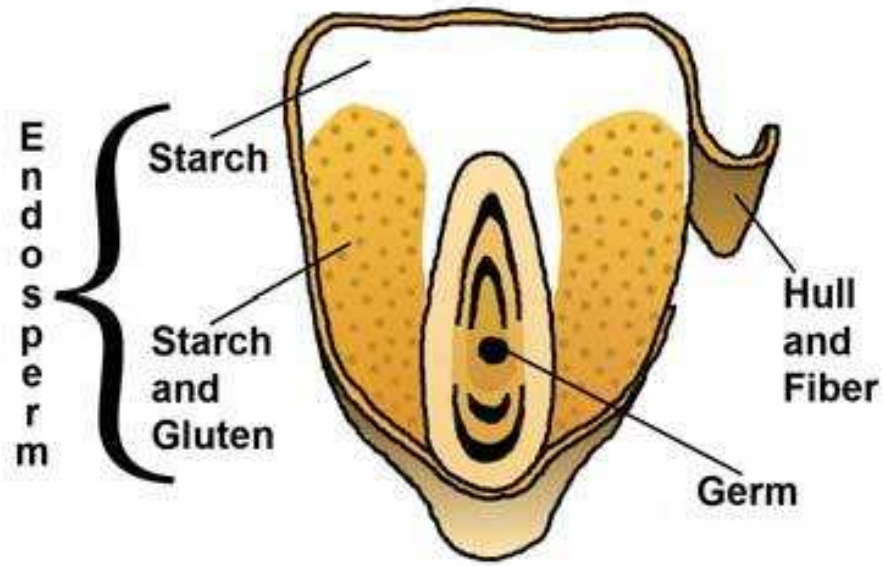
Source: Van Soest, JAS 26:119.

Schroeder, JW. 2010. Forage Nutrition for Ruminants. North Dakota State University Extension Service

Grains

- seeds from cereal plants – (corn, oats, sorghum, rice and wheat)
- provides energy
- < 18% crude fiber and < 20% protein
- up to 85% CHOs and 6% fat

A corn seed



wikis.lib.ncsu.edu

Protein supplements

- contains > 20% protein
- soyabean meal……
- animal by-products; poultry, fish
- monogastric vs ruminant
- consider non protein nitrogen (NPN)
  (urea, ammoniated products)

Fish meal anambrayouthfarmers.blogspot.com

The effect of species and cutting intervals (weeks) on biomass, DM and CP yield (kg/ha) of *Gliricidia sepium*, *Leucaena leucocephala* and *Trichanthera gigantea* at UFS

SPECIES	Cutting Intervals (Weeks)	Fresh Biomass Yield (kg/ha)	DM Yield (kg/ha)	Crude Protein Yield (kg/ha)
G. sepium	6	9,653[a]	8,607[a]	2,799[a]
	8	14,516[a]	12,764[a]	3,951[a]
	12	16,440[a]	15,030[a]	4,203[a]
L. *leucocephala*				
	6	2,001[b]	1,809[b]	638[b]
	8	4,137[b]	3,755[b]	1,255[b]
	12	4,821[b]	4,446[b]	1,301[b]
T. gigantea				
	6	5,564[c]	4,775[c]	1,264[c]
	8	10,331[c]	9,052[c]	2,224[c]
	12	11,314[c]	9,992[c]	2,218[c]
Specie		***	***	***
Cutting interval		**	**	**
Specie*cutting interval		NS	NS	NS

a,b,c: Means within a column with different superscripts differ significantly ($P < 0.05$).

*$P < 0.05$; ** $P < 0.01$; *** $P < 0.001$; NS = not significant

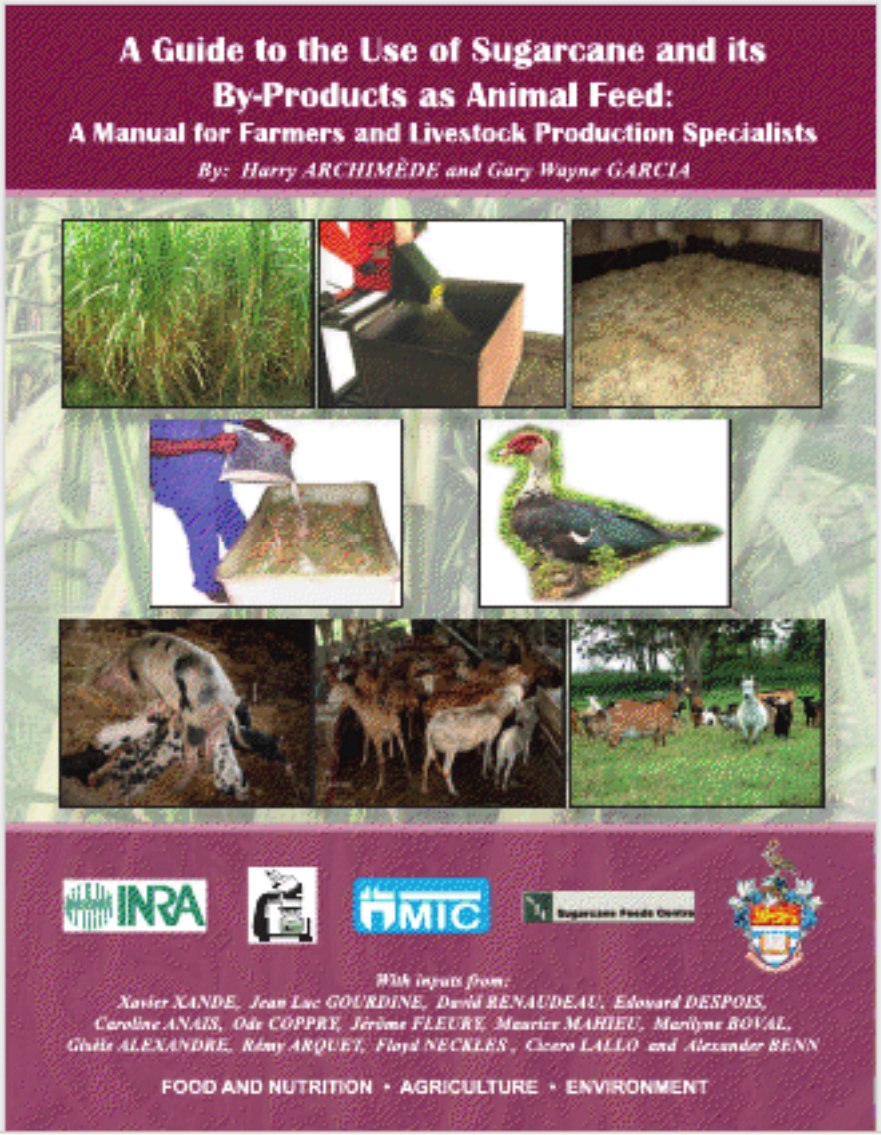
Lallo CHO. 2012. Appropriate feeds and sustainable feeding systems for hair sheep production in the Caribbean: In Sustainable food production practices for the Caribbean. Eds Ganpat WG and Isaac WP. Ian Randle Publishers, Kingston.

Nutrient composition of some by-product/non-conventional feedstuffs. (*crude protein equivalent)

Classification	DM%	CP%	Energy DE MJ/kg DM	Ca %	P%
Low-to-moderate Energy/ High-Nitrogen					
Poultry litter	30	22	9.8	1.8	1.9
Dried Brewers Grain	90	24	11.2	0.5	0.3
High Energy/High-Nitrogen					
Coconut Meal	90	22	13.9	0.2	0.6
Poultry By-product Meal	90	58	14.6	2.1	0.6
Fish Meal	90	60	13.0	-	-
Soya Bean Meal	90	44	13.8	0.25	0.60
Dried Brewer's Yeast	93	45	12.9	0.11	1.40
High-Energy/Low -Nitrogen					
Cassava Tubers /Waste	32	2.5	14.7	0.3	0.1
Molasses	80	3.0	12.6	1.0	0.1
Dried Citrus Pulp	90	7.0	12.7	0.13	0.07
Rice End bits	90	9.0	16.3	0.08	0.03
Low-Energy /Low-Nitrogen					
Sugarcane Bagasse	70	1.9	8.1	-	-
Rice Hull	90	2.8	3.0	-	-
Others					
Urea	1.0	288*	-	-	-
Sulphate of Ammonia	1.0	133*			

Lallo CHO. 2012. Appropriate feeds and sustainable feeding systems for hair sheep production in the Caribbean: In Sustainable food production practices for the Caribbean. Eds Ganpat WG and Isaac WP. Ian Randle Publishers, Kingston.

http://www12.brinkster.com/ostasp/index.aspx



A guide to the use of sugarcane and its by-products as animal feeds:

a manual for farmers and livestock production specialists

Harry ARCHIMÈDE

and

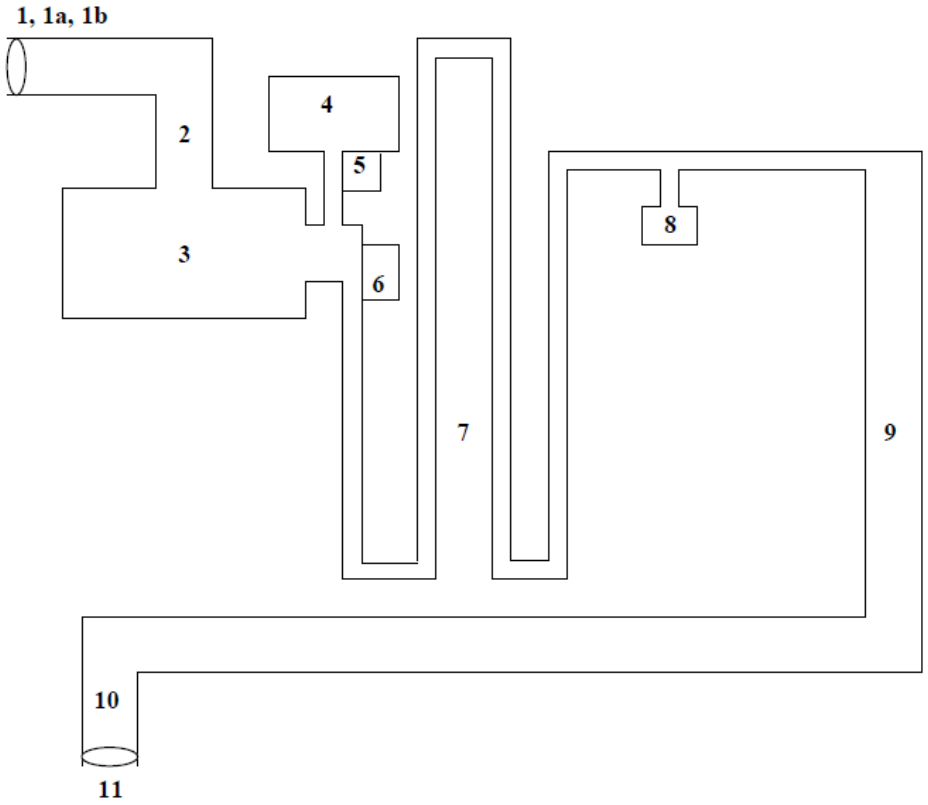
Gary Wayne GARCIA

Digestion

Digestion

- the process by which carbohydrates, proteins and fats are broken down into units that are small enough to be absorbed through the gut wall
- physical and chemical process
- digestive enzymes in the inactive form – zymogens/proenzymes
- monogastric vs ruminant
- ruminant - complex digestive systems; digests material with a high fiber content; microbial fermentation

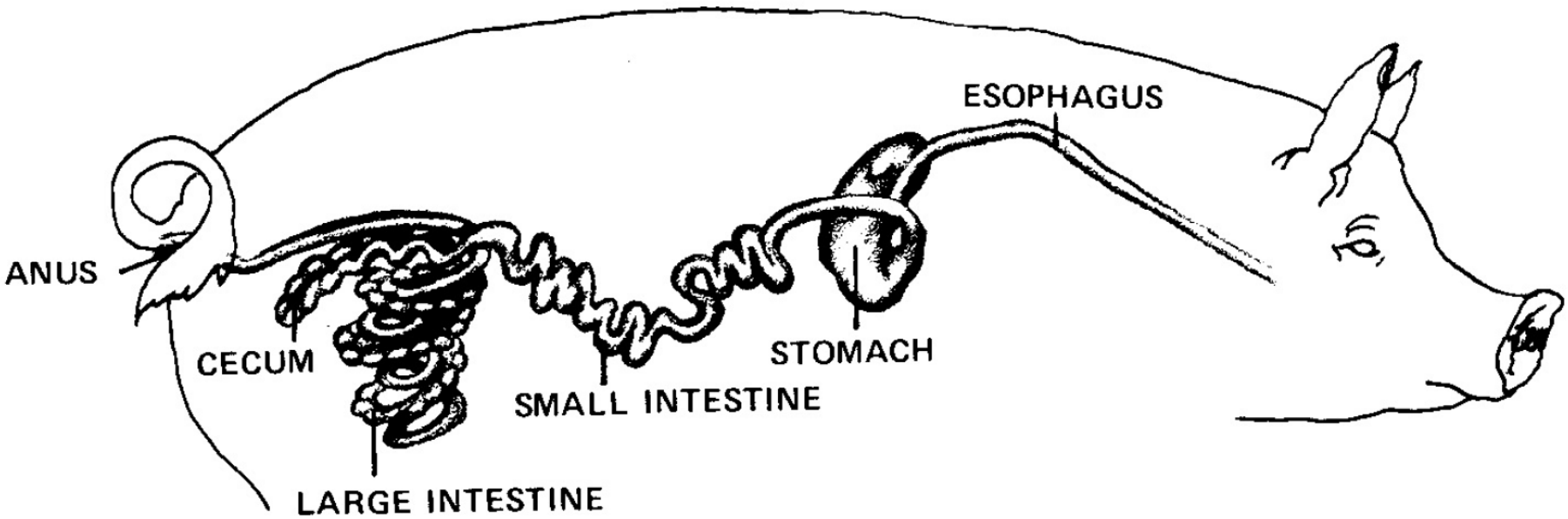
SCHEMATICS OF THE DIGESTIVE SYSTEM OF NON-RUMINANTS



1	Mouth	7	Small intestines	
1a	Teeth	8	Cecum	
1b	Salivary glands	9	Colon	Large intestines
2	Oesophagus	10	Rectum	
3	Stomach	11	Anus	
4	Liver			
5	Gallbladder			
6	Pancreas			

http://www12.brinkster.com/ostasp/courses2.aspx

Monogastric - Digestive Tract

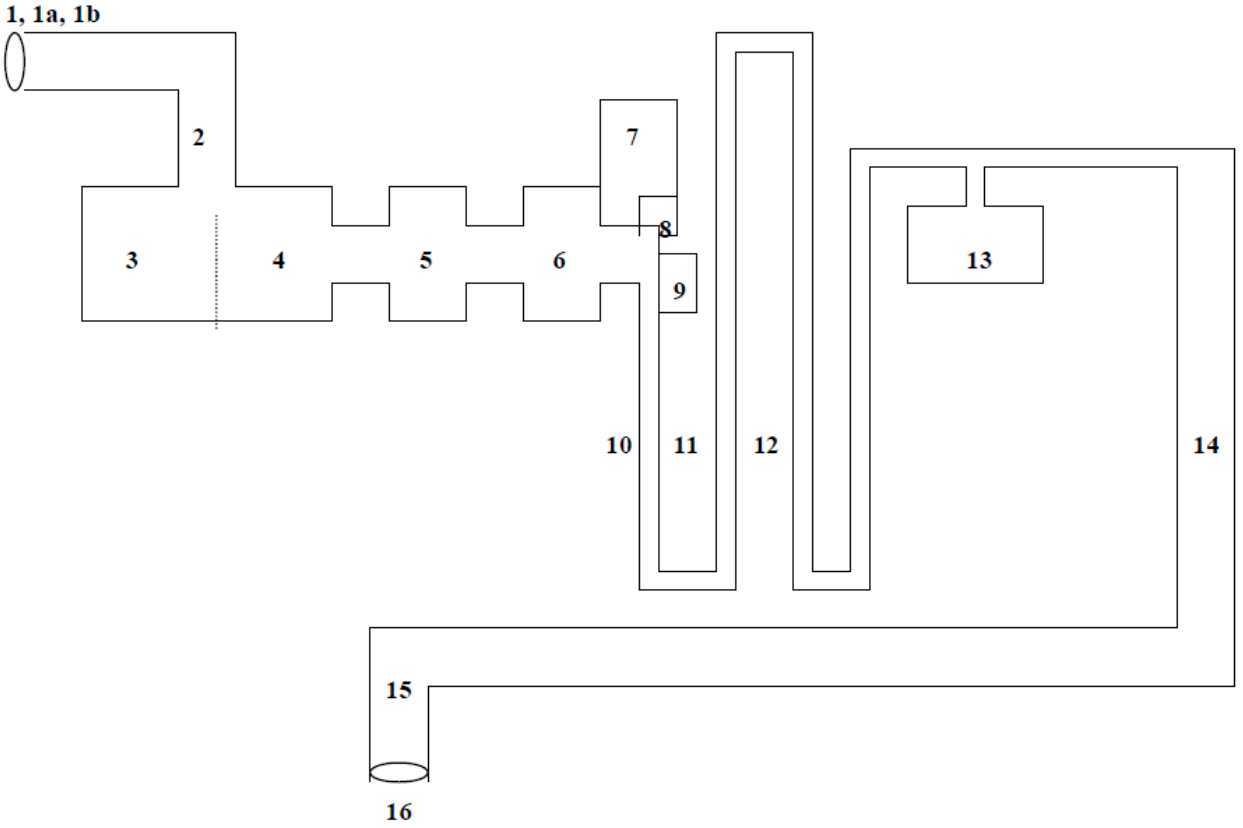


Rounds W and Herd DB. The Cow's Digestive System. Texas Agricultural Extension Service

Monogastric - Digestion

Enzyme	Site of Action	Source	Substrate	Optimum pH	Product(s)
Salivary amylase	Mouth	Saliva	Starch	6.7	Maltose
Pepsin	Stomach	Gastric glands	Protein	1.6–2.4	Shorter polypeptides
Pancreatic amylase	Duodenum	Pancreatic juice	Starch	6.7–7.0	Maltose, maltriose, and oligosaccharides
Trypsin, chymotrypsin, carboxypeptidase	Small intestine	Pancreatic juice	Polypeptides	8.0	Amino acids, dipeptides, and tripeptides
Pancreatic lipase	Small intestine	Pancreatic juice	Triglycerides	8.0	Fatty acids and monoglycerides
Maltase	Small intestine	Brush border of epithelial cells	Maltose	5.0–7.0	Glucose
Sucrase	Small intestine	Brush border of epithelial cells	Sucrose	5.0–7.0	Glucose + fructose
Lactase	Small intestine	Brush border of epithelial cells	Lactose	5.8–6.2	Glucose + galactose
Aminopeptidase	Small intestine	Brush border of epithelial cells	Polypeptides	8.0	Amino acids, dipeptides, tripeptides

SCHEMATICS OF THE RUMINANT DIGESTIVE SYSTEM



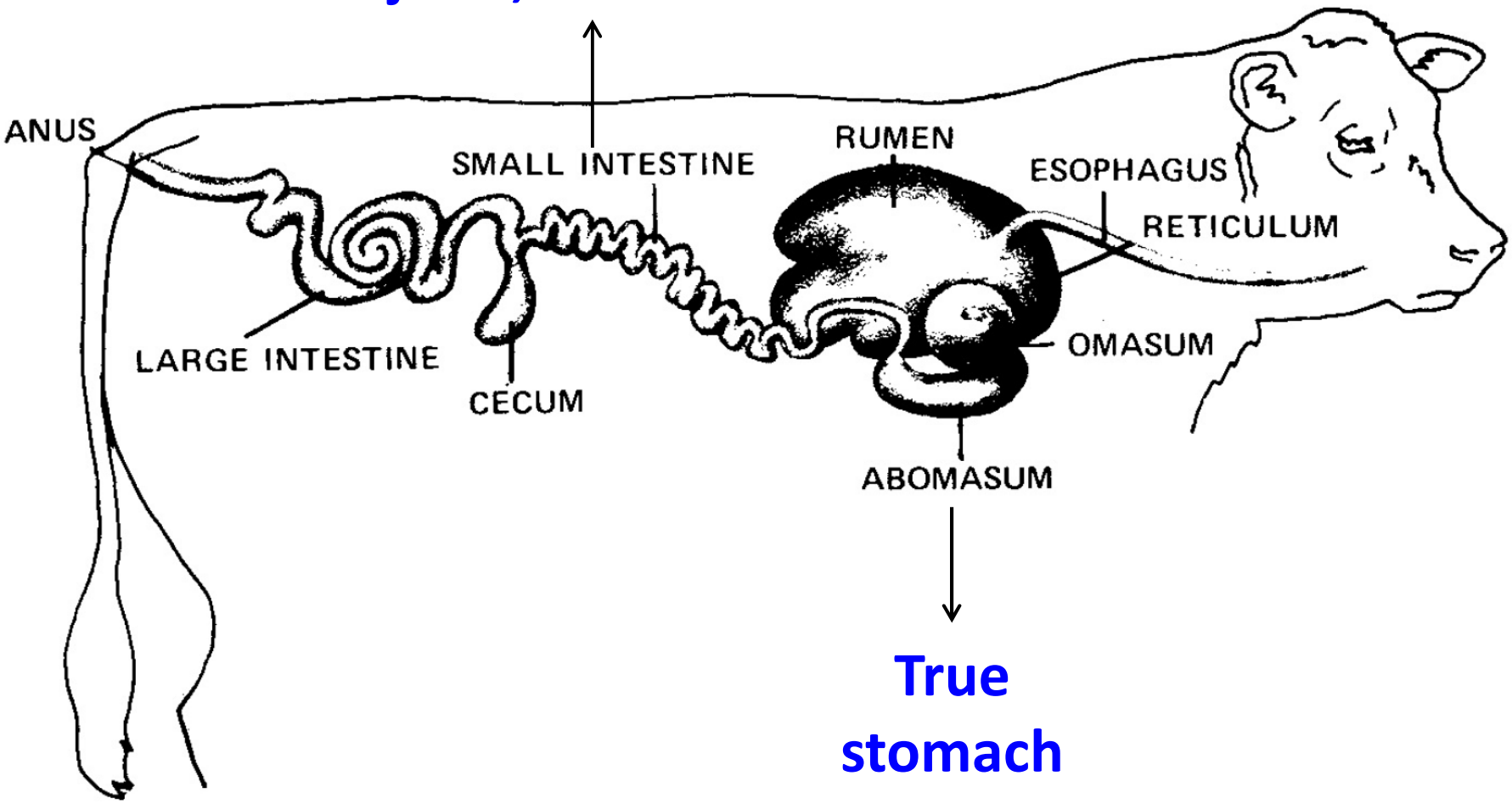
1	Mouth	
1a	Teeth	
1b	Salivary glands	
2	Oesophagus	
3	Reticulum	Ruminant Stomach
4	Rumen	
5	Omasum	
6	Abomasum	
7	Liver	
8	Gallbladder	

9	Pancreas	
10	Duodenum	Small Intestines
11	Jejenum	
12	Ileum	
13	Cecum	Large Intestines
14	Colon	
15	Rectum	
16	Anus	

http://www12.brinkster.com/ostasp/courses2.aspx

Ruminant - Digestive Tract

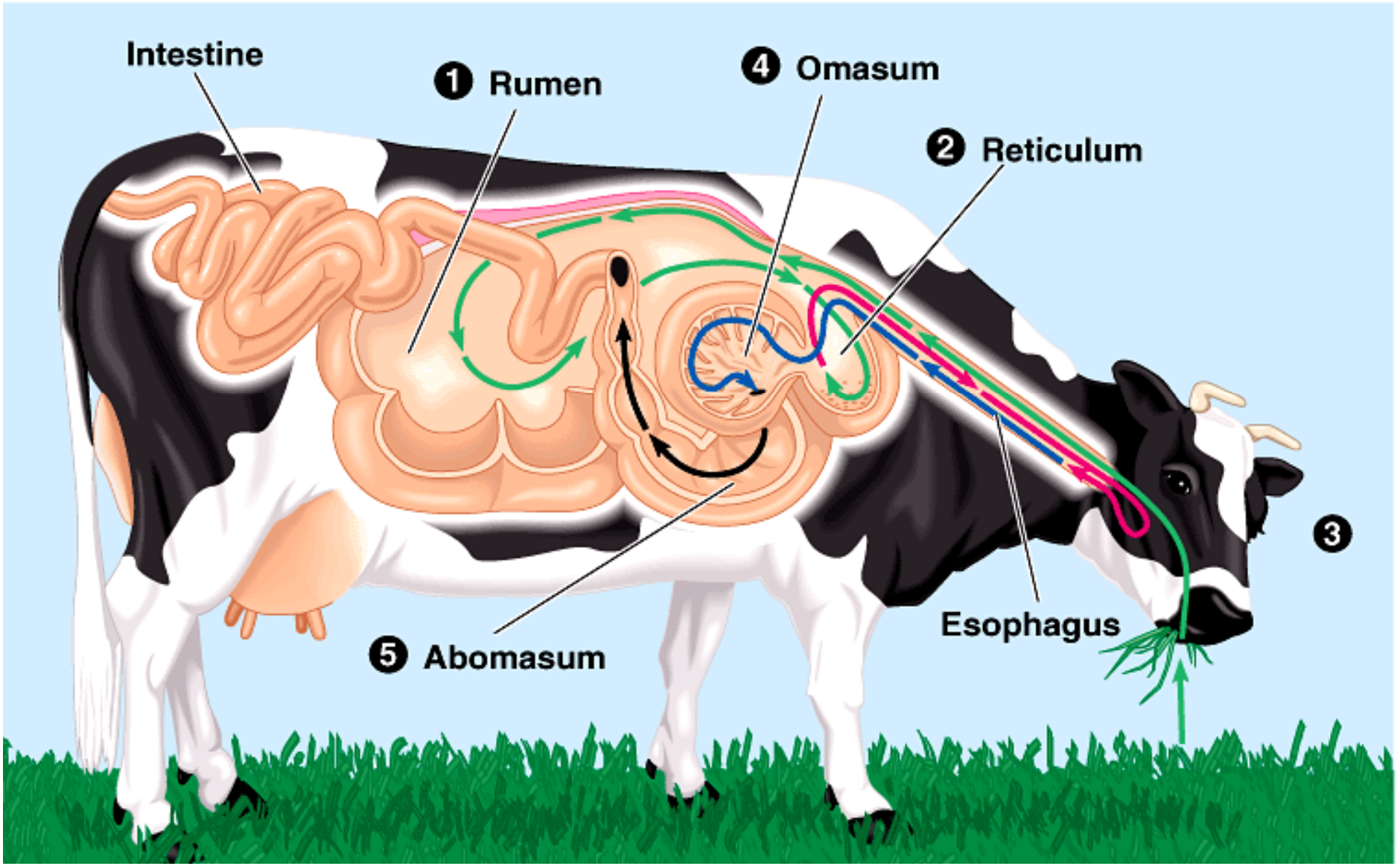
bile, pancreatic juice, microvilli



True stomach

Rounds W and Herd DB. The Cow's Digestive System. Texas Agricultural Extension Service

Ruminant - Digestive Tract



mun.ca

Rumen Ecology

- 1 ml of rumen content:
  - pH 6-7
  - 10-50 mill bacteria; 1 mill protozoa; fungi
  - celluolytic, hemicellulolytic, amylolytic, proteolytic
  - ammonia producers
  - vitamin B and K synthesizers
  - methane producers
  - products utilized for energy are acetic, propionic and butyric acids

Volatile Fatty acids

- Acetic acid

  – oxidized to produced ATP

  - main source of acetyl CoA for lipid synthesis

  - ↑ with high roughage diets
- Propionic acid

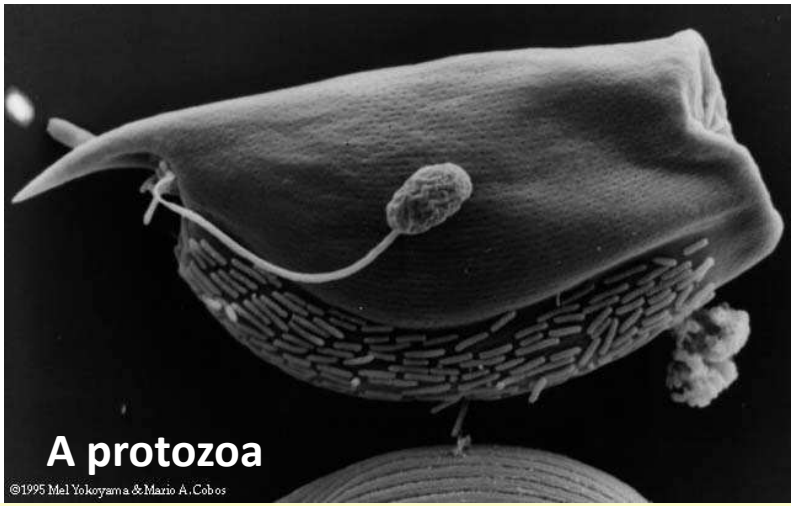
  - used in the liver for gluconeogenesis

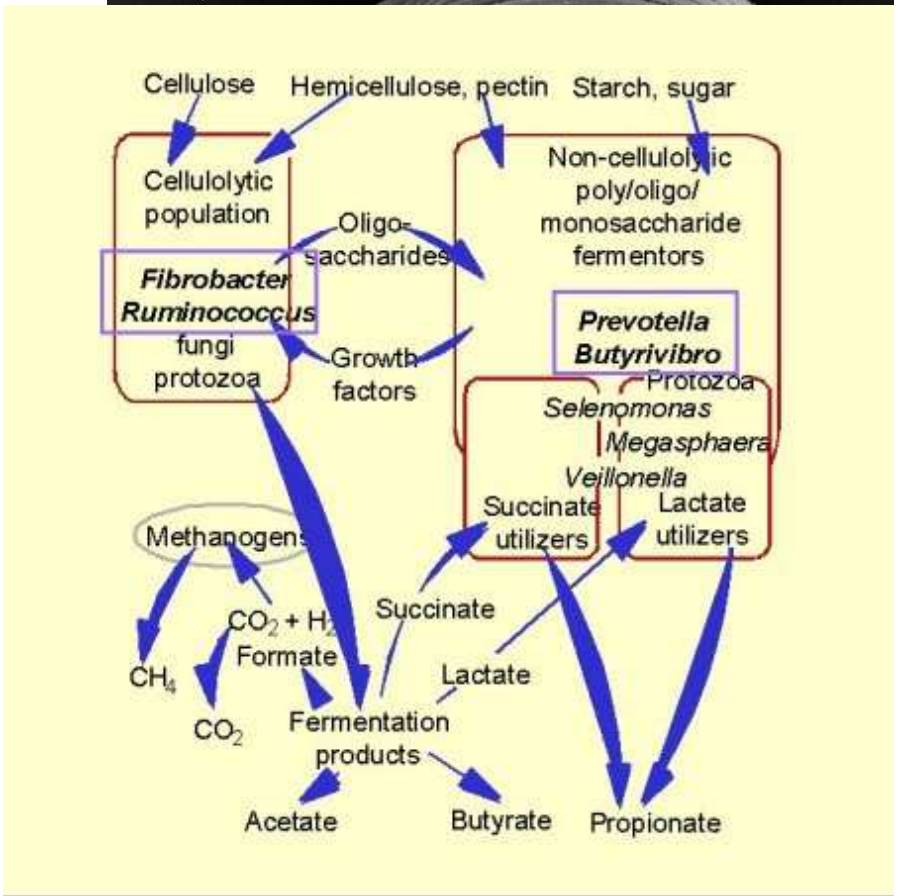
  - ↑ in high concentrate ration diets
- Butyric acid

  - also oxidized for energy

Rumen functions

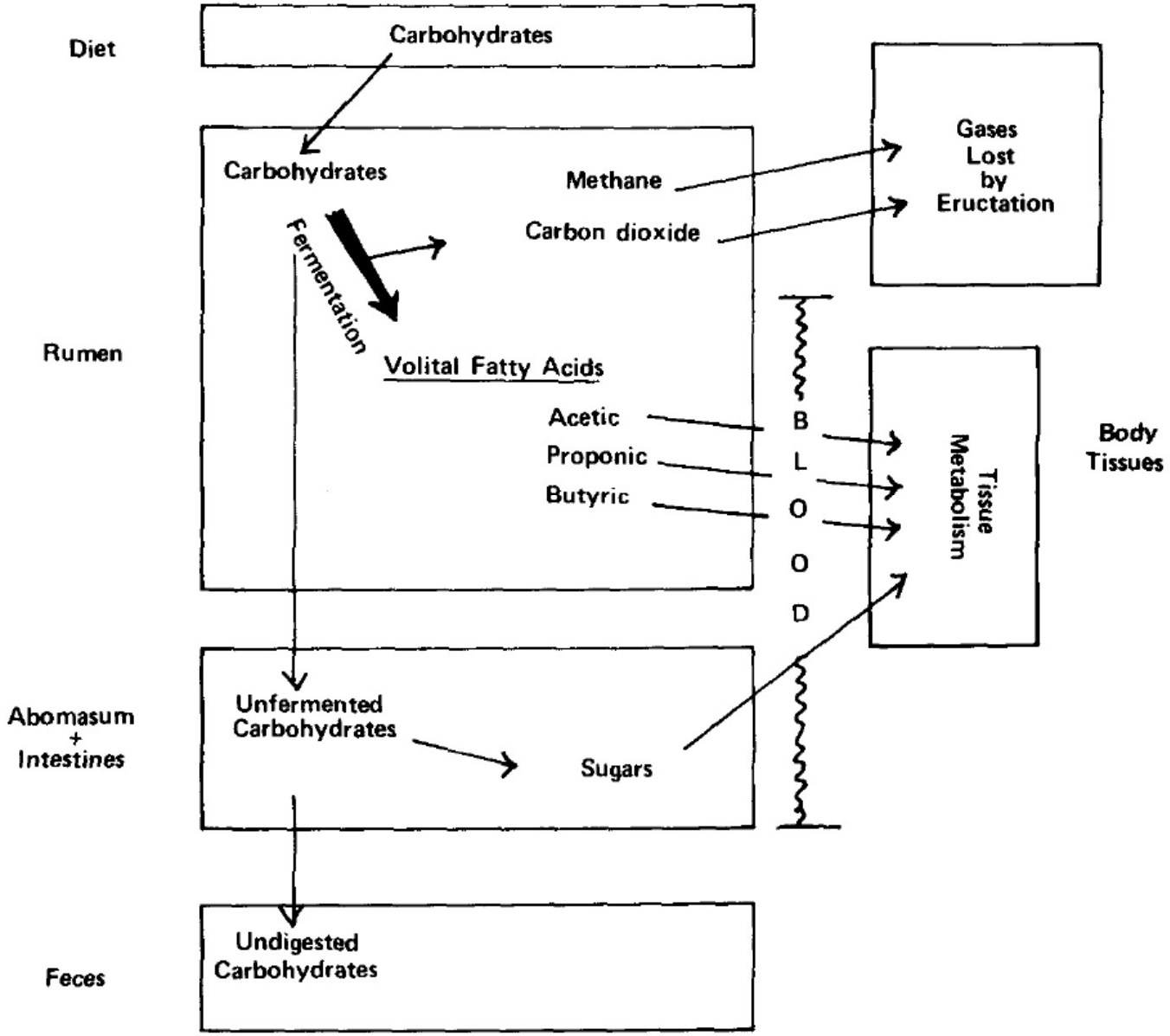
- GIT microbial communities:
- digests and ferments plant polymers
- synthesizes vitamins
- bioconverts toxic compounds to non toxic residues
- stimulates the immune system
- maintains gut peristalsis
- maintains intestinal mucosal integrity
- reduces colonisation by pathogens





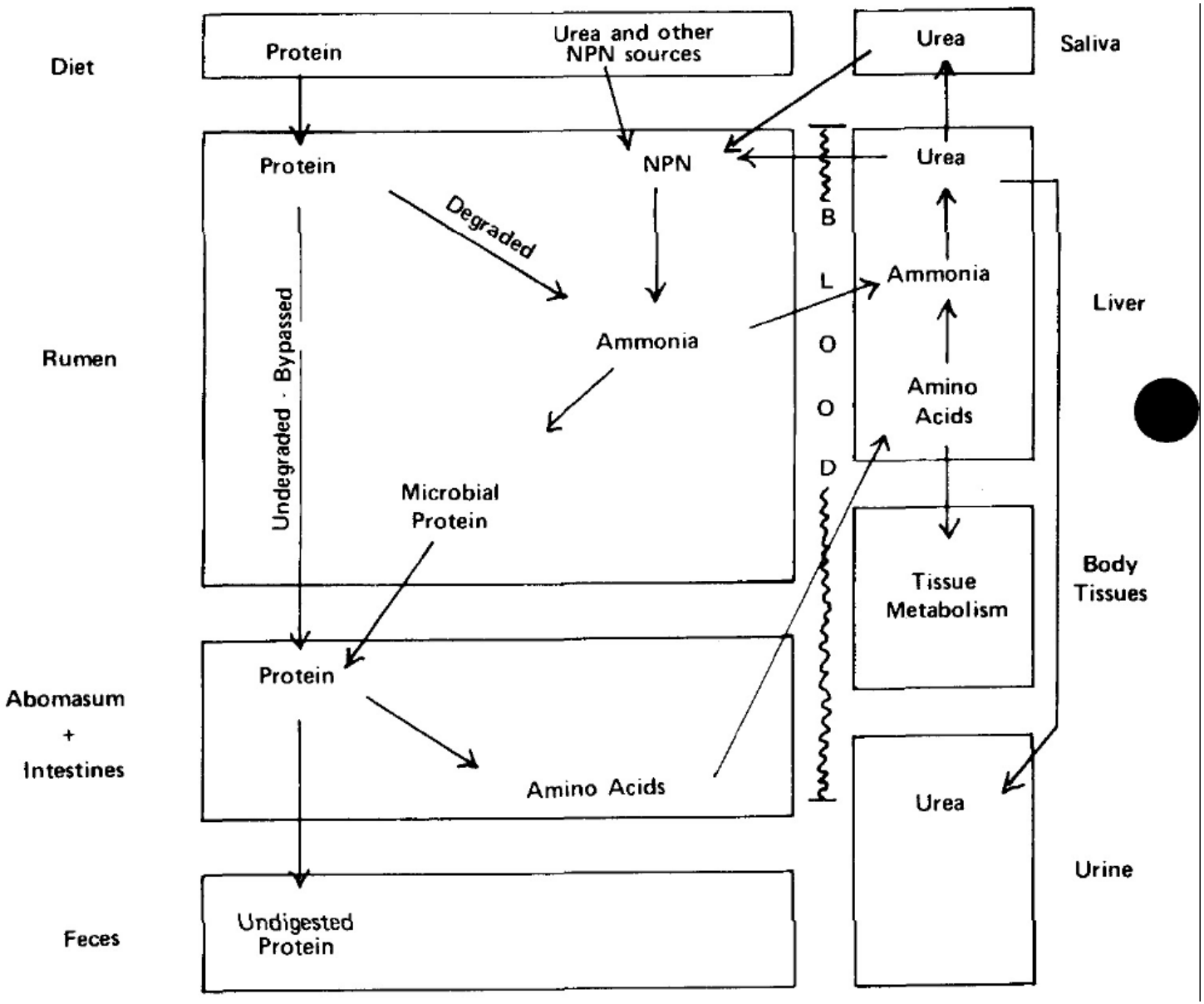
icvi.org/rumenomics/images/rumen_microb

Digestion and utilization of carbohydrates in ruminants



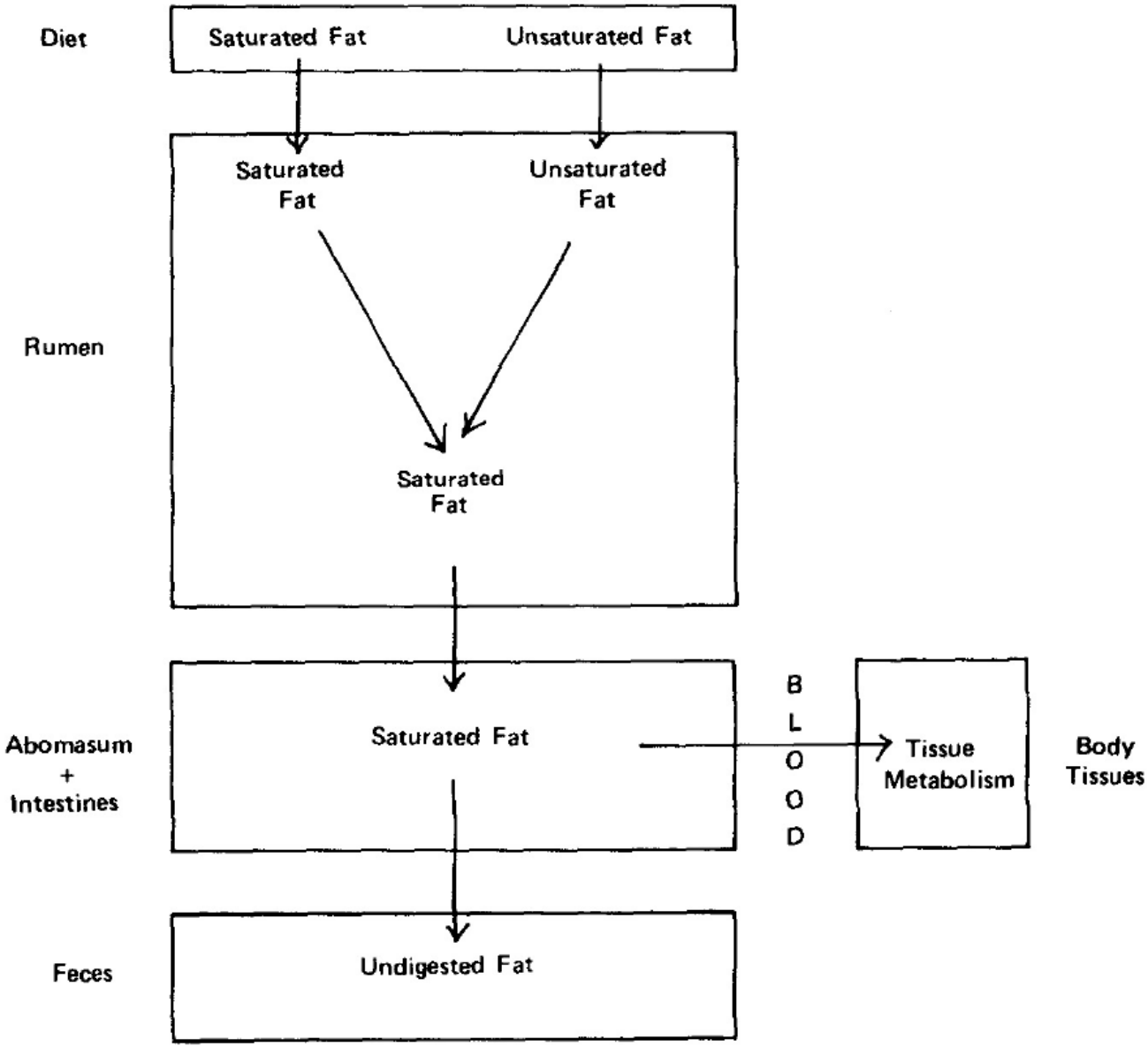
Rounds W and Herd DB. The Cow's Digestive System. Texas Agricultural Extension Service

Digestion and utilization of proteins in ruminants



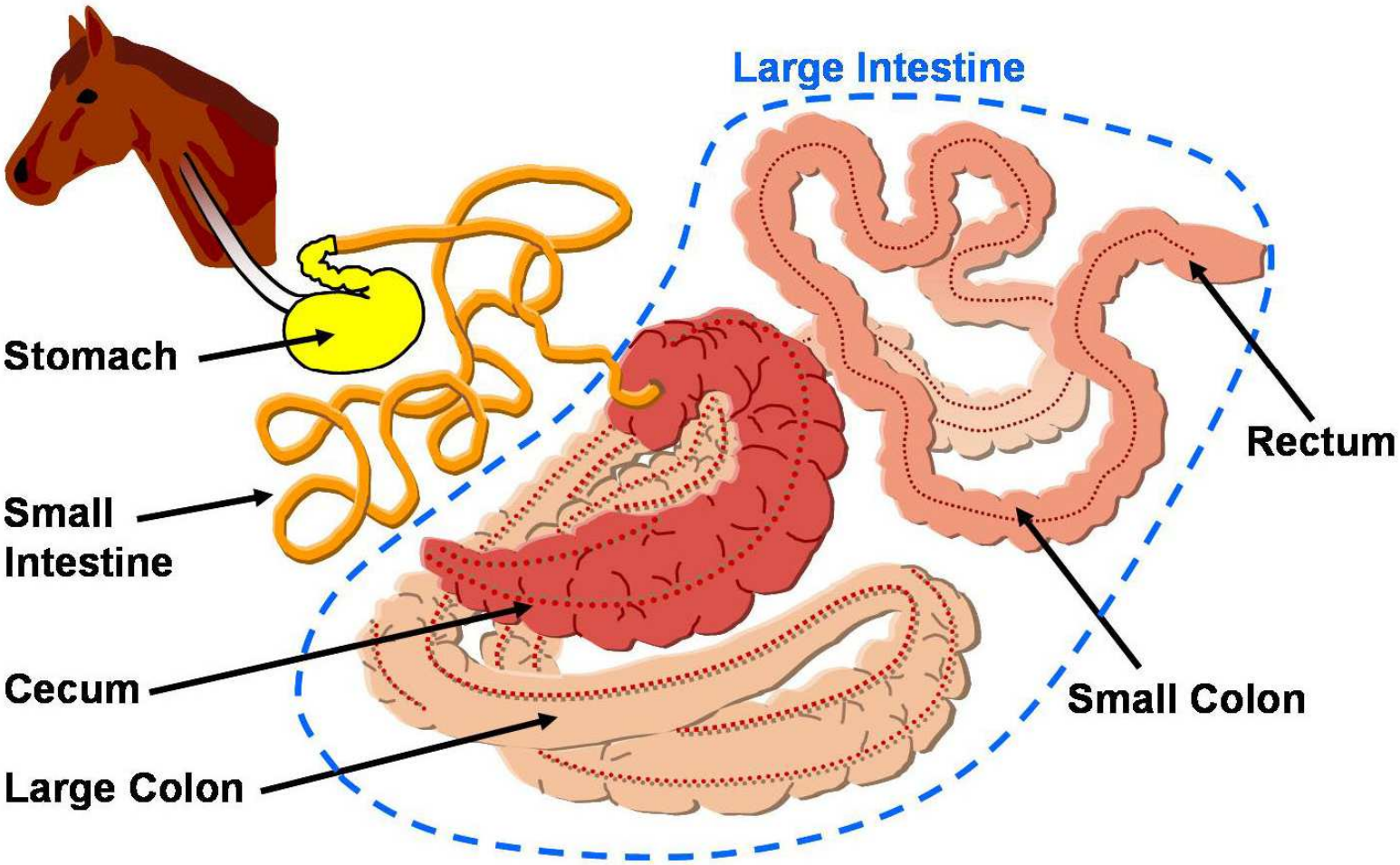
Rounds W and Herd DB. The Cow's Digestive System. Texas Agricultural Extension Service

Digestion and utilization of fats in ruminants

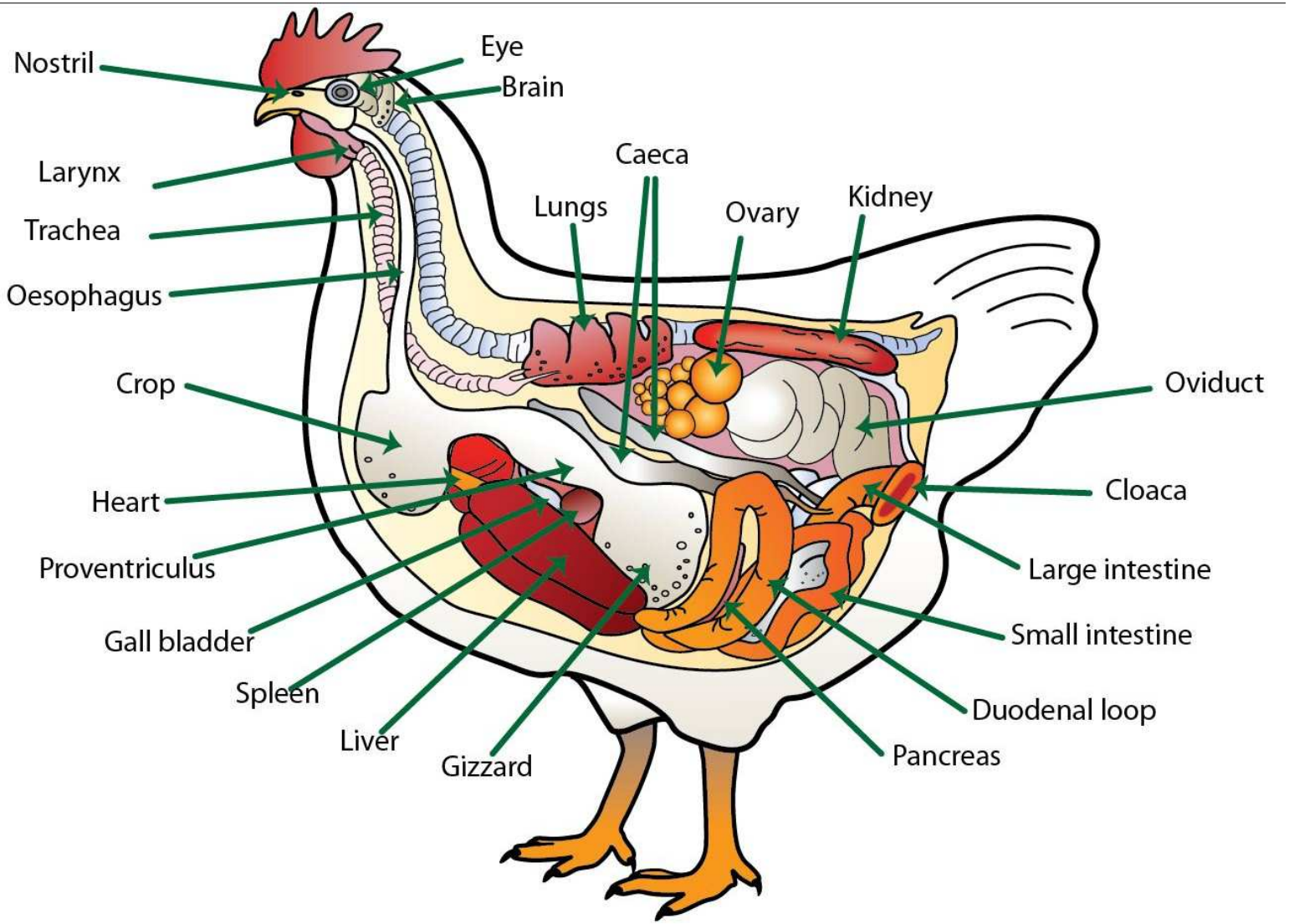


Rounds W and Herd DB. The Cow's Digestive System. Texas Agricultural Extension Service

Non-ruminant herbivores (equine)



Non-ruminant herbivores (avian)



poultryhub.org

1.6 Feed Additives

1.6.1 Probiotics

Probiotics

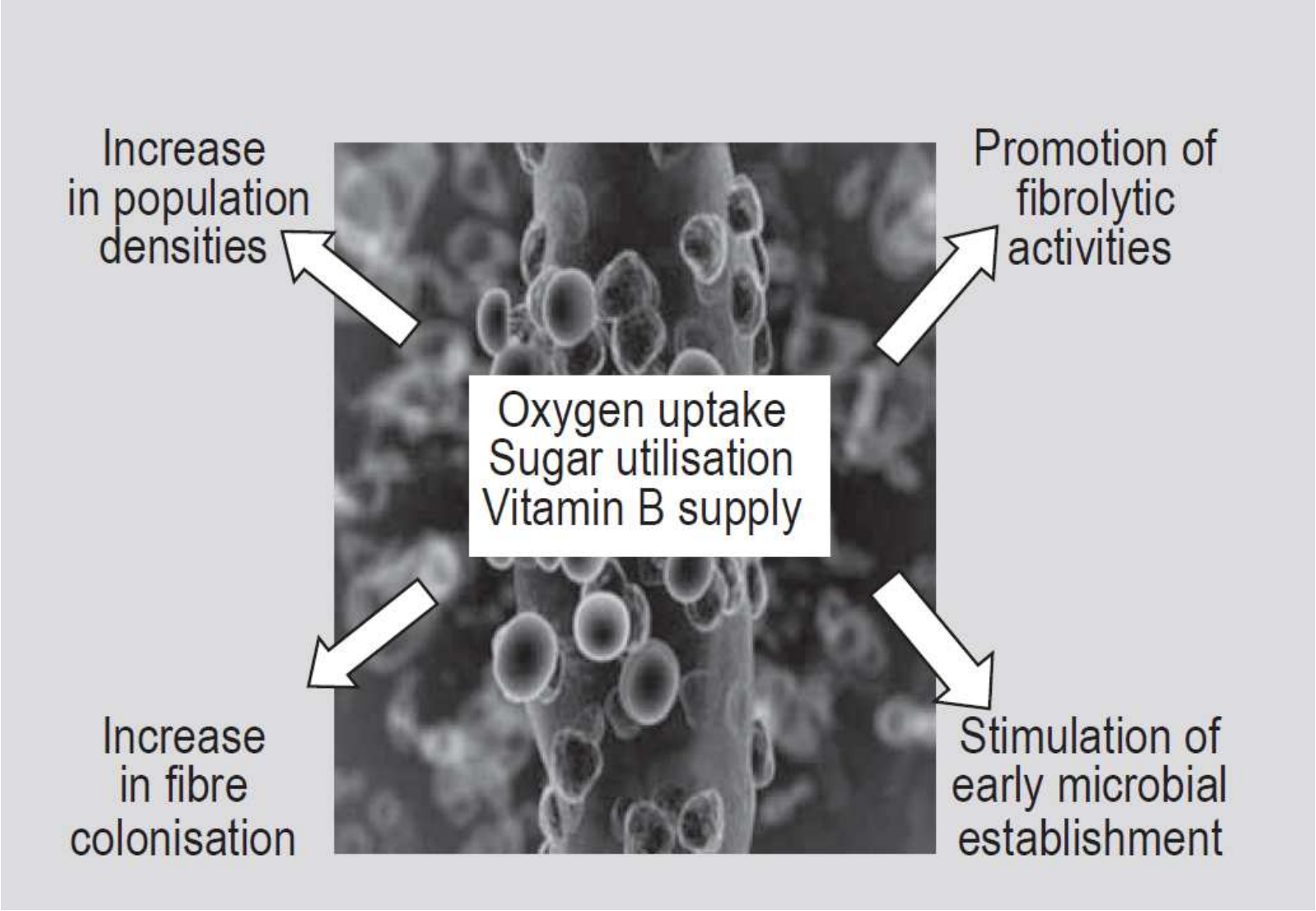
"live microorganisms, which, when administered in adequate amounts, confer a health benefit on the host".

Prebiotics are a dietary fibre that trigger the growth of bacteria having favorable effects on the intestinal flora.

***Lactobacillus reuteri* -**	chicken and turkeys to prevent infections and support growth and development
Propionibacterium,* and *Lactobacillus species, Bacillus cereus, Bacillus licheniformis, and Saccharomyces cerevisiae	reduces adverse effects from dietary changes
***Saccharomyces cerevisiae* -**	↑ dry matter intake and milk production in dairy animals
Daily live yeast supplementation	↑ daily gain, final weight, intake and feed/gain ratio in beef cattle

FAO/WHO. 2001. FAO/WHO Consultation Report.
Chauchevras-Durand F and Durand H. 2010.

Main effects and mechanisms of action of live yeast probiotics on ruminal fibre-degrading communities.



Chauchevras-Durand F and Durand H. 2010. Beneficial

Main targets for probiotics' use in ruminants

Young ruminants	Dairy cattle	Beef cattle
Promoting optimal maturation of the rumen microbiota	Increasing milk yield and quality	Promoting weight gain
Increasing digestive safety at weaning	Increasing feed efficiency	Increasing feed efficiency
Reducing risk of pathogen colonisation	Promoting health (limit acidosis)	Promoting health (reduce acidosis)
		Limiting shedding of human pathogens

Main applications for probiotics' use in pigs

(*Saccharomyces boulardii*, *Lactobacillus* spp., *Enterococcus* spp., *Pediococcus* spp., *Bacillus* spp.)

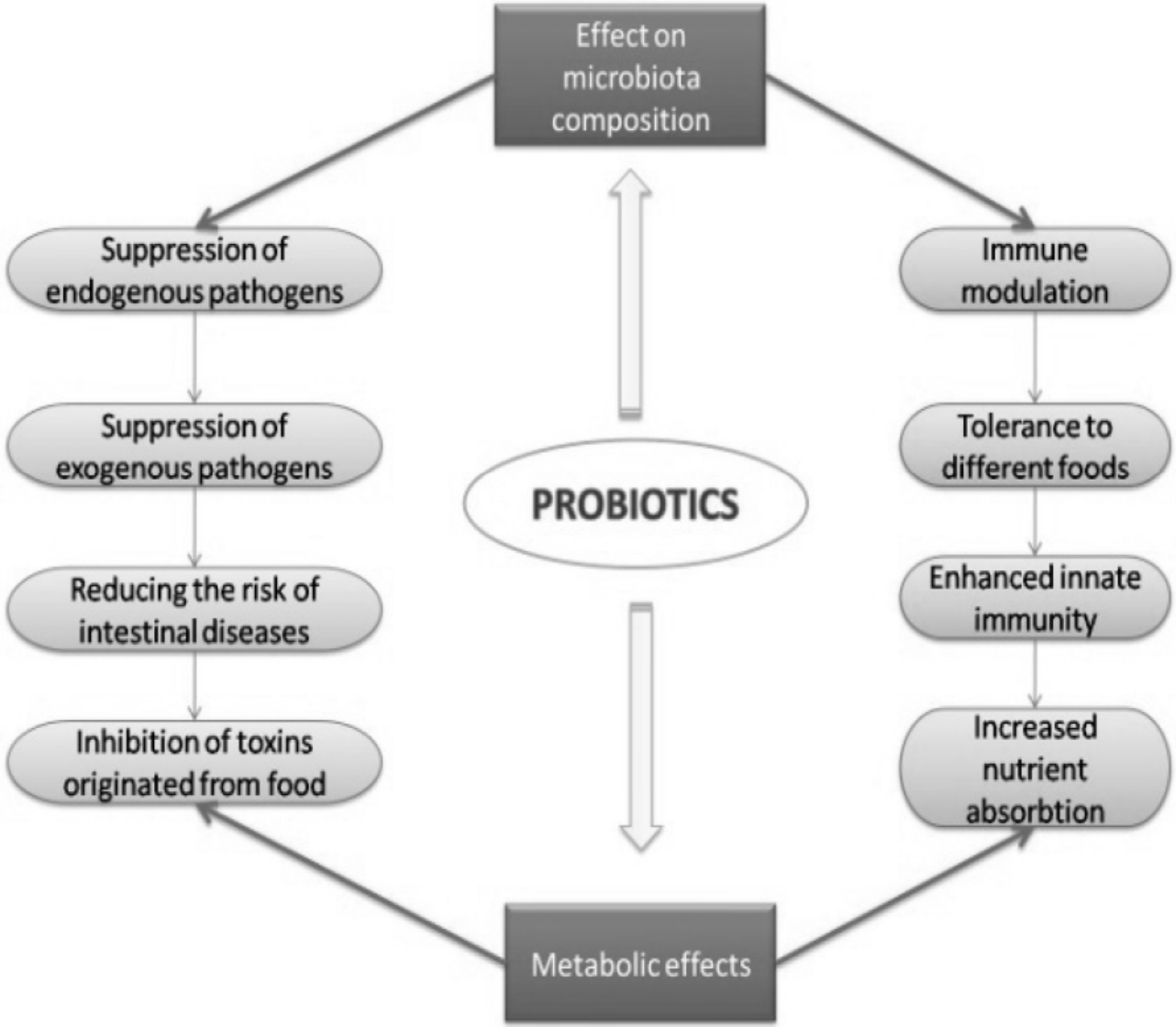
Gestating sow	Lactating sow and piglets	Fattening pigs
Improve diet digestibility	Improve colostrum quality, milk quality and quantity	Improve feed efficiency
Limit constipation	Increase litter size and vitality	Improve meat quality
Decrease stress	Increase piglet weight	Reduce risk of diarrhoea
	Reduce risk of diarrhoea	

Main targets for probiotics' use in equines

Gestating mares	Foals	Racing horses
Increase diet digestibility	Promote growth	Avoid hindgut disorders (acidosis, colic) and increase digestibility of diet
Improve milk quantity and quality	Limit diarrhoea	Limit stress (transportation, race, etc.)

Chaucheyras-Durand F and Durand H. 2010. Beneficial

Probiotics effect on animal health



Corcionivoschi N et al. 2010. Animal Science and Biotechnologies;

1.6.2 Essential Amino Acids

Amino Acids (AAs) - monogastrics

Essential Amino Acids

- Phenylalanine
- Valine
- Threonine
- Methionine
- Arginine
- Tryptophan
- Histidine
- Isoleucine
- Leucine
- Lysine

Non-essential Amino Acids

- Alanine
- Aspartic Acid
- Citrulline
- Cysteine* (from methionine)
- Glutamic Acid
- Glycine
- Hydroxyproline
- Proline
- Serine
- Tyrosine* (from phenylalanine)

*** semi essential**

Amino Acids - monogastrics

- soyabean is common source
- corn and other cereals are deficient
- other plant based AAs sources…….animal protein by-products……..synthetic AAs?
- diets are formulated to meet the swine requirements for lysine (most limiting AAs)
- all other AAs expressed as a % of the lysine requirements

Amino Acids - ruminants

- proteins are hydrolyzed to peptides then AAs by microbes; AAs are rapidly degraded to organic acids, ammonia and CO_2
- absorbed AAs comes from microbial protein synthesis and from dietary AA sources that are not degraded in the rumen
- rumen microbes synthesize all essential AAs; role of NPN
- production of microbial protein alone is insufficient to supply adequate amounts of AAs for optimal prod'n; in cattle, methionine and lysine are generally the first limiting AAs for production
- protected amino acid supplements involves "post ruminal" degradation