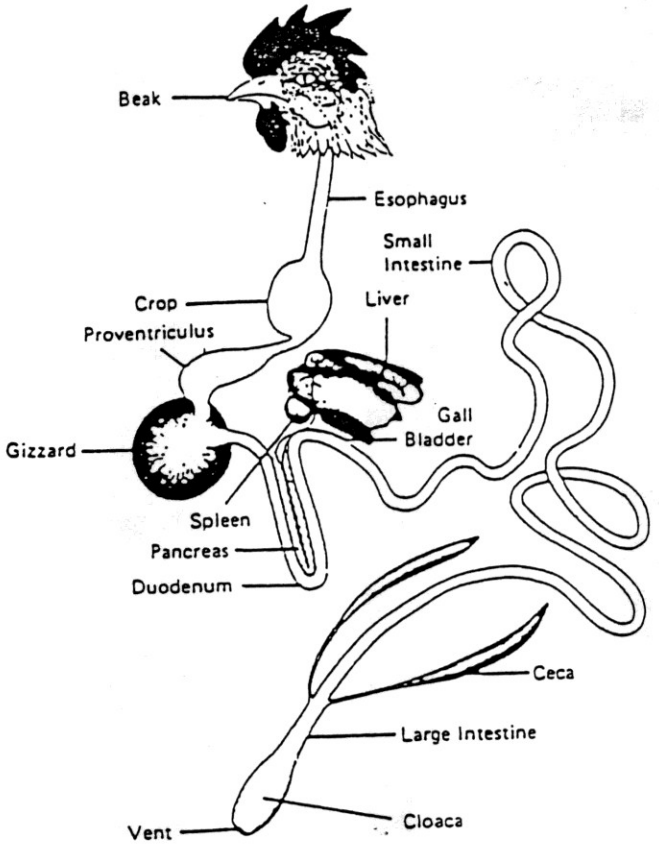
The Animal GIT System and Digestion



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130740 Tropical Feed Resources and Feeding Technology

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Digestion and Absorption:

- The process of digestion includes:
  - The prehension of food or feed
  - The mechanical chewing and grinding
  - Mixing with digestive acids and enzymes to chemically break down feedstuffs
- The process of absorption includes:
  - Transport of the digested foods across the intestinal mucosa to the blood or lymph system

General Terms

- Prehension: to take into the mouth
- Mastication: chewing
- Deglutition: swallowing
- Regurgitation: the backward flow of food through the esophagus

Three Major Categories

- Carnivore: consume flesh of other animals, examples are dogs and cats
- Omnivore: consume both plants and flesh, examples are primates
- Herbivore: consume plant material, examples are horses and cattle

Carnivore

- Very Well developed stomach
- Uncomplicated intestine
- Limited fiber digestion

Omnivore

- Combination of carnivores/herbivores
- More complicated GIT than carnivores
- Colonic digesters
  - Pigs, humans
- Cecal digesters
  - rat

Herbivore

- Cow, horse, rabbit
  - Each has a different type of GIT
- Cow- ruminant
- Horse- simple stomach, large cecum, large intestine
- Rabbit- larger stomach, very large cecum, large intestine

Types of Stomachs

- Simple Stomach
  - Man, Pig
- Complex Stomach
  - Cattle, Sheep, Goats
- Simple Stomach with enlarged ceacum
  - Horses, Rabbits, Guinea Pigs

Parts of Digestive Tract

- Mouth: initial opening of alimentary canal
  - Salivary Glands
    - secrete juices that contain enzymes to help break up the food
  - Mastication
    - chewing, crushing, preparing food for swallowing

Parts of Digestive Tract

- Pharynx: funnel shaped muscle between mouth and esophagus
  - part of digestive and respiratory tracts
- Esophagus: muscular tube connecting pharnyx to stomach
  - muscle contractions move food down to stomach

Parts of Digestive Tract

- Stomach: located between esophagus and small intestine
  - Two basics types
    - Simple
    - Ruminant

Parts of Digestive Tract

Simple Stomach

- Humans, swine, rabbits and horses
  - Divided into three regions
    - cardiac
    - fundus
    - pylorus

Simple Stomach

- Digestion:
  - is mechanical, muscle contractions
  - is chemical, enzymes soften and break down macromolecules of food
    - enzymes are catalysts, they start the chemical reactions

Simple Stomach

- Enzymes that break down food
  - Gastric-break down proteins in stomach
  - Liver and pancreatic-break down fats in small intestine
  - Intestinal-break down carbohydrates and proteins in small intestine

Parts of Digestion Tract

Ruminant Stomach

- Sheep, Cows and Goats
- Occupies 3/4 of the abdominal cavity

Different Digestive Tracts

- Farm animals have a variety of digestive systems
  - Ruminants: have 4 different compartments to the stomach
    - Examples include cattle, sheep, goats
  - Nonruminants (also known as monogastrics)
    - Hogs, dogs, and cats have a single, simple stomach
    - Poultry have a two part stomach
    - Horses have a large, functional cecum

Pregastric vs Postgastric

- Pregastric: Fermentation that occurs in the rumen of ruminant animals. It occurs before food passes into the portion of the digestive tract in which digestion actually occurs.
- Postgastric: The fermentation of feed occurs in the cecum, behind the area where digestion has occurred.

Pregastric vs Postgastric

- Ruminants
  - More efficient
  - Less intake
- Non- ruminant herbivores
  - Only postgastric
  - Less efficient
  - Greater intake

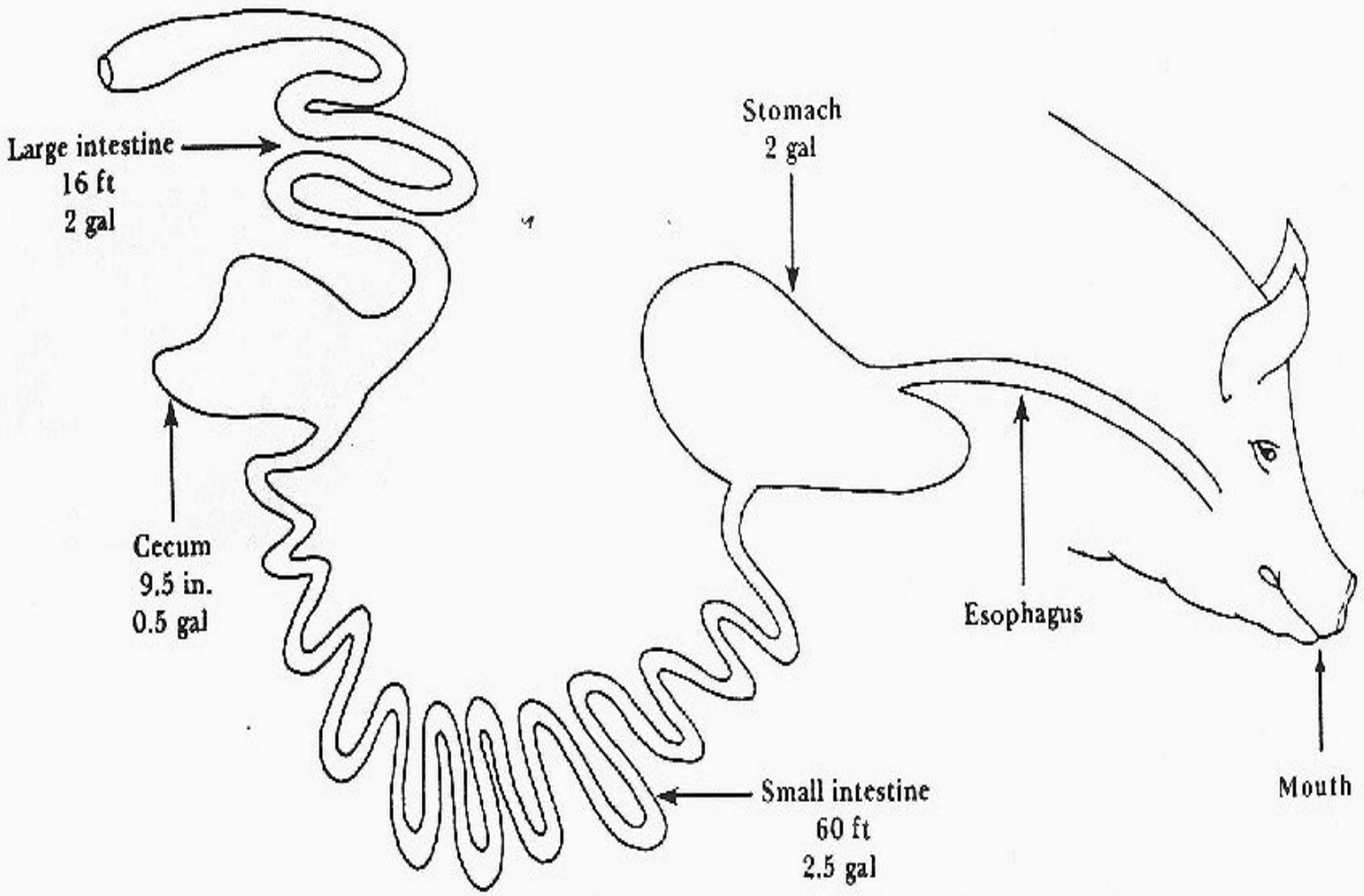
Non-ruminant digestive system

Non-ruminant digestive system

- Mouth- prehension and chewing of food; some carbohydrate enzyme activity
- Esophagus
- Stomach
  - Storage
  - Muscular movements, mixes feed
  - Secretes Digestive Juices (hydrochloric acid)
    - pH about 2
- Small intestine- partially digested feed is mixed with bile, pancreatic juice, and intestinal juice. Most food nutrients are absorbed from the villi in the small intestine

Non-ruminant digestive system

- Liver- produces bile that acts on fats
- Large intestine- absorbs water and adds mucus to the undigested feed, which is feces
- Anus- end of tract
- Non-ruminants cannot eat and digest as much roughage as ruminants



Simple digestive tract—14 × body length. Total capacity 7 gal. 44 teeth.

FIGURE 1-5. Digestive system of the pig.

Small Intestine

- Duodenum
  - Active Digestion Site
  - Produce enzymes
    - Pancreas
      - Helps to neutralize ingesta entering the SI
    - Liver
      - Produces bile; breaks down fats
    - Intestinal Walls

Small Intestine

- Jejunum
  - Active in nutrient absorption
- Ileum
  - Active in nutrient absorption
- Villi
- pH 6 to 7

Large Intestine

- 3 Sections
  - cecum
  - colon
  - rectum
- Active in water resorption
- Secretion of some minerals
- *Bacterial Fermentation*

Equine Digestive Systems

Characterized by non-ruminant animals that consume and digest feeds high in fiber

Equine Digestive Systems

- Mouth
  - intact top and bottom incisors
  - molars adapted to chewing fibrous feeds
  - no digestive enzymes in saliva
- Saliva
  - contains no enzymes
  - may secrete up to 10 gallons/day
  - stimulated by scratching

Horses are Different

- Esophagus
  - not well adapted for regurgitation
  - connects mouth and stomach
  - only one way peristaltic movement
    - Impossible for regurgitation

Horses are Different

- Stomach
  - much smaller in comparison to other species
  - not very extensive muscular contraction
  - So how should we feed differently?
- Small Intestine
  - similar to monogastric and ruminant systems
  - no gall bladder to store bile
    - Can't handle a high fat diet
  - enlarged cecum to aid in fiber breakdown

Horses are Different

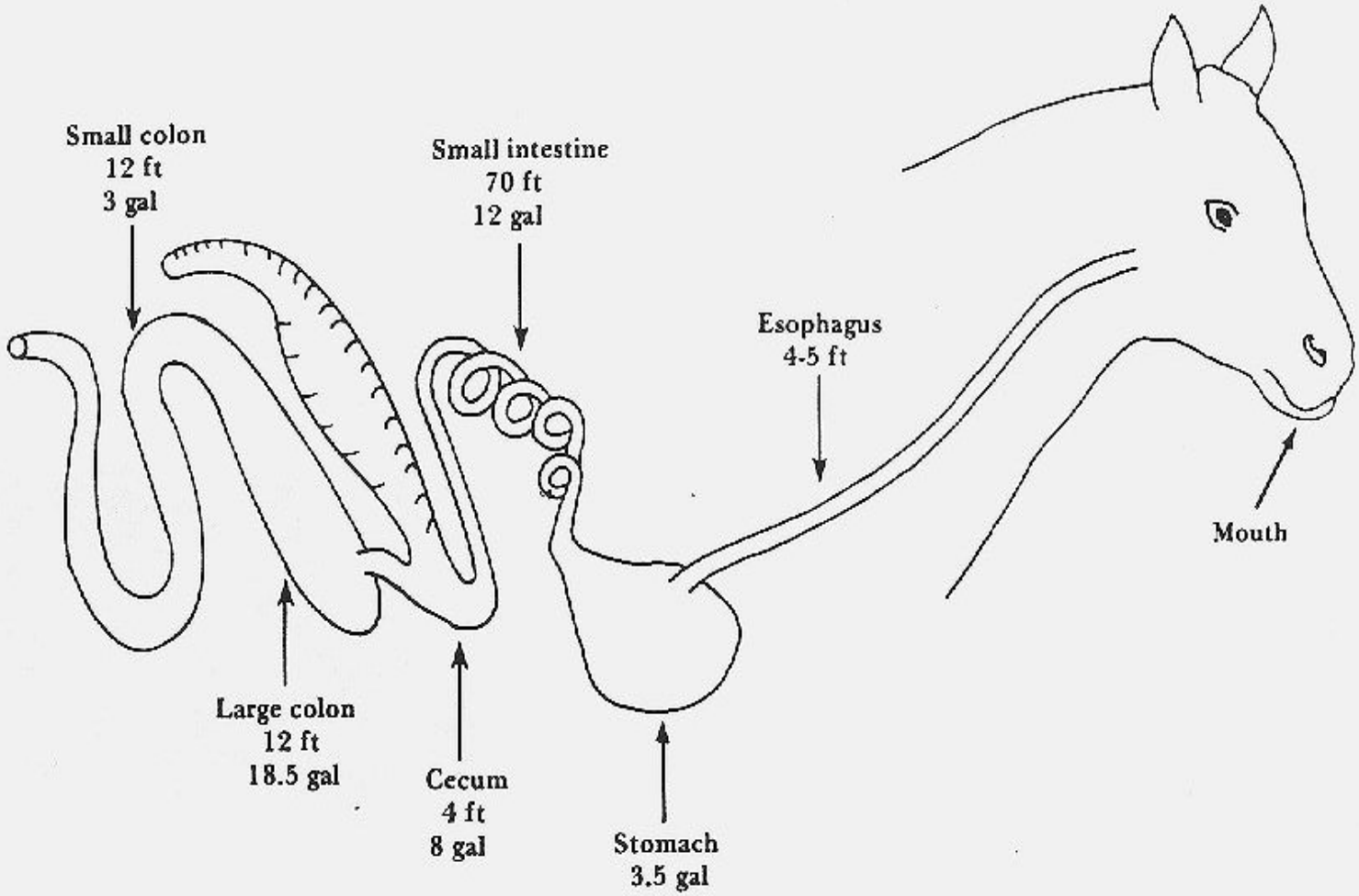
- Large Intestine
  - over 60% of GIT
  - similar to monogastric systems
  - 4 parts
    - cecum
    - large colon
    - small colon
    - Rectum
  - Cecum and colon take up most of the volume of the equine digestive system

Cecum and Large Colon

- Similar to Rumen
  - bacterial cellulose breakdown
  - bacterial protein breakdown
  - VFA production
  - Water Soluble Vitamin production

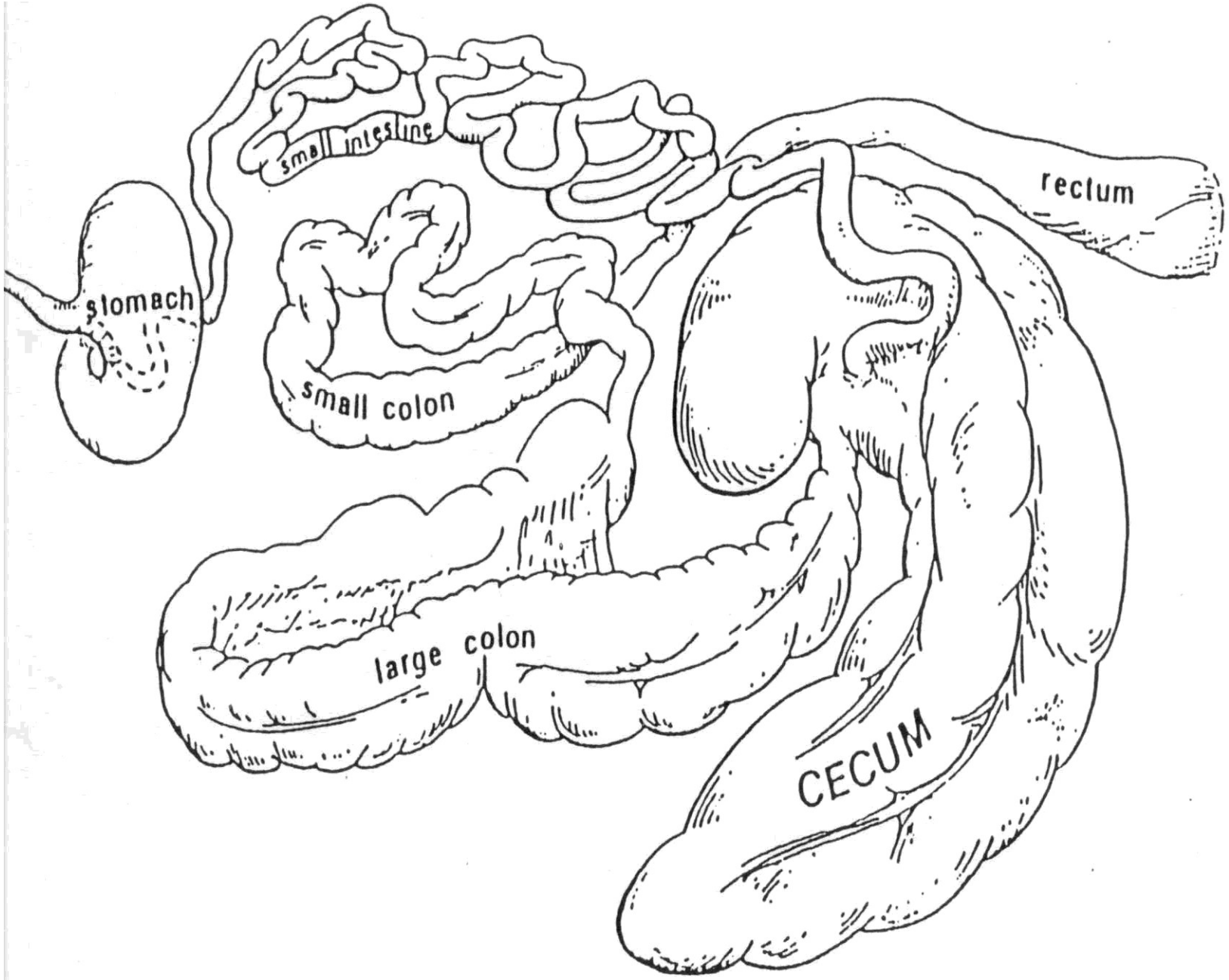
Small Colon and Rectum

- Primary site for water resorption
- Can become impacted with feed



More complex digestive tract–12 X body length. Total capacity 45 gal. 40 or 42 teeth.

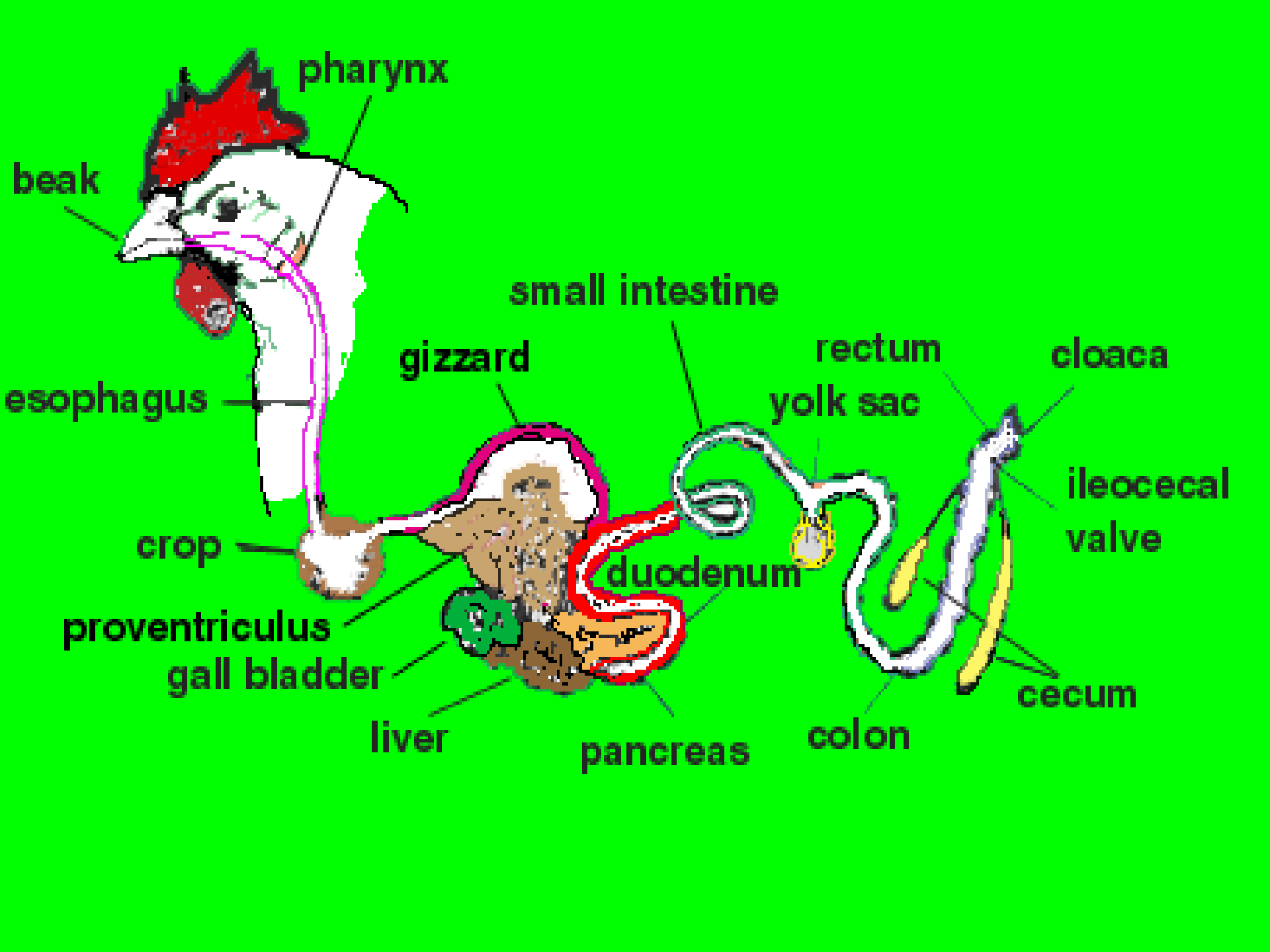
FIGURE 1–7. Digestive system of the horse.


small intestine
rectum
stomach
small colon
large colon
CECUM

Accessory Organs

- Pancreas
  - produces and secretes digestive enzymes
  - produces insulin which regulates carbohydrate metabolism
- Liver
  - produces bile-breaks down fatty acids
  - stores iron, handles fats and carbohydrates in the blood

Nonruminant Digestive Systems –Aves (Birds)


pharynx
beak
small intestine
gizzard
rectum
cloaca
esophagus
yolk sac
ileocecal
valve
crop
duodenum
proventriculus
gall bladder
cecum
liver
pancreas
colon

Poultry digestive system

- Mouth- Beak because poultry have NO teeth
  - can be used to reduce particle size
- Esophagus
  - ingesta holding and moistening
  - connects mouth to crop
  - Salivary Amylase
  - Fermentation in some species
- Crop- stores feed

Avian Species

- Proventriculus
  - Gastric juice production
  - pH 4
  - Rapid pass through of food

Avian Species

- Gizzard (ventriculus)
  - thick muscular wall
  - crushes and mixes feed with digestive juices
  - particle size reduction (similar to mastication)
  - nonglandular
  - normally contains grit and gravel to assist in crushing feed particles
  - no enzymatic secretion
- Liver- produces bile that acts on fats

Avian Small Intestine

- Functions in mixes juices, digestion and absorption of feed and nutrients just as in other monogastrics
- pH is slightly acidic
- Most enzymes found in mammals except?

Avian Large Intestine

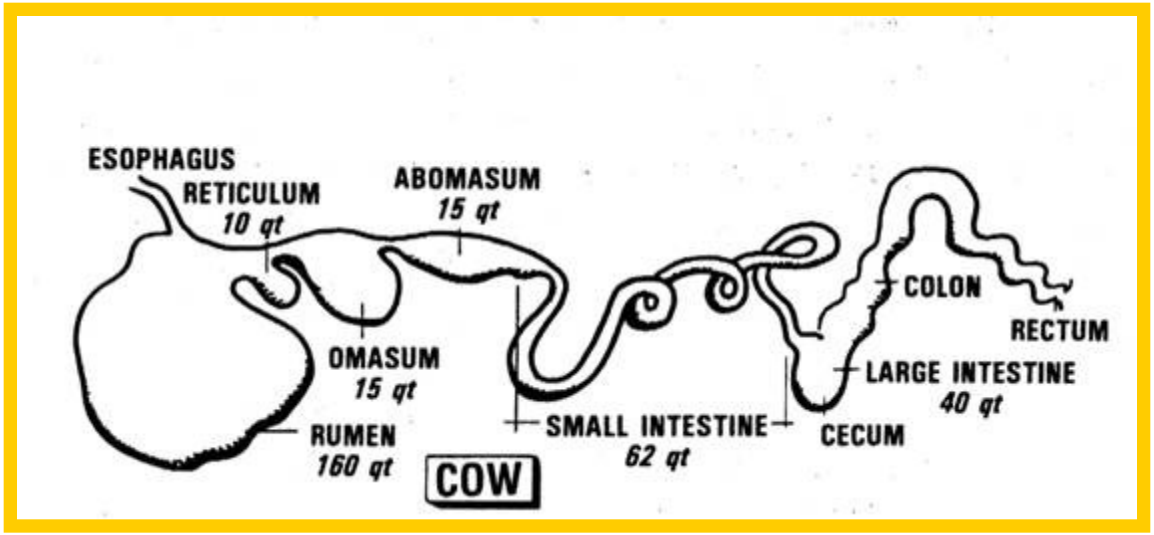
- Contains 2 blind pouches instead of ?
- Mostly water absorption
- adds mucus to undigested feed, which is feces
- Some bacterial activity but less than in most mammals
- very short in comparison

Poultry digestive system

- Vent- anus where both solid wastes (feces) and liquid wastes (urine) pass out of the body
- Poultry digestive system has several special features because poultry have no teeth

Ruminant

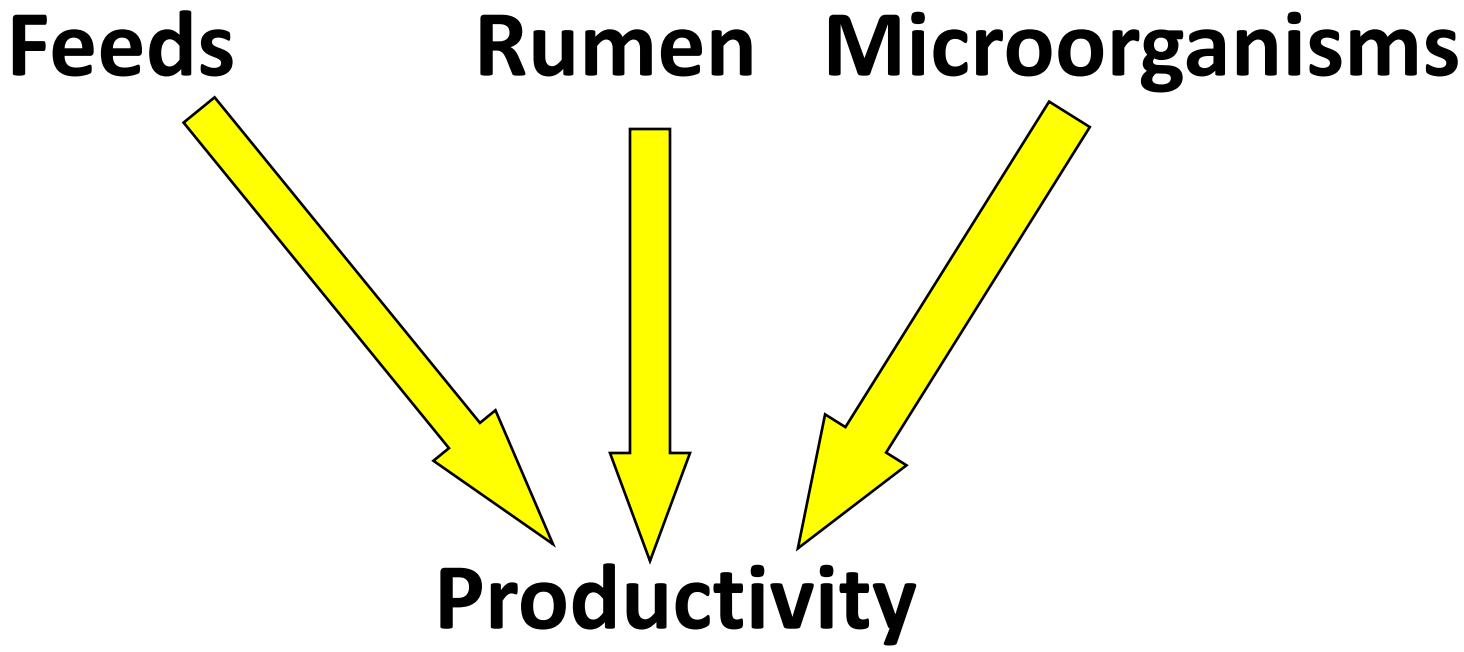
- Most herbivores
- Four <u>compartment</u> stomach
- Fore-gut fermentation vat to digest plants



The Ruminant

Nature’s Amazing Plant-Digesting Machine

Ruminant Nutrition and Feeding:



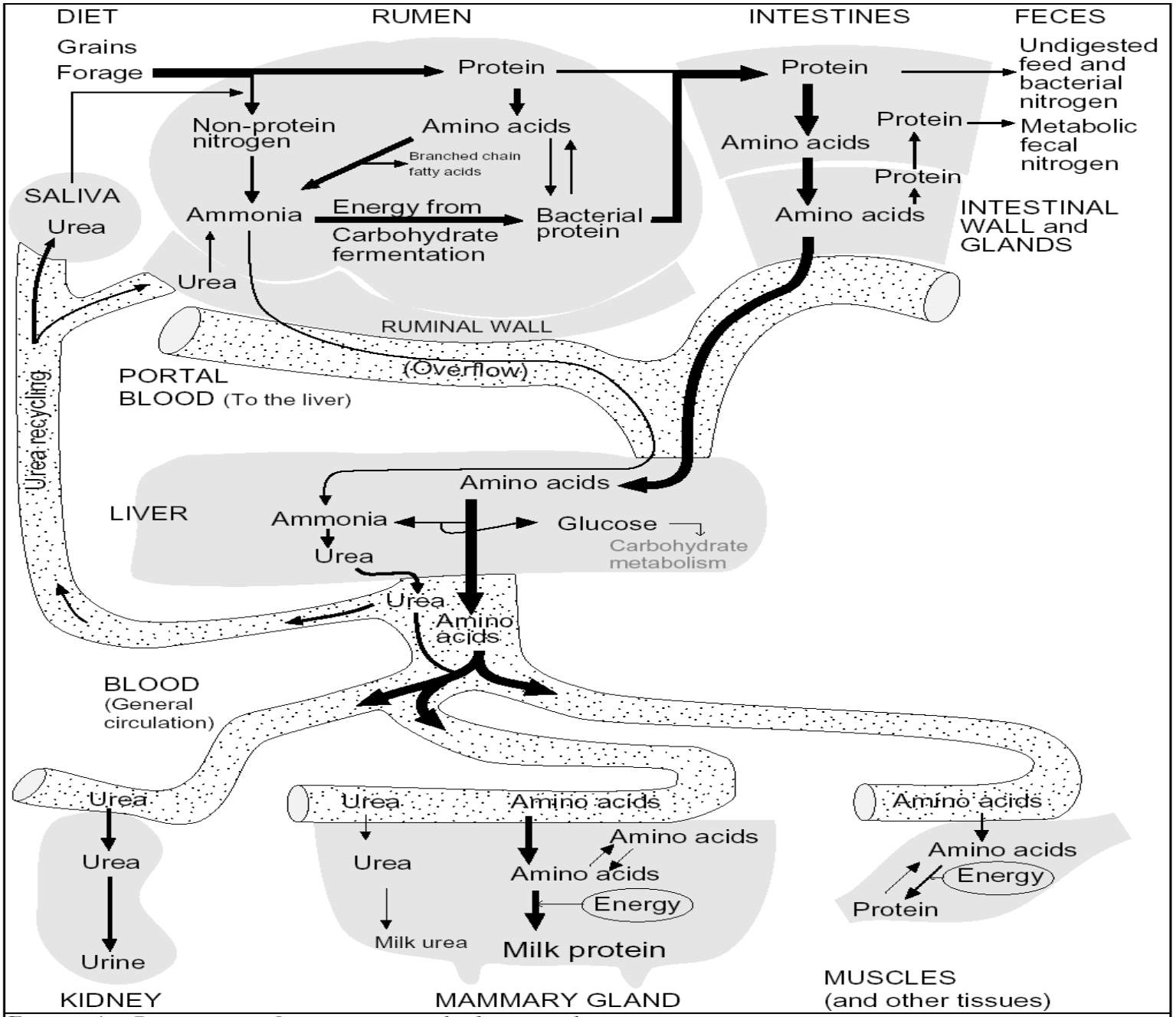


Figure 1: Overview of protein metabolism in dairy cows

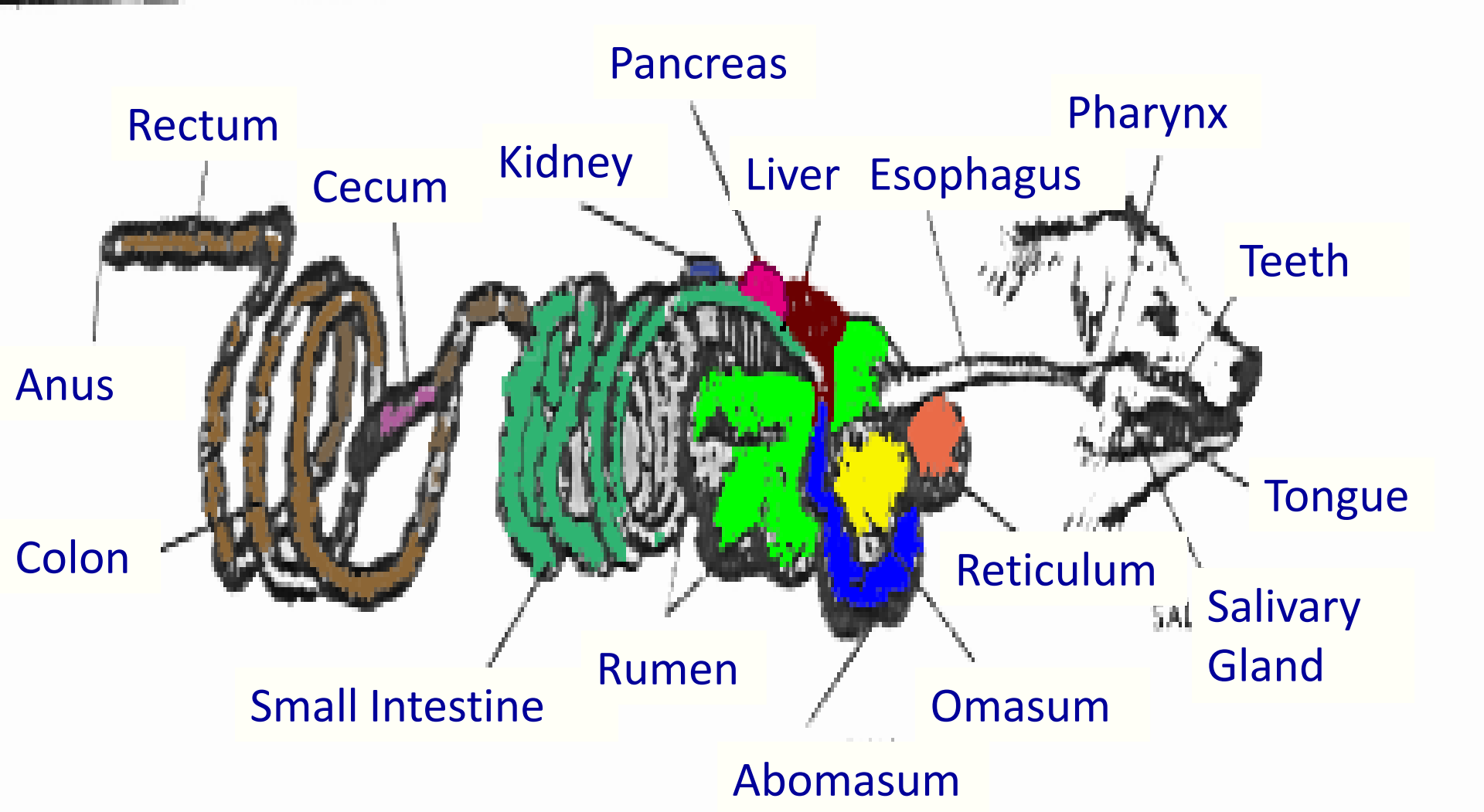
Ruminant Facts (Bovine)

I thought Dumbo was an elephant

- Chews cud
- 40,000-60,000 jaw movements/day
- No upper incisors - dental pad
- Does not “bite” grass - wraps tongue
- Uses fermentation to digest plants
- Symbiotic relationship with bacteria
- Produces 13 gallons of gas/hour
- Produces 40 liters of saliva/day

Ruminant Digestive Systems

- Functions of the digestive system of animals include:
  - ingestion (eating)
  - chewing (mastication)
  - swallowing (deglutition)
  - absorption of nutrients
  - elimination of solid wastes (defecation)


Pancreas
Rectum
Pharynx
Kidney
Cecum
Liver
Esophagus
Teeth
Anus
Tongue
Colon
Reticulum
Salivary Gland
Rumen
Small Intestine
Omasum
Abomasum

Ruminant Digestive Systems

- The digestive system of ruminant animals includes the :
  - Mouth - grasps the food
  - Teeth - grind the food
    - *Ruminants have only one set of teeth in the front of the mouth (incisors), and two sets in the back (molars).*

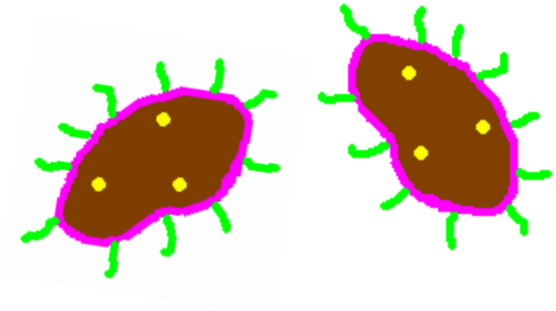
Ruminant Digestive Systems

- Tongue - covered with finger-like projections (***papillae***) that contain taste buds.
- Salivary glands - secrete saliva, that moistens food and is mixed with the food material to aid in swallowing.

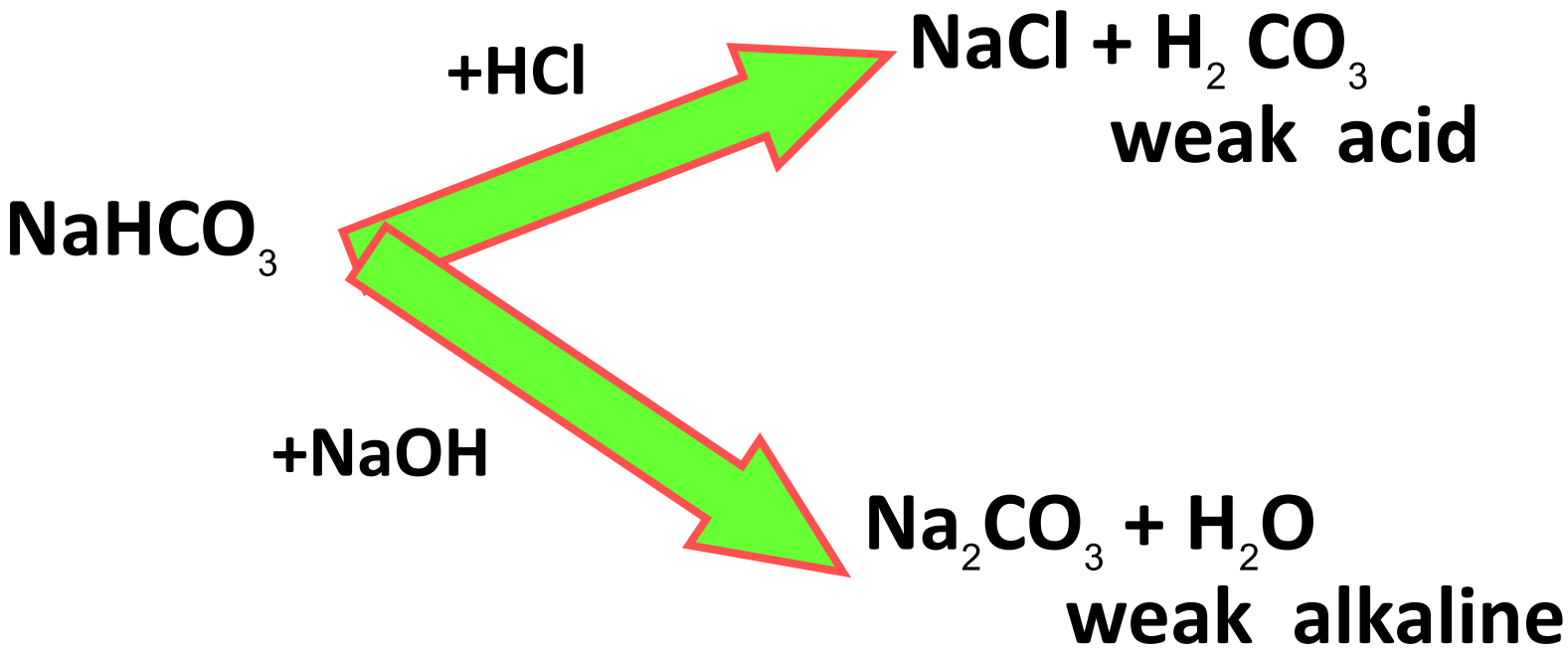
Ruminants..

- the 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

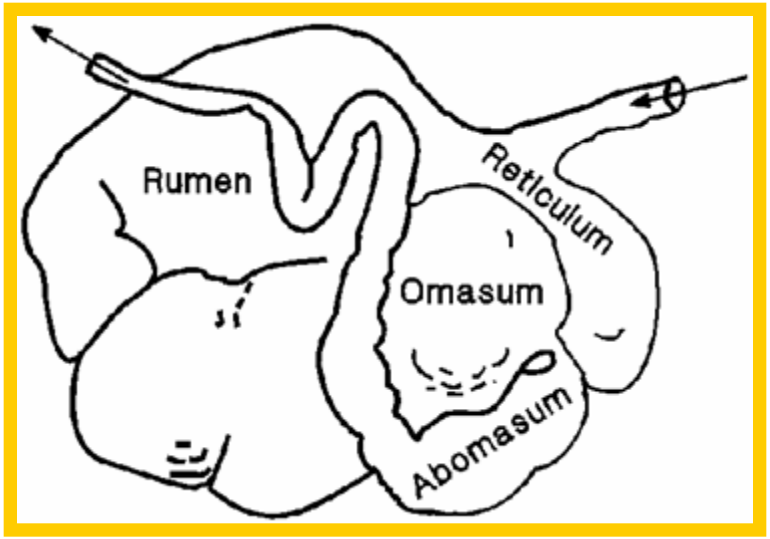


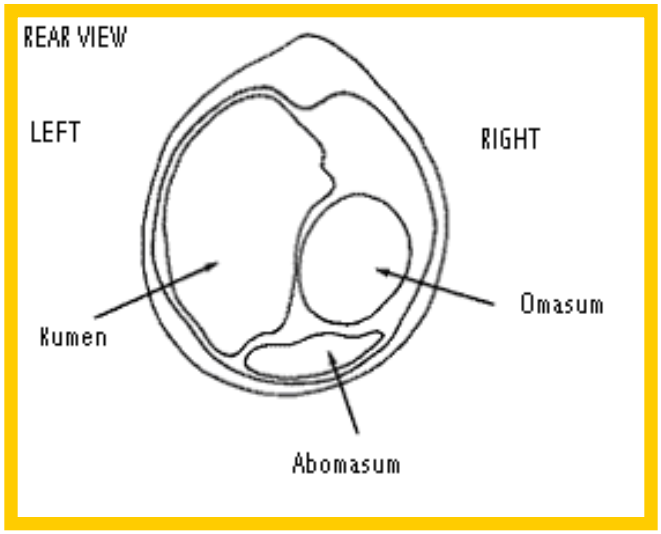
Ruminant Digestive Systems

- **Pharynx - funnels food into the esophagus, preventing food material from entering the lungs.**
- **Esophagus - food tube that leads from the mouth to the stomach.**

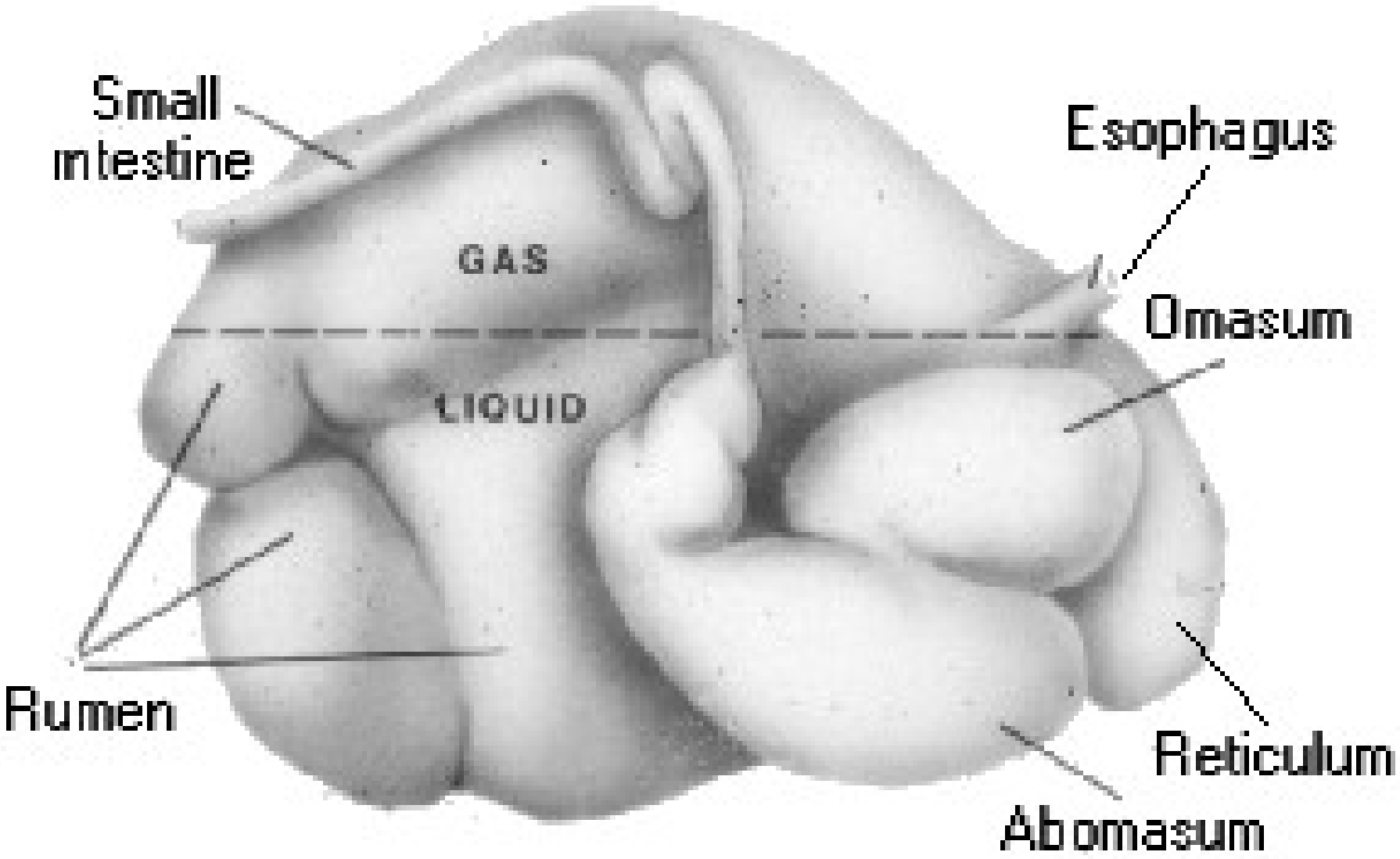
Stomach Compartments

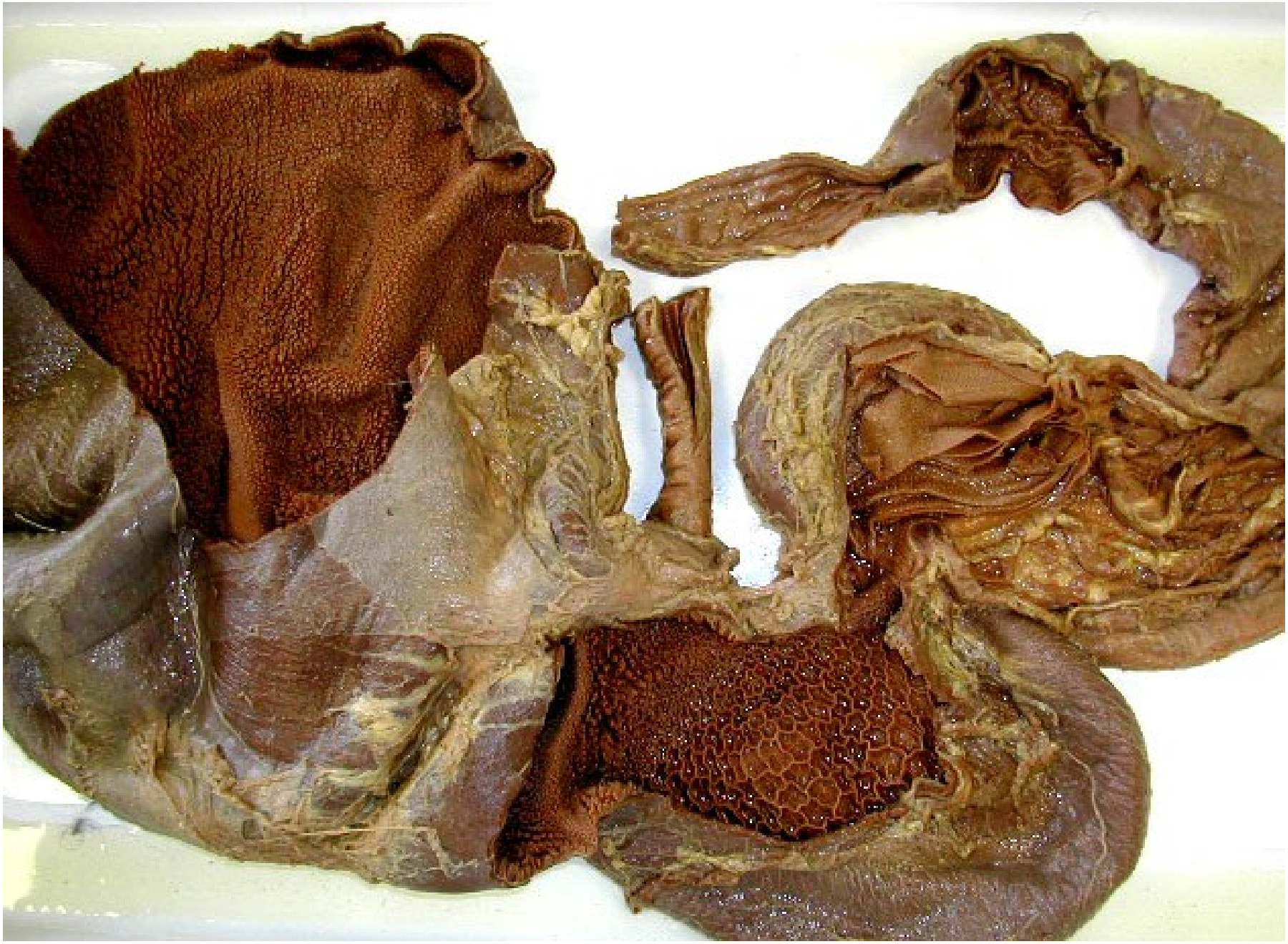
- Rumen - fermentation vat
- Reticulum - rumen's "assistant"
- Omasum - dehydrator
- Abomasum - glandular stomach

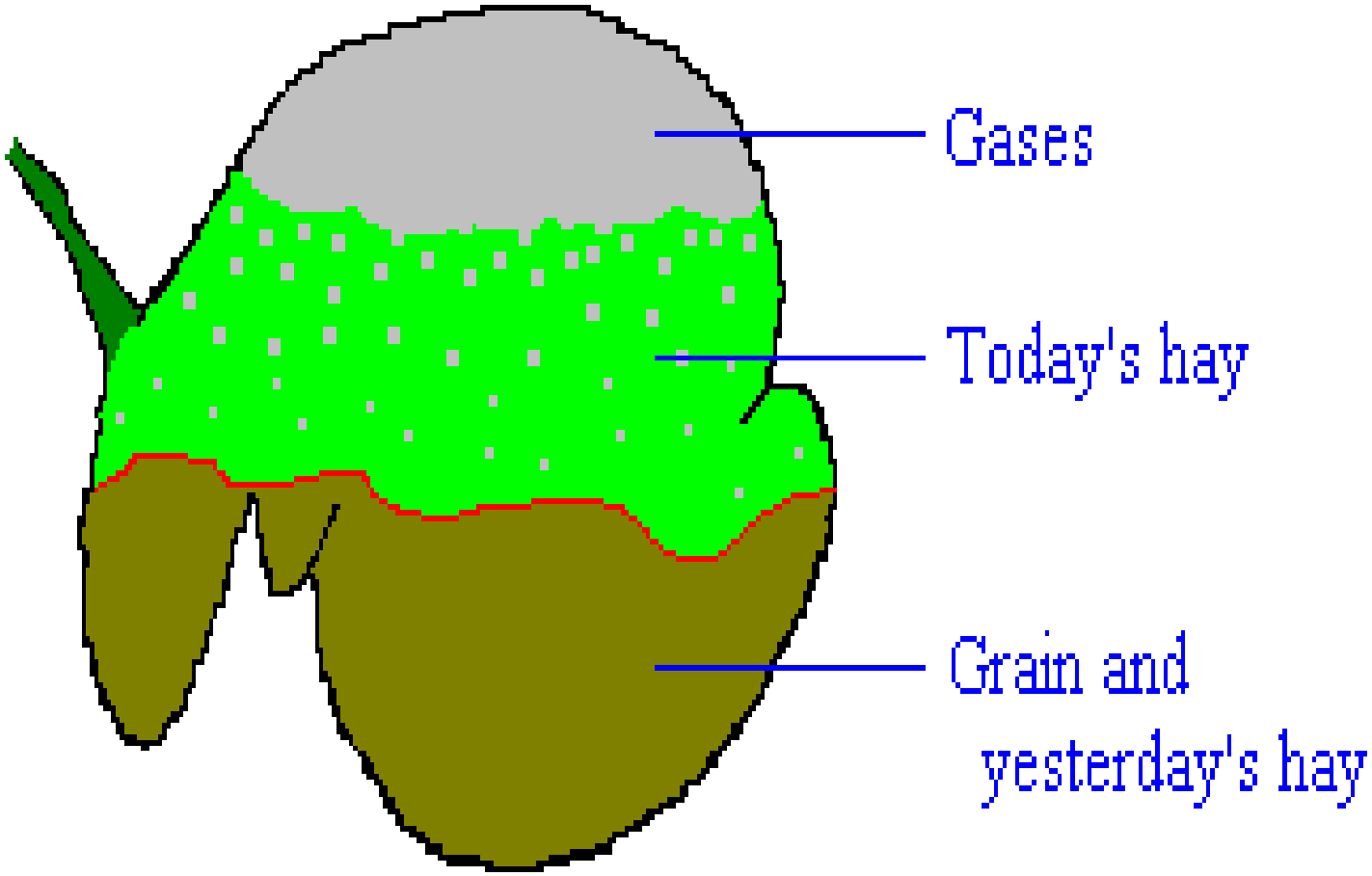


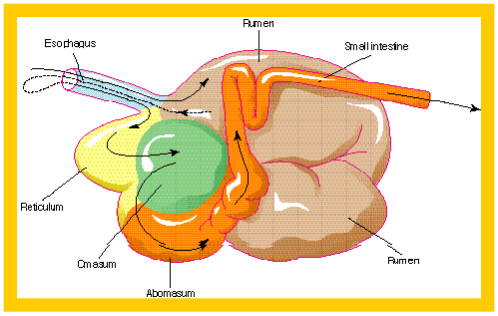


Rumen + Reticulum = Reticulorumen


Small intestine
Esophagus
GAS
Omasum
LIQUID
Rumen
Reticulum
Abomasum




Gases
Today's hay
Grain and
yesterday's hay



Rumen

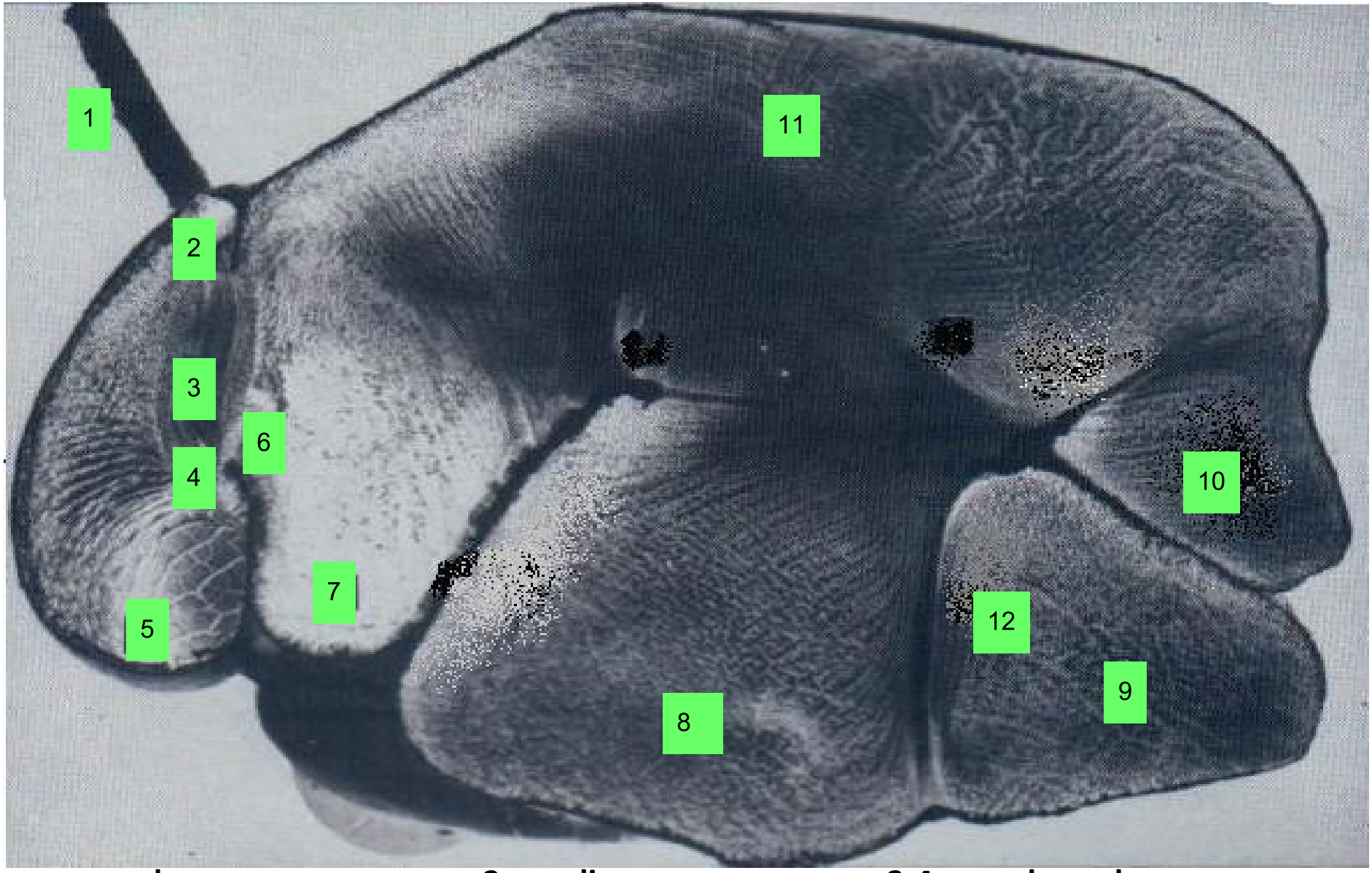
- Largest compartment (80%)
- On left side of animal
- Contains micro-organisms
- Ferments cellulose
- Absorbs VFA's
- Divided into chambers
- Continually contracting
- Contains papillae
- Produces CO_2 and CH_4
- pH close to neutral (6 - 7)

Ruminant Digestive Systems

- Rumen - the organ that allows for bacterial and chemical breakdown of fiber.
  - The rumen has a very thick, muscular wall.
  - It fills most of the left-side of the abdomen

Ruminant Digestive Systems

- The walls of the rumen contain papillae (that can be up to 1 cm. in length), where the bacteria that are used to breakdown fiber live.
- In some ruminants (dairy cattle) the rumen can have a capacity of 55-65 gallons!



1= esophagus 2= cardia 3-4 =esophageal groove

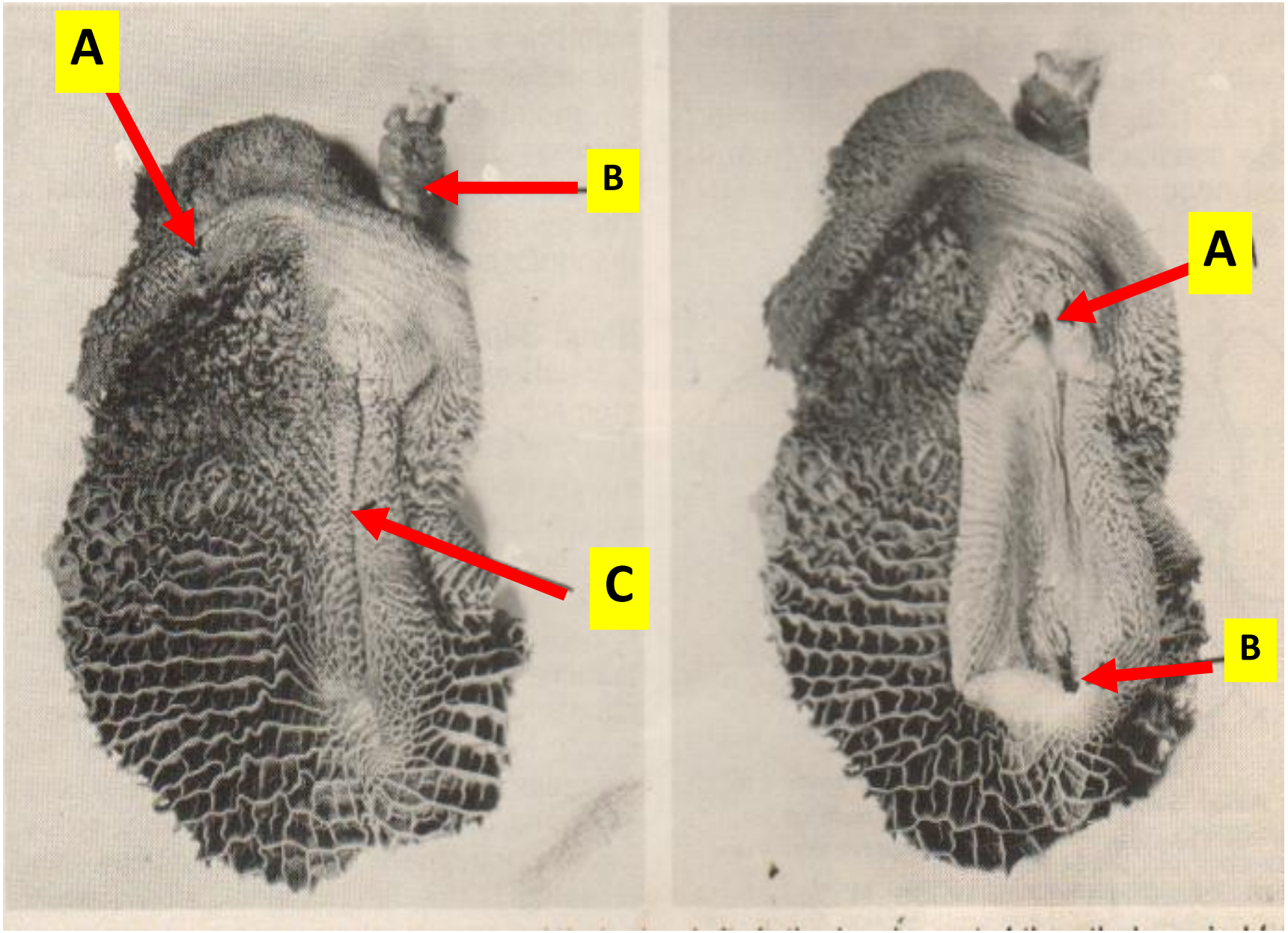
5= reticulum 6=space between reticulum and rumen cranial sac

7= cranial sac of rumen 8= ventral of rumen 9= caudal-ventral blind sac

10= caudal-dorsal blind sac 11= dorsal of rumen


Papillae in Rumen


Papillae in Rumen



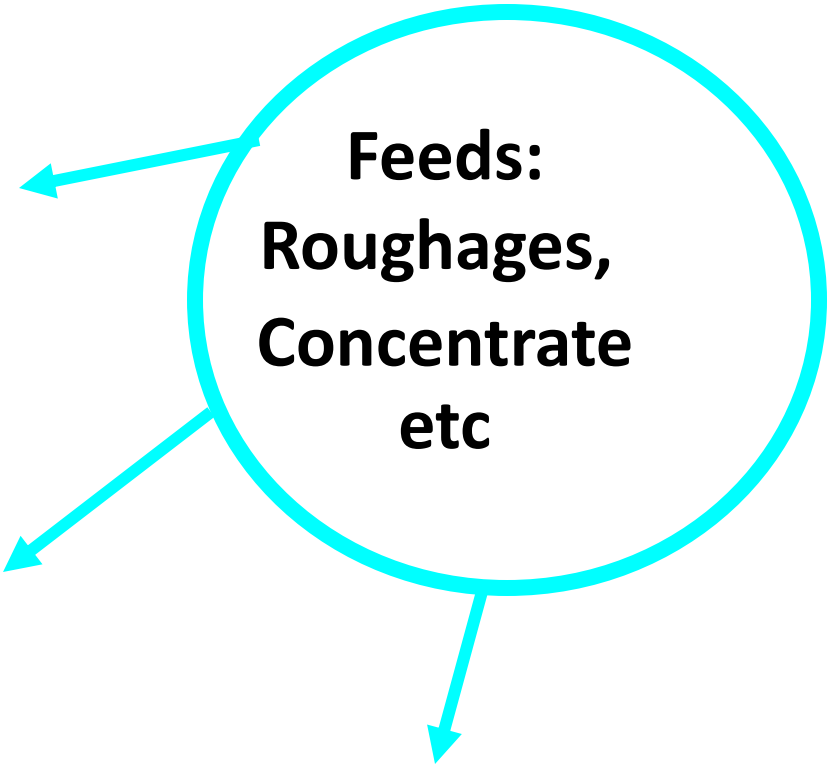
A= reticulo-ruminal fold
B=esophgus
C= esophagus/reticular groove

A = cardia
B= reticulo-amasal orifice

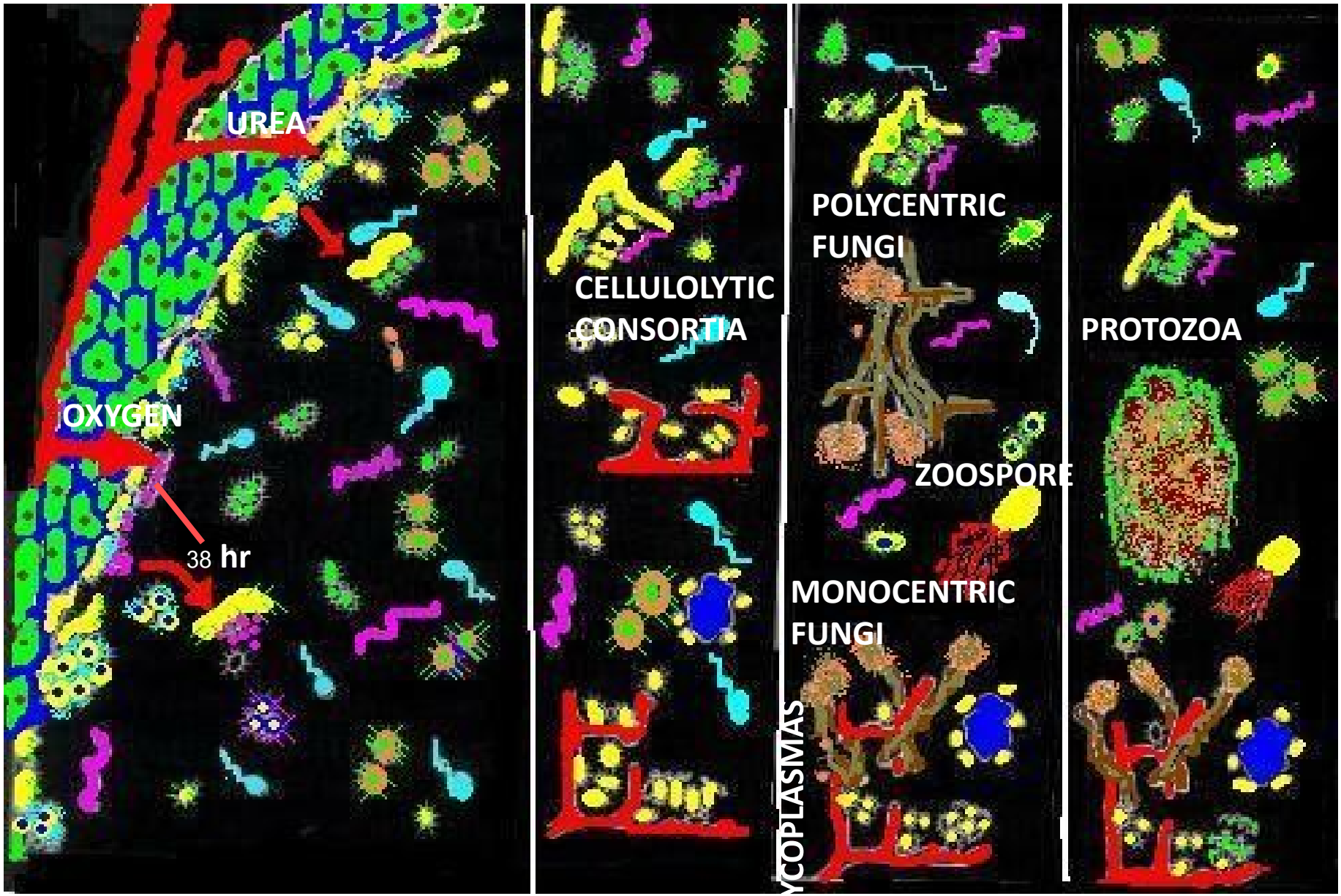
Rumen as a Fermentation Vat :

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)

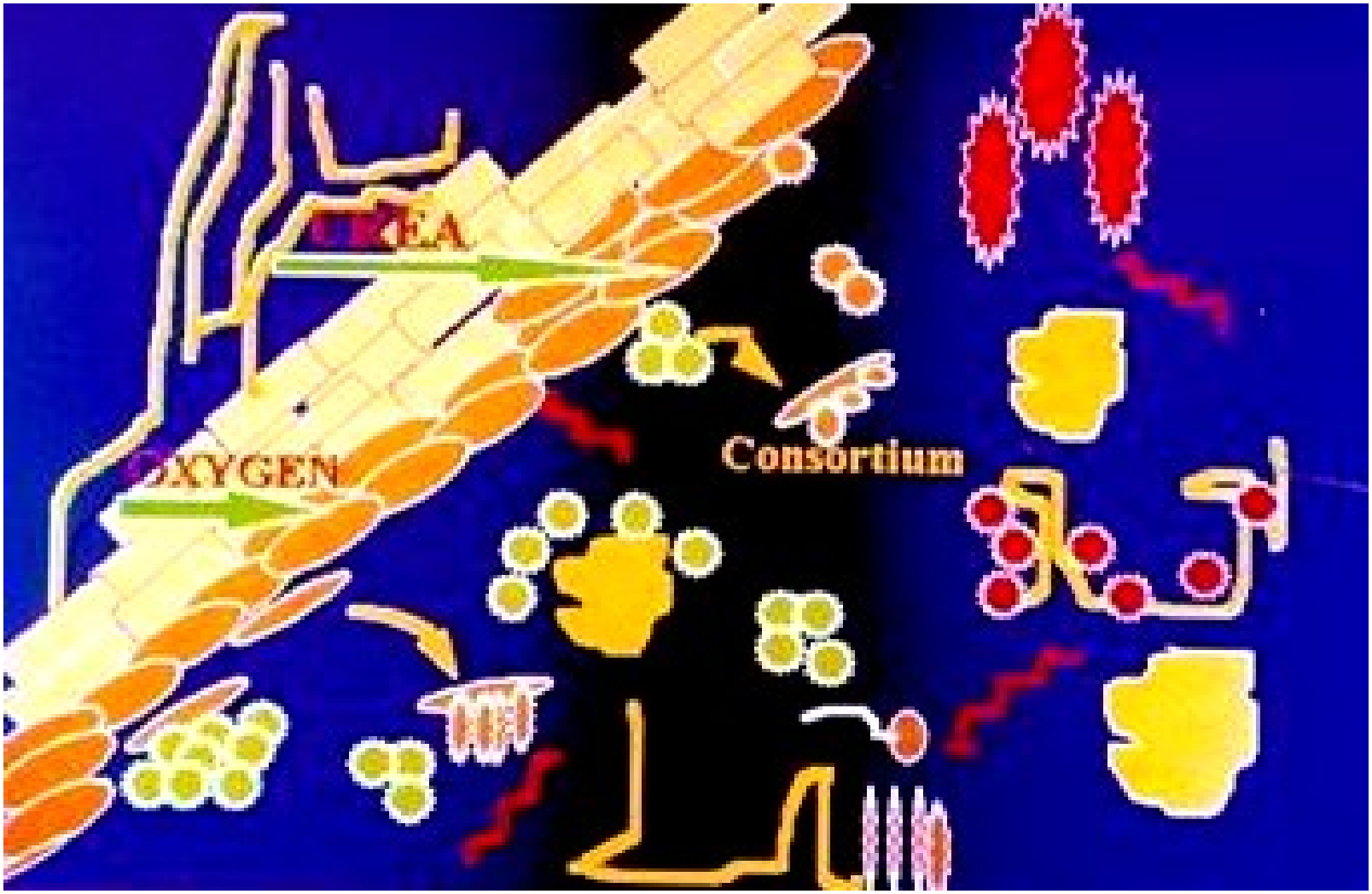


Diagrammatic representation of the sequential development of the microbial ecology of the newborn ruminant.

Rumen Bacteria

- 10^{10} -10^{12} cells/ml rumen fluid
- Cellulolytic bacteria
- Amylolytic
- Proteolytic
- NH_3-N utilizing

  etc



Distribution of rumen bacteria

75% = **bacteria adhered to feeds**

20% = **flow in rumen fluid**

5% = **adhered to inner surface to rumen epithelium**

Rumen Protozoa

- Ciliated protozoa
- $10^{4-}10^{6}$ cells/ml
- larger > bacteria

  38 *micron* in length

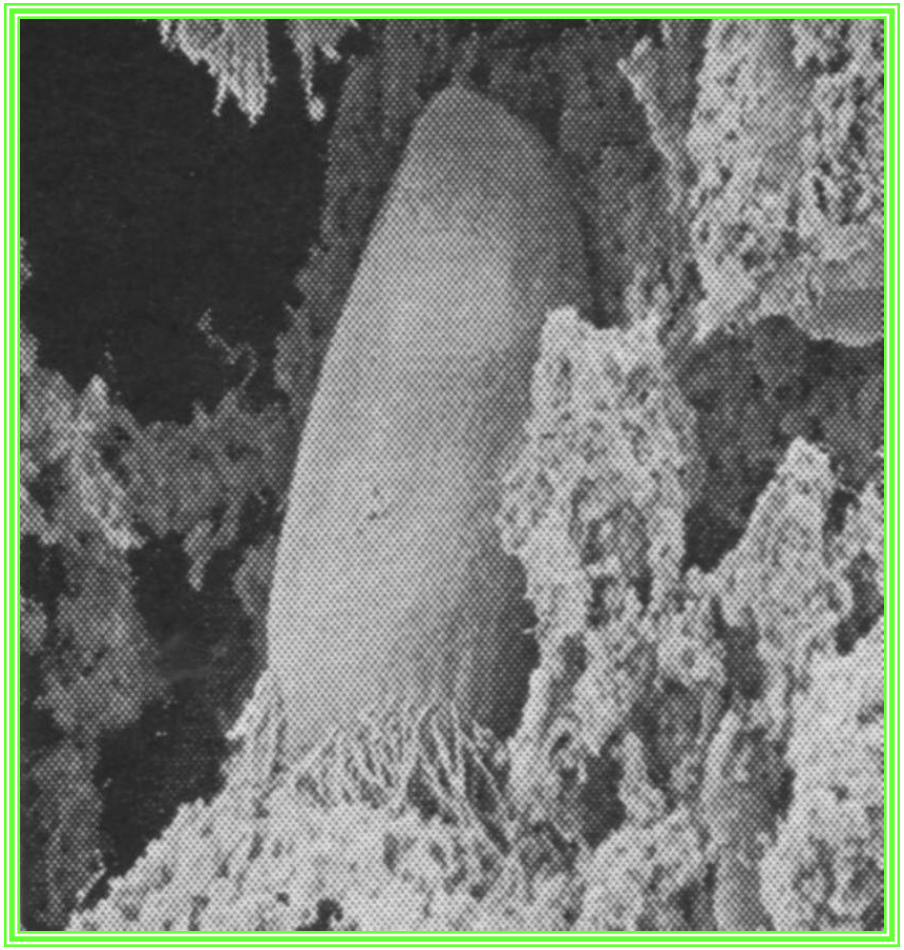
  15 *micron* in width
- moves rapidly

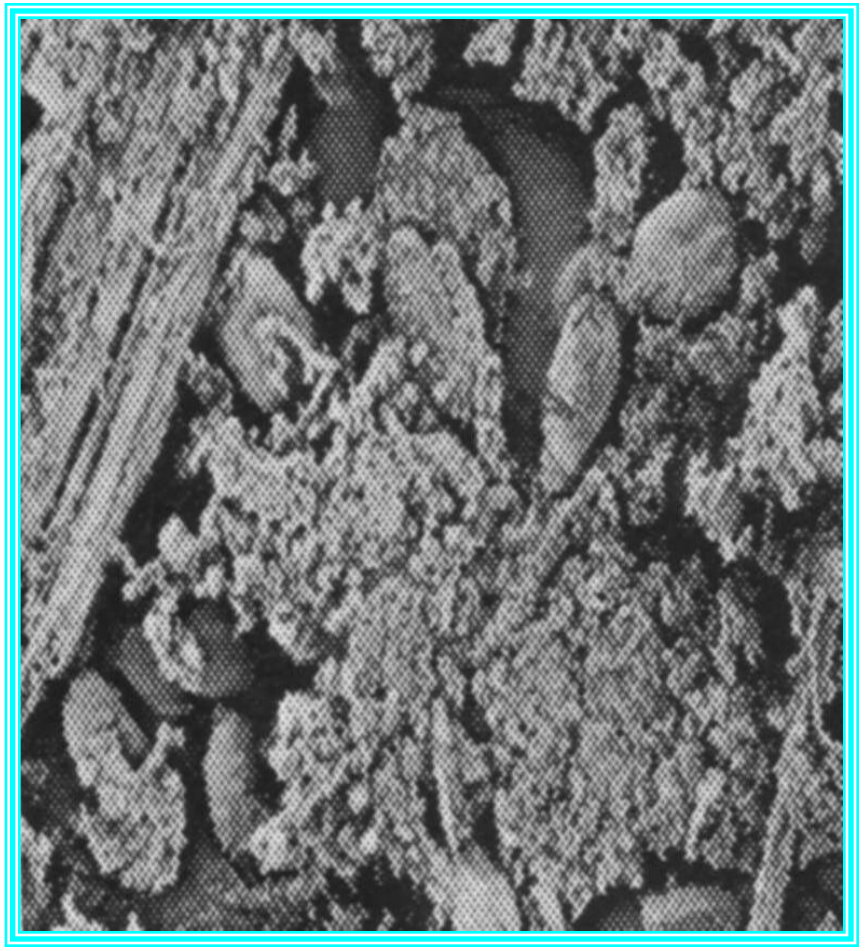
- **Holotrich- Subclass**
  - **absorbs sugar**
- **Entodinimorph (tuft)**
  - **digest starch**

- **Stores surplus CHO**
- **Can not use NPN**
- **Engulf bacteria 200 cells/min**

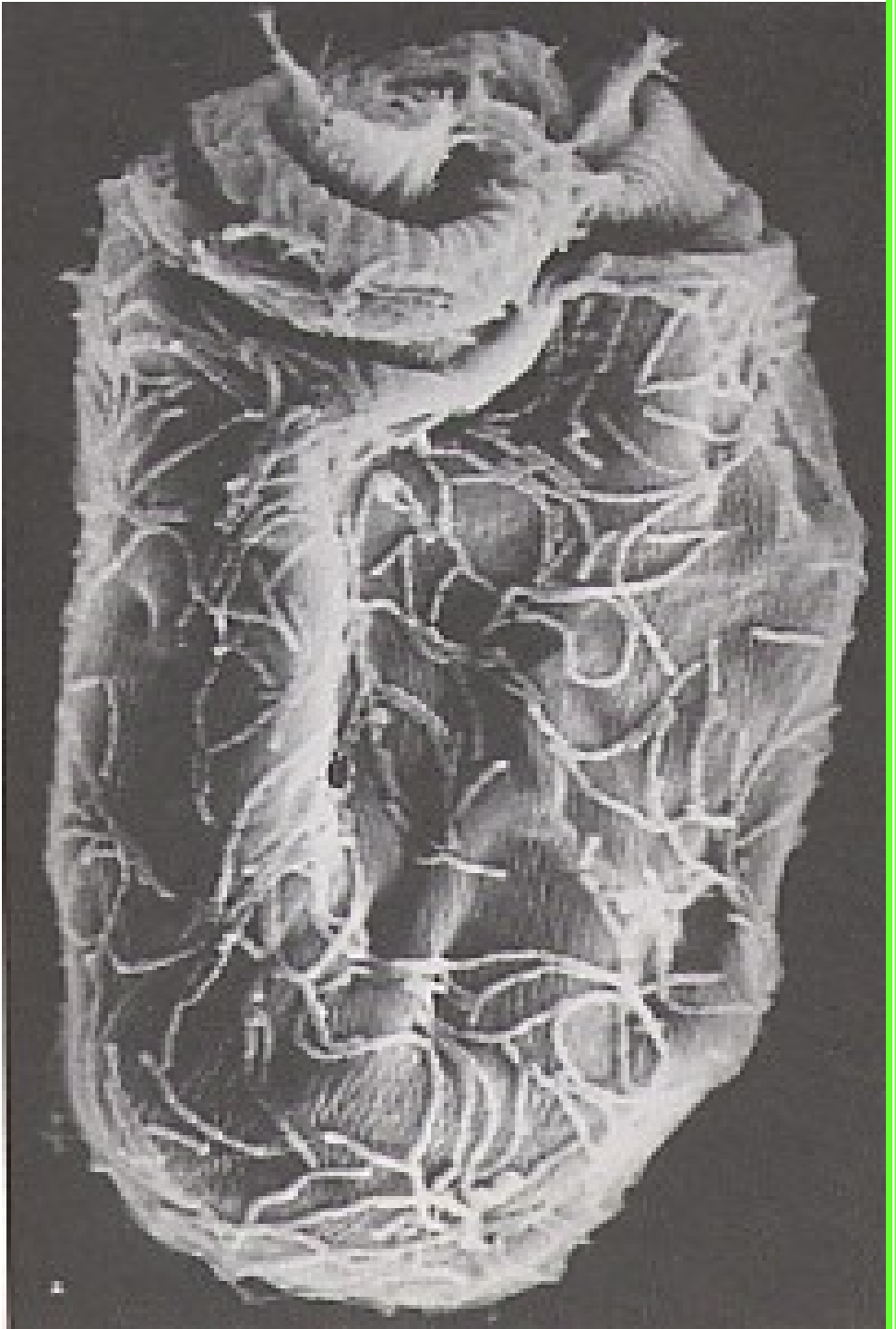
  1% bacteria/min
- **Defaunation vs Nondefaunation**

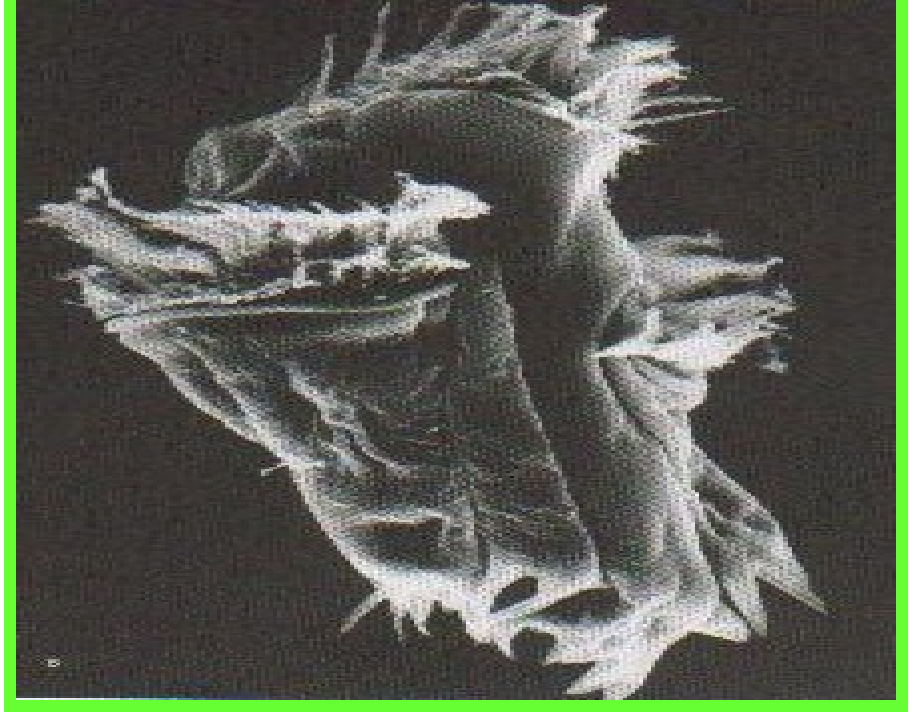
Rumen protozoa,
***Holotrich* sp.**
(**Hungate**, 1966)



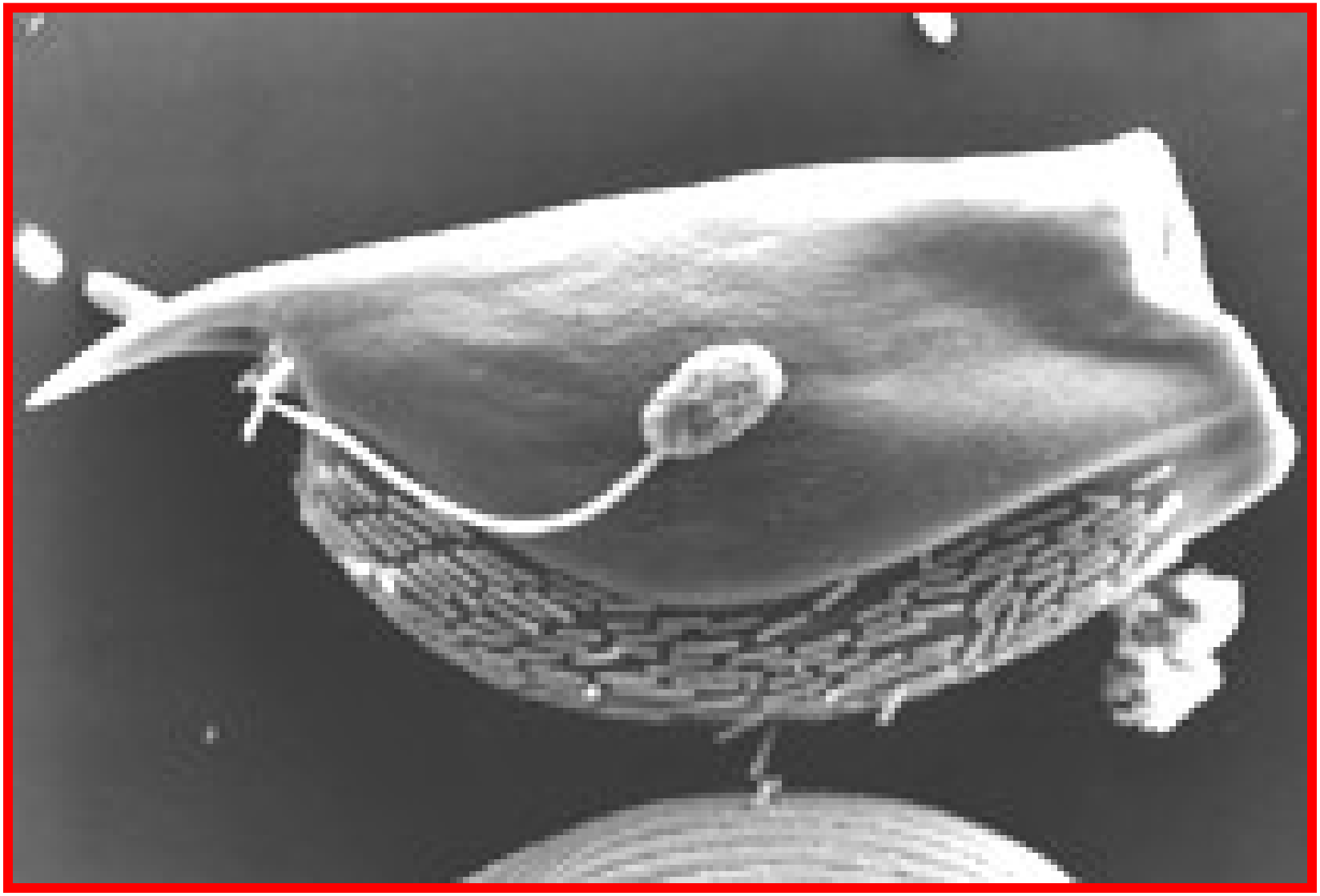


Rumen protozoa, *Entodiniomorph* sp. of swamp buffalo (Wanapat et al., 2000b)





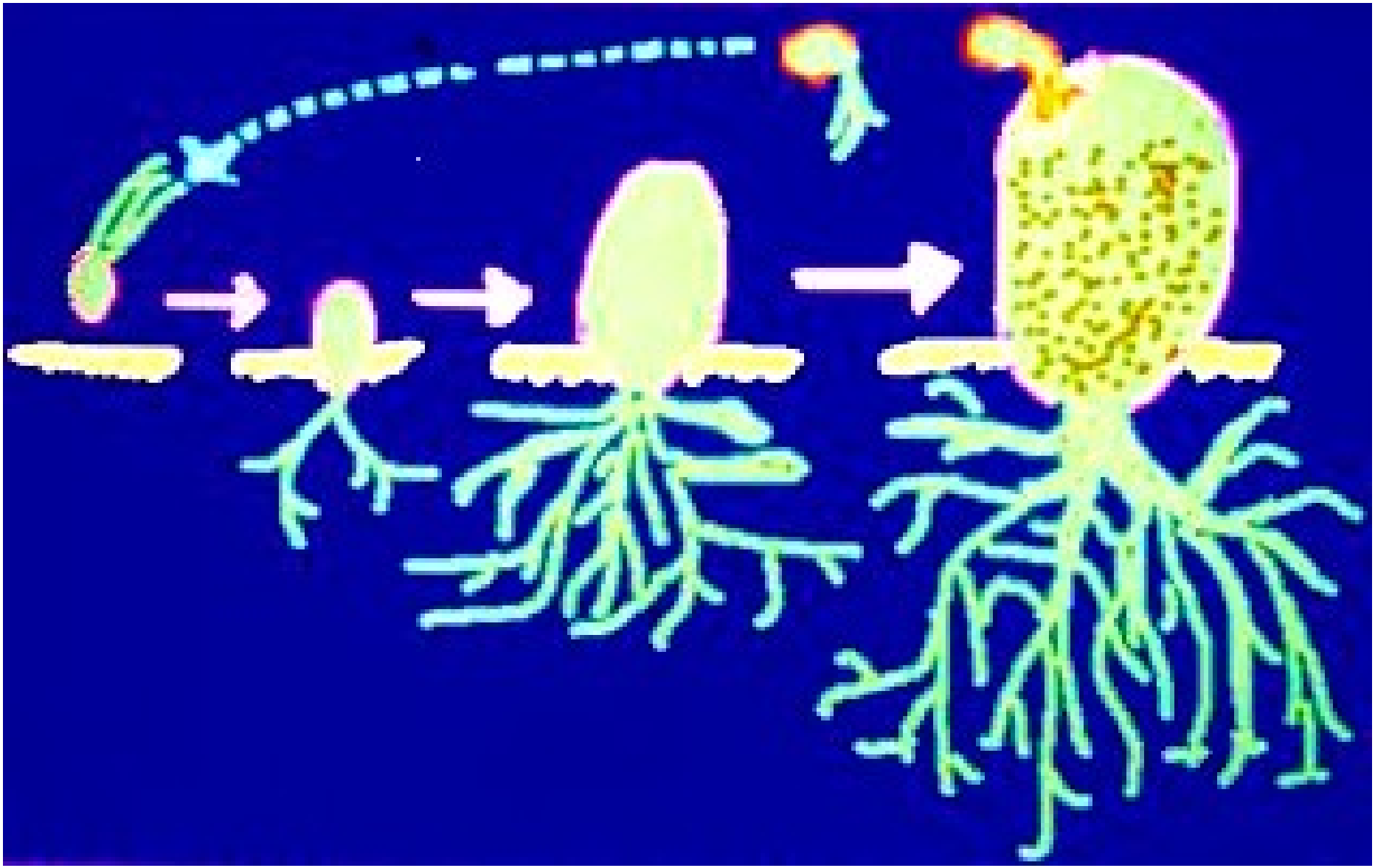
Entodiniomorph *Diplodinium* with adherent methanogenic bacteria



Symbiosis of bacteria protozoa and fungal zoospores

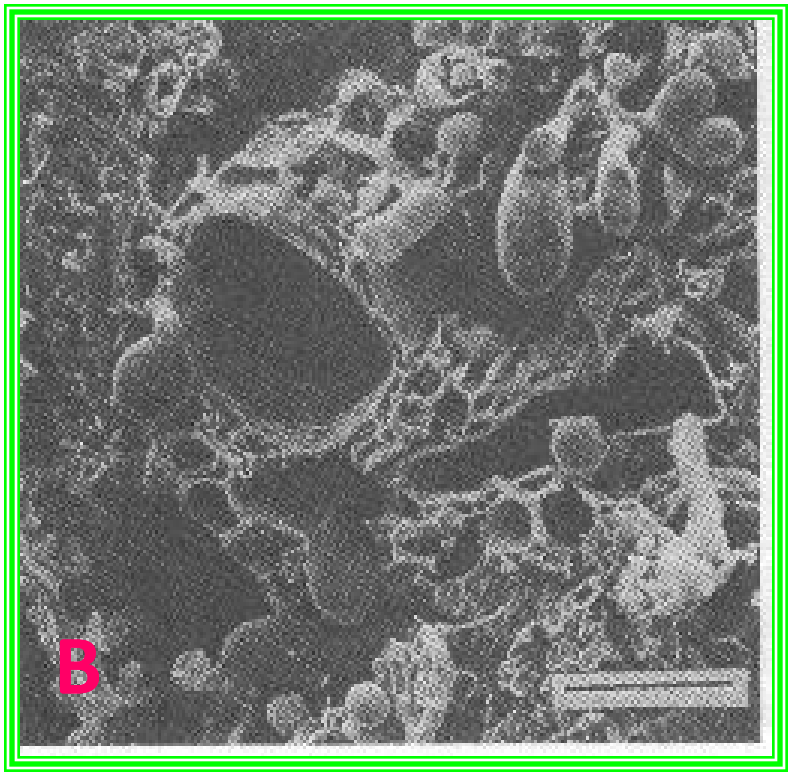
Rumen Fungi

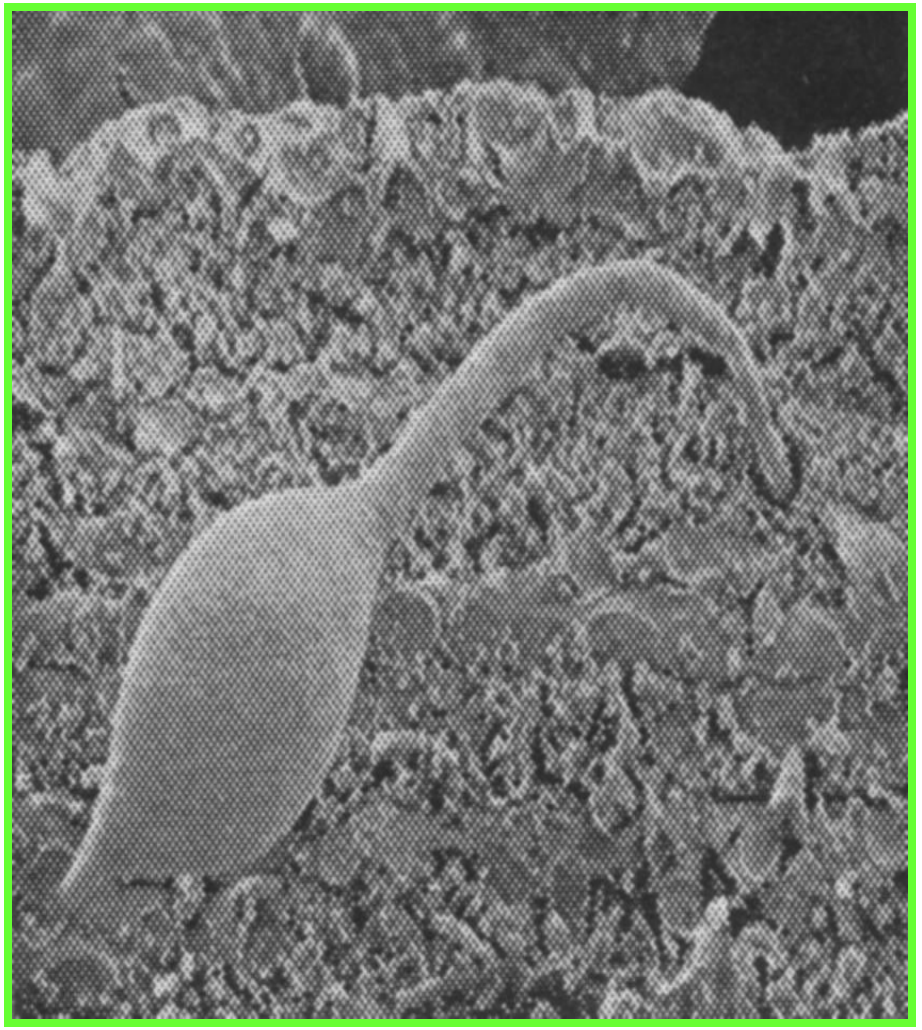
- ~ 8% of total rumen microbes
- ~ 20 genera
- low in number
- digest fiber with bacteria



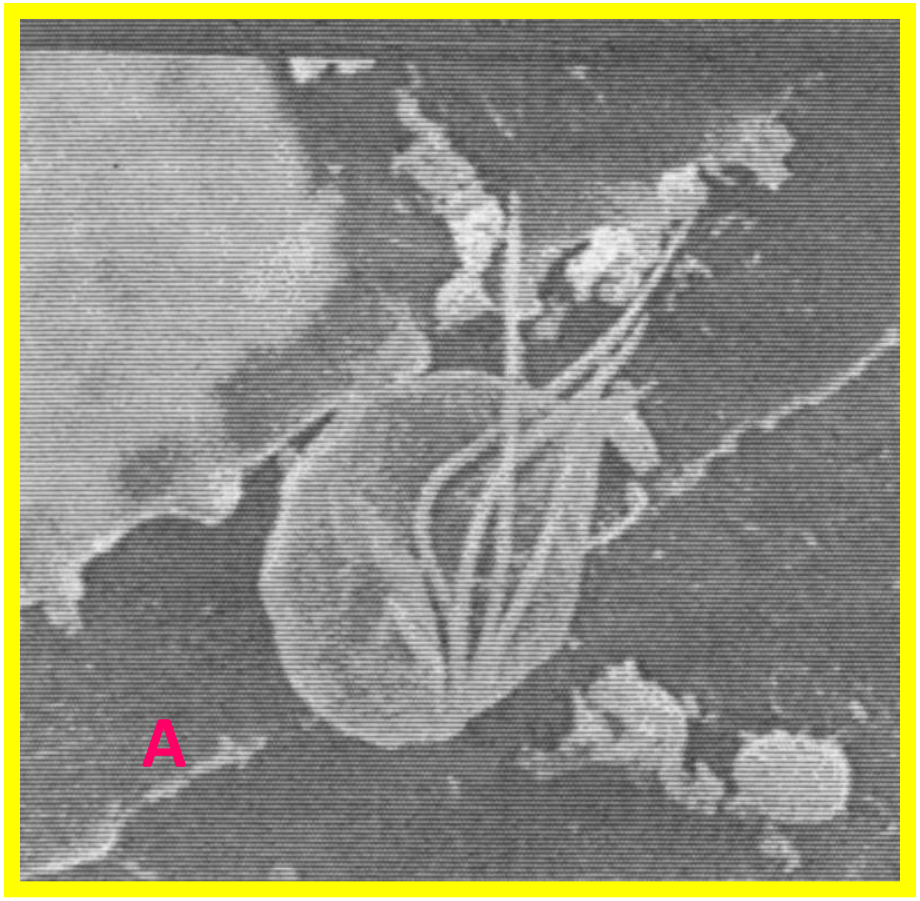
Life cycle of rumen fungi

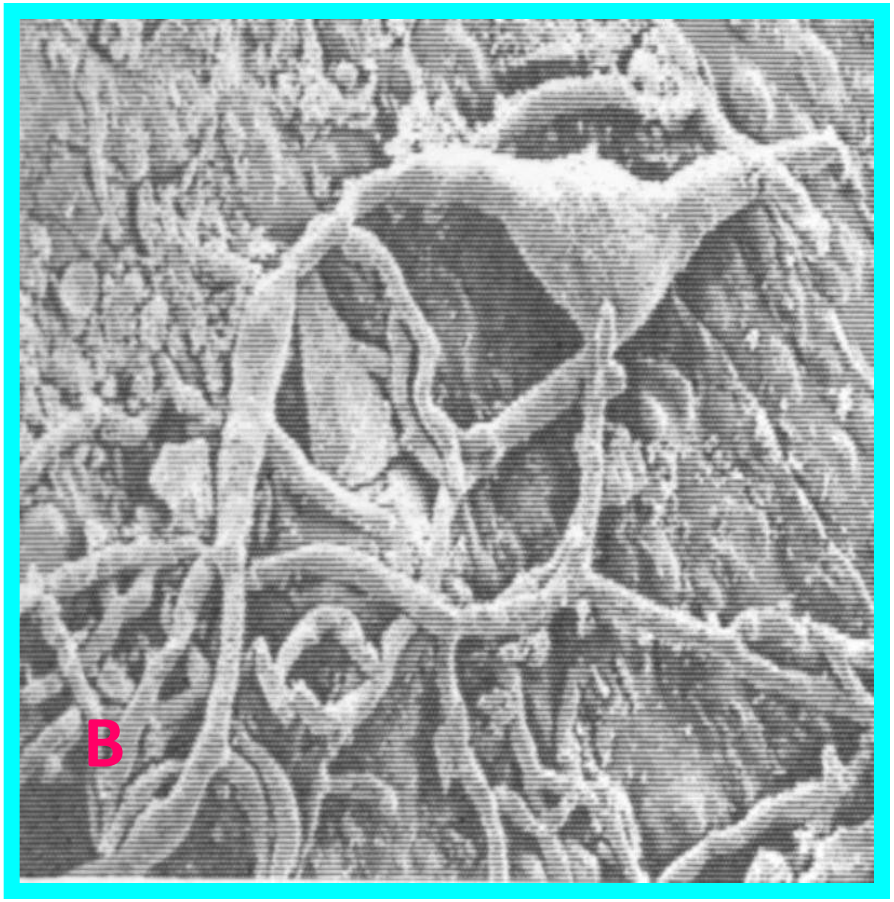
Rumen fungi on fiber digestion





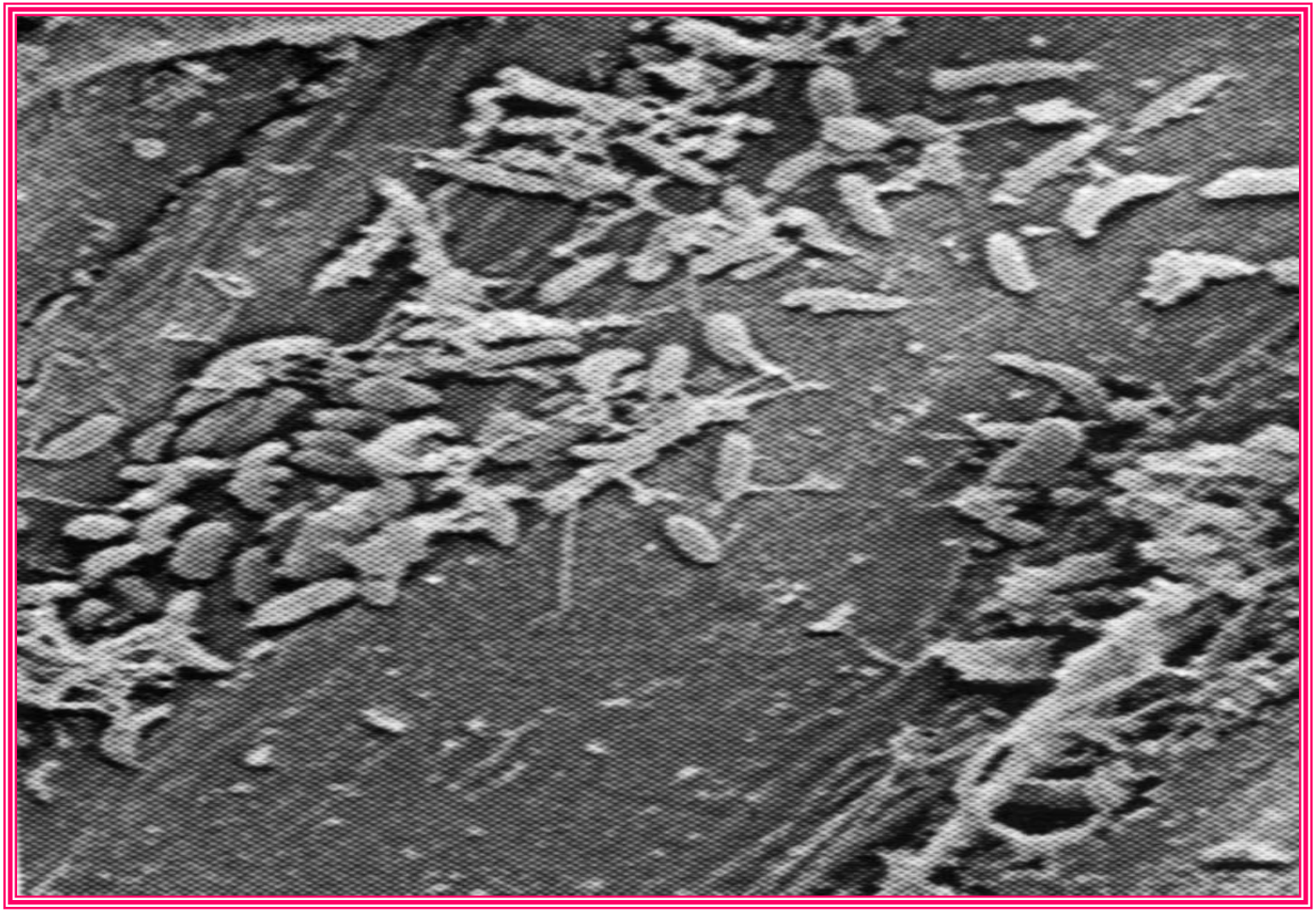
Rumen fungus of swamp buffalo, ***Anaeromyces*** **sp. with acuminate apex (Wanapat et al.,** 2000**b)**



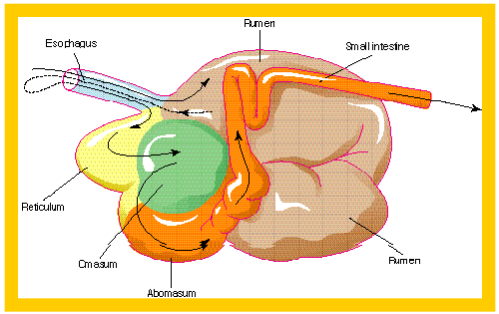


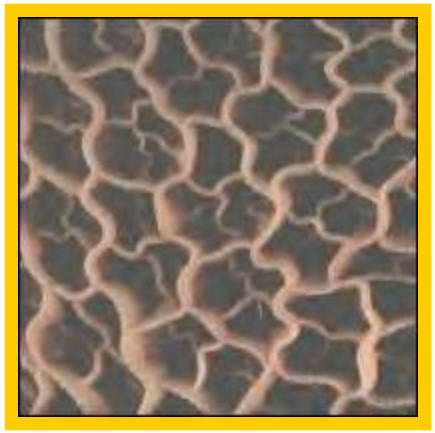
A = Rumen fungal sporangium with flagellae

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



Reticulum





- Smallest compartment (5%)
- 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

Ruminant Digestive Systems

- At this point, ruminant animals have a ***multi-chambered "stomach"***
  - Reticulum - honeycomb-like interior surface, this part helps to remove foreign matter from the food material.


Omasum - full


Reticulum - full


Reticulum - cleane

Ruminant Digestive Systems

- *Ruminant animals grasp mouthfuls of food and swallow it before it is chewed.*
  - *They wrap their tongue around a mouthful of grass, clamp down their teeth, and pull to break the grass at its weakest point, and swallow.*

Ruminant Digestive Systems

- *Ruminants will“chew their cud” (regurgitate) their food material and then grind it with their molars at a time when the animal is resting.*
- *This is done until the food particles are small enough to pass through the reticulum into the rumen.*

Ruminant Digestive Systems

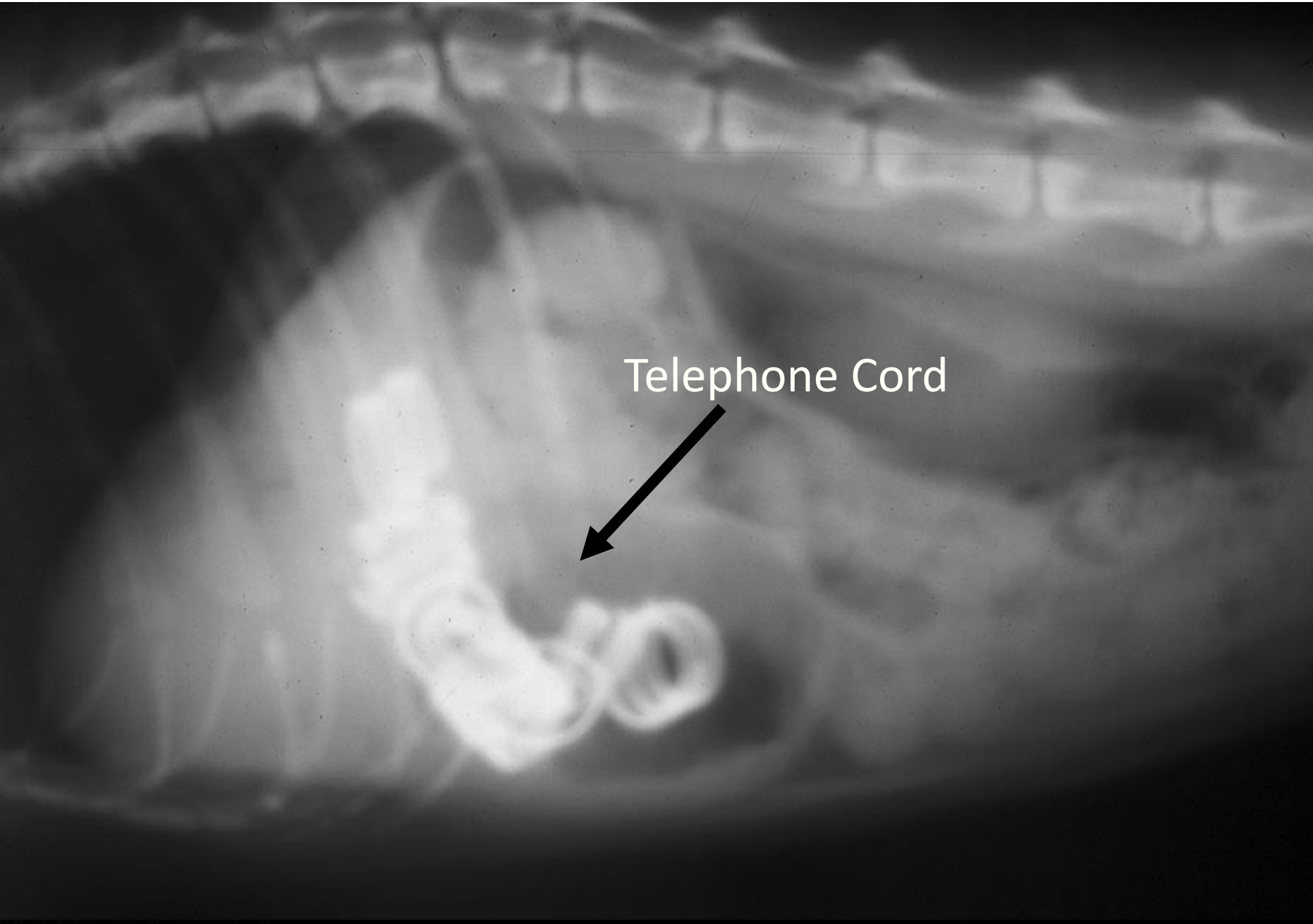
- *Since ruminant animals do not "chew" their food when it is taken in, at times foreign material like rocks, nails, small pieces of wire, can be swallowed.*

Ruminant Digestive Systems

- *While the animal is "chewing its cud" foreign particles that are heavy are allowed to "sink" in the reticulum, preventing many foreign particles from entering the rest of the digestive system.*
- *Once foreign material enters the reticulum, it stays there for the life of the animal.*

Ruminant Digestive Systems

- *If enough of this foreign material remains in the reticulum, it may cause damage and infection of the reticulum (hardware disease).*



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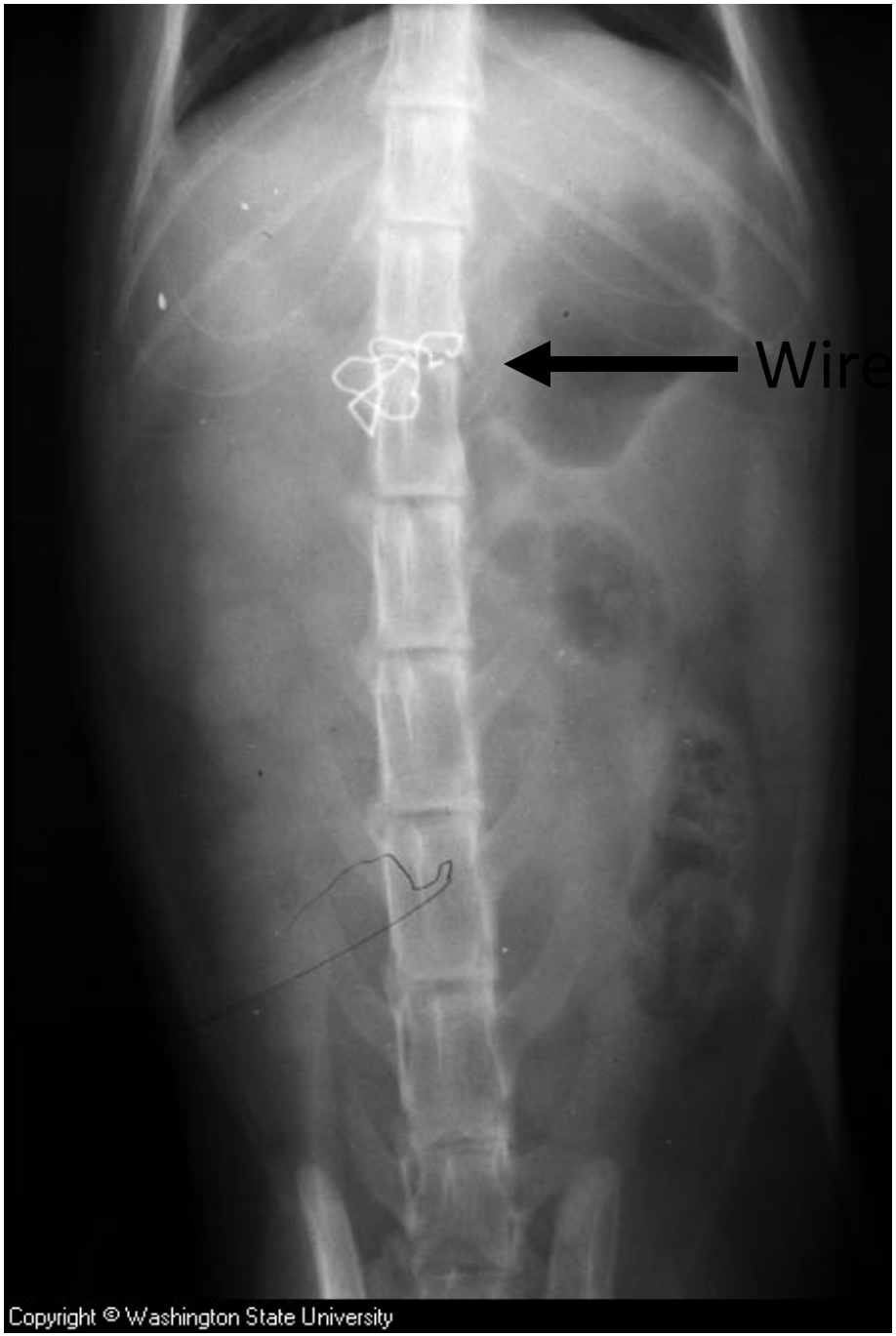
Wire
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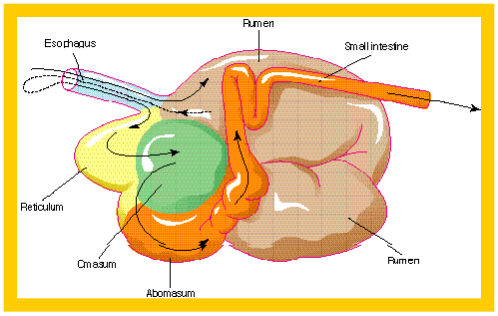
Sponge taken from digestive system of an animal



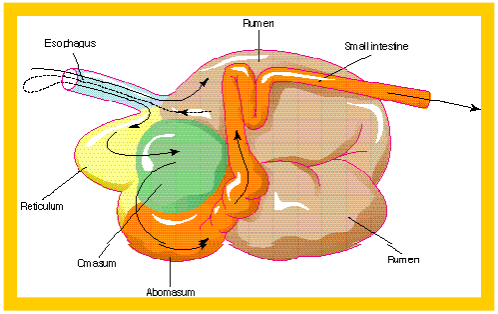
Omasum

- Third compartment (7-8%)
- Globe-shaped
- Lining called “many plies”
- Reduces feed particle size
- Absorbs water and dries out ingesta
- Absorbs volatile fatty acids

Ruminant Digestive Systems

– Omasum - section that is round and muscular.
  - “Grinds” the food material and prepares the food material for chemical breakdown.
  - reswallowed cud will be sent here

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

Ruminant Digestive Systems

- Abomasum- (7-8%) very similar to the stomach of non-ruminants.
  - this is where the majority of chemical breakdown of food material occurs.
  - mixes in digestive enzymes (***pepsin, rennin, bile, etc***.).

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***

Ruminant Digestive Systems

- The food material is continually squeezed as it is moved through the small intestine, becoming more solid.
- The majority of the food material absorption occurs in the duodenum and the jejunum.

Ruminant Digestive Systems

- Large Intestine - begins to prepare unused food material for removal from the body
  - *a portion of the large intestine in some animals contain pouches that may contain enzymes for further species-specific digestion (horses and rabbits (**cecum**)).*

Ruminant Digestive Systems

- Colon - collects the unused food material that is to be removed from the body
- Rectum - “poop chute”
- Anus - opening through which the waste is removed.
  - Controlled by sphincter muscles, that also help protect the opening.

Flow of food in ruminant

mouth

swallow

oesophagus

rumen

fermentation

curd

reticulum

regurgitation

mouth

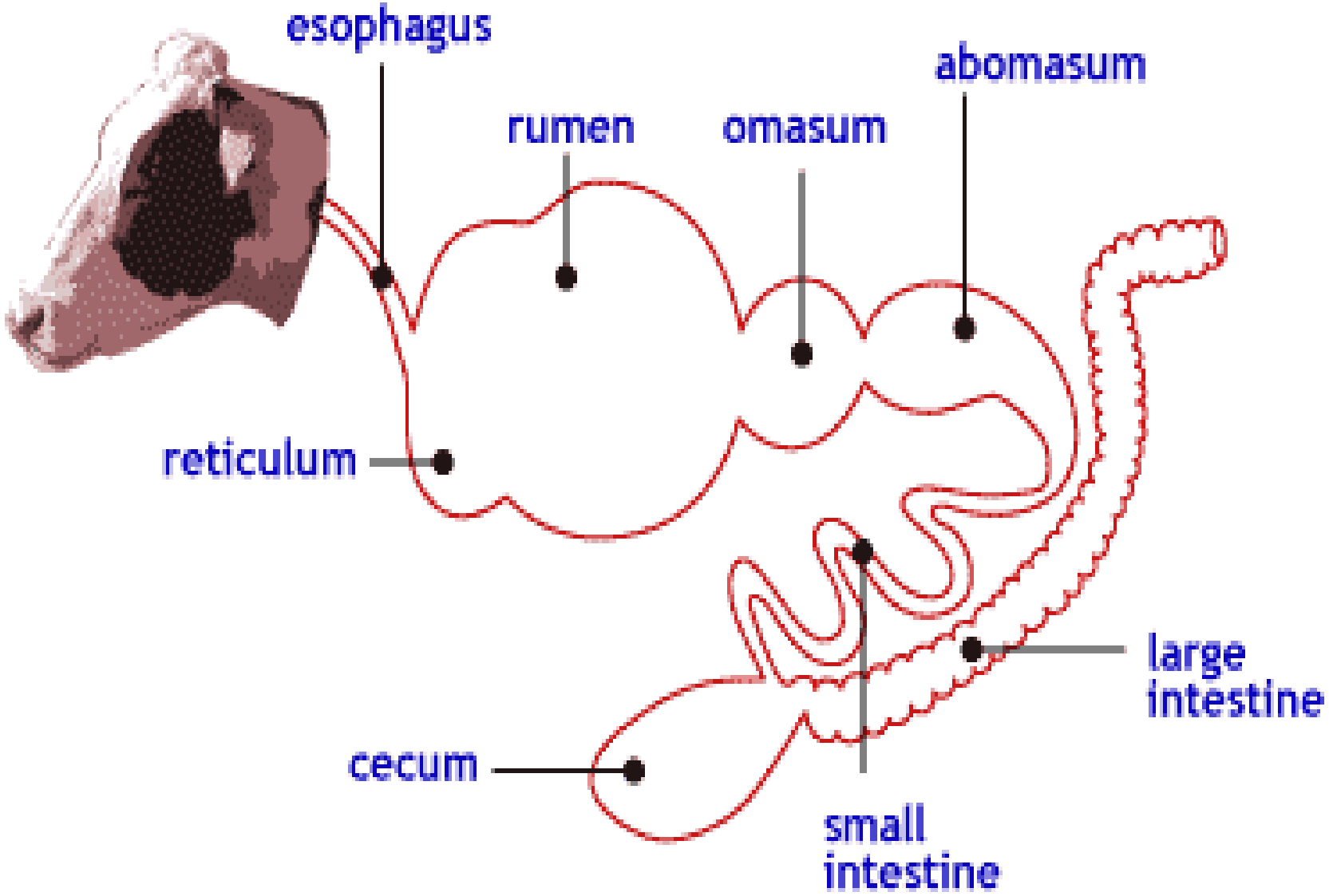
swallow

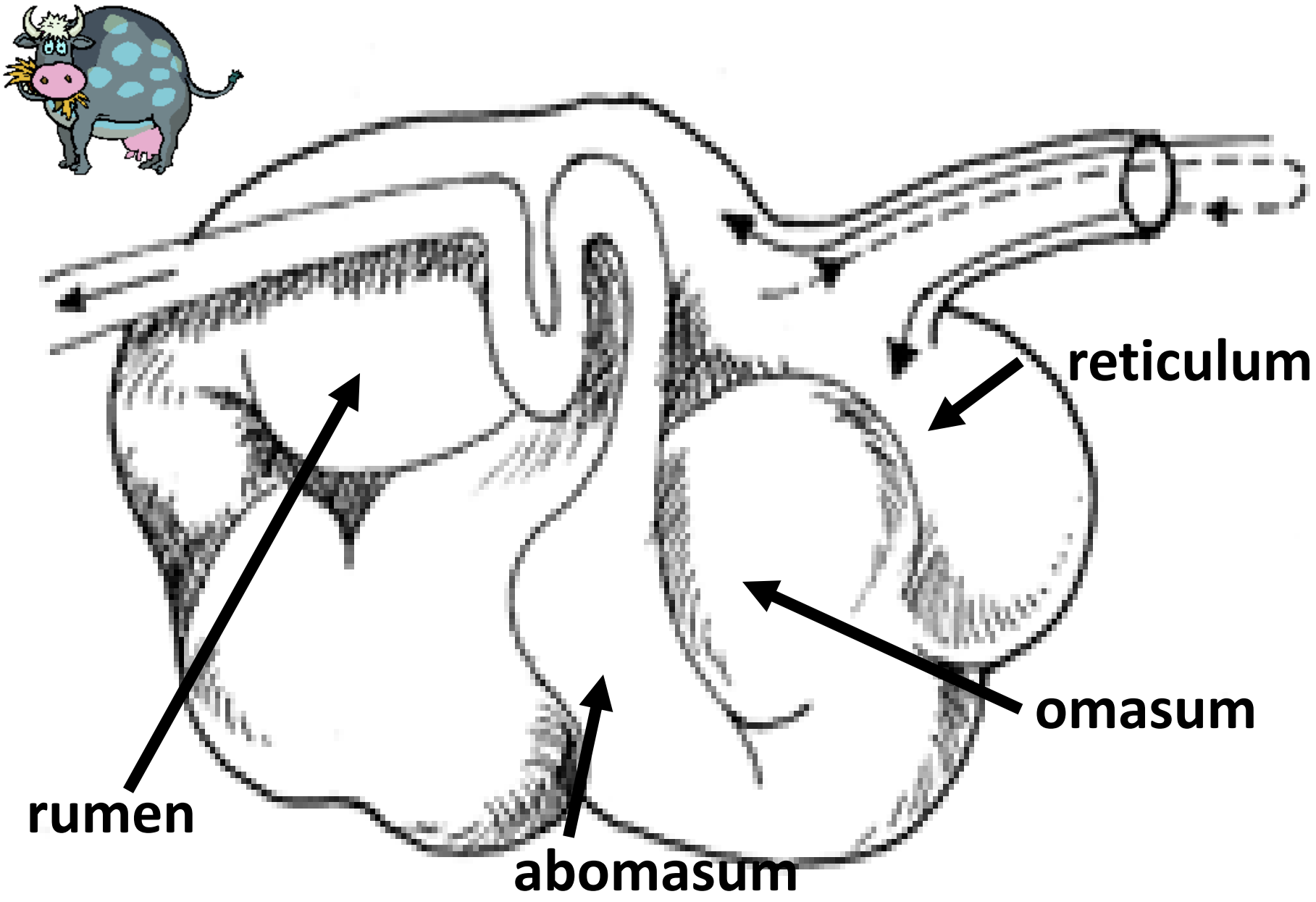
omasum

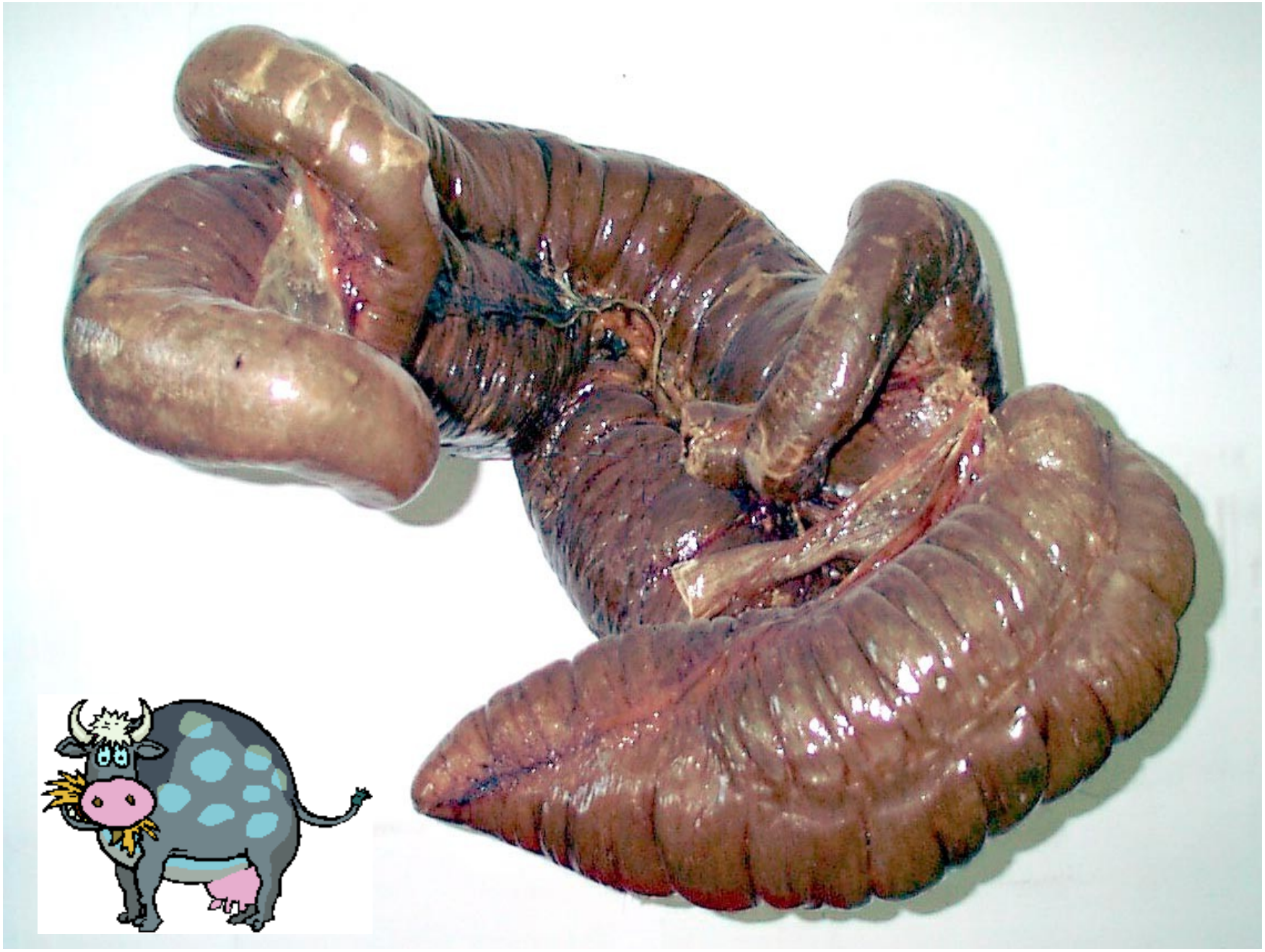
- H_2O

abomasum

chyme


esophagus
rumen
omasum
abomasum
reticulum
large intestine
cecum
small intestine


reticulum
omasum
rumen
abomasum



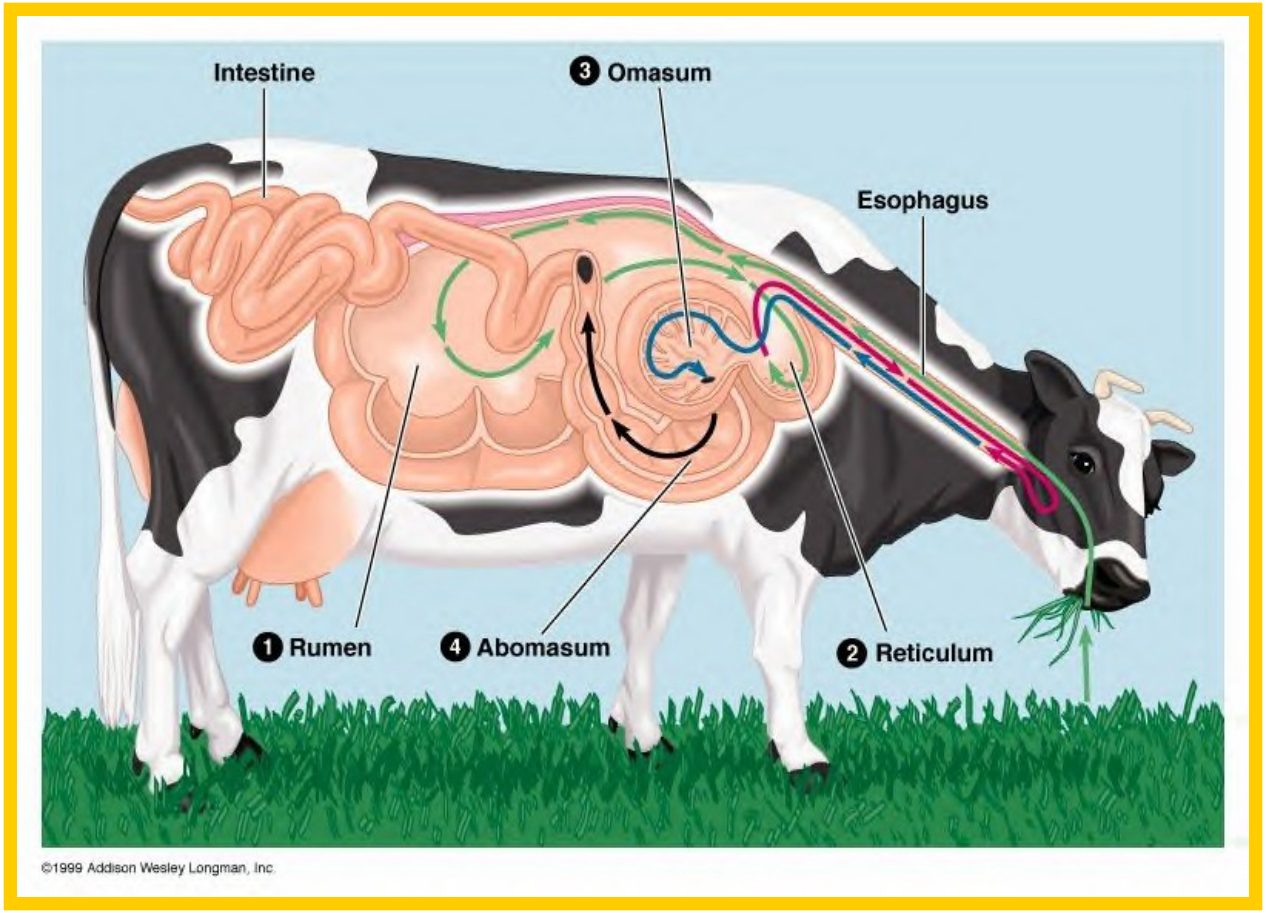
Rumination process:

- Regurgitation
- Swallowing
- Re-mastication
- Re-insalivation
- Reswallowing

Ruminant Digestive Systems

- *In conclusion, the rumen allows for bacteria to breakdown fiber, enabling ruminants to gain the proteins and energy from plant sources.*
- *Non-ruminant animals cannot obtain the nutritional value from most plant sources unless the food has been modified (ground, mashed, etc.)*

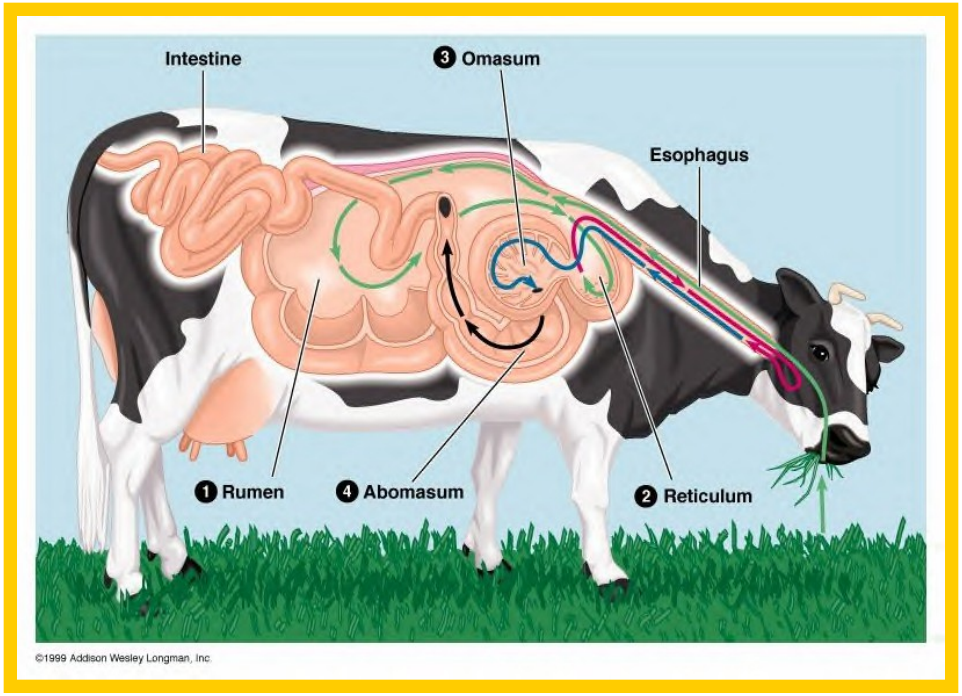
Ruminant Digestion



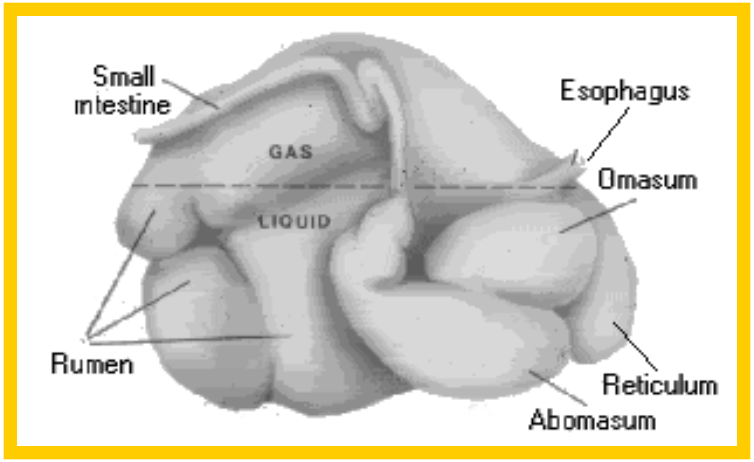
Ruminant Digestion

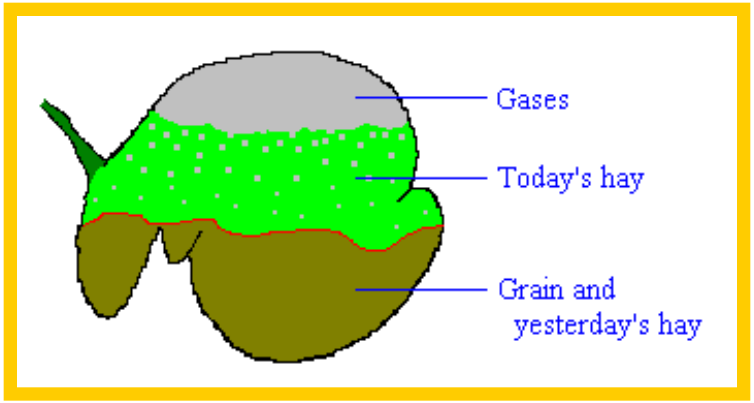
- Intake
- Mastication (chewing)
- Swallowing
- Regurgitation
- Remastication
- Fermentation
- Eructation
- Absorption
- Digestion

Rumination



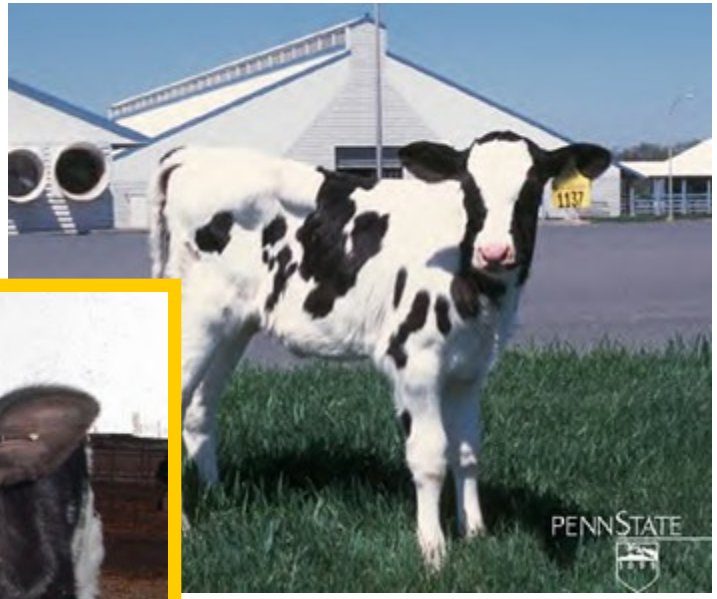
Fermentation





- Anaerobic bacteria break down cellulose
- VFA's released by bacteria passed to bloodstream through papillae
- CO_2 and CH_4 produced by bacteria
- Bacteria controlled by protozoa
- Ingesta passed to omasum by contractions

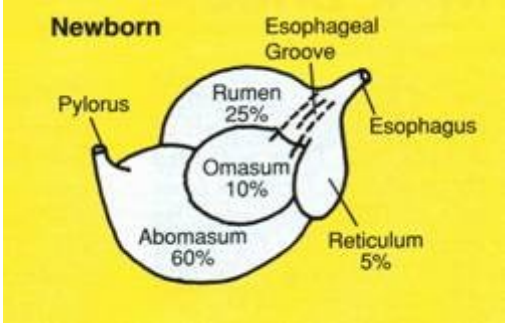
Calf Digestive Tract Development



Calf Digestive Tract Development

Newborn

- Only abomasum is functional
- Sucking action forms esophageal groove
- Milk passes directly to abomasum
- Milk curdles and digests slowly
- Rumen does not develop as long as calf is on milk only



Abomasum - 4 liters

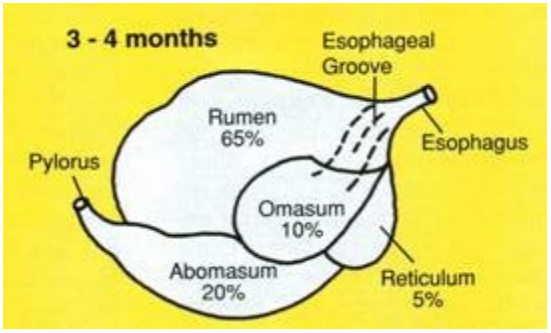
Rumen - 1.7 liters

Total Size - 6.7 liters

Calf Digestive Tract Development

12-16 Weeks

- Feed (grain) consumption causes rumen to develop
- Rumen is populated with micro-organisms from environment
- Bacteria produce VFA's which cause rumen to develop papillae and increase in size
- Calf can digest hay and grass once rumen develops



Abomasum - 4 liters

Rumen - 13 liters

Total Size - 20 liters

Thanks you!