Animal production 1
(Physiology)

Digestive System

Lec.6

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Level: 1
Food safety
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Digestive System

Objectives:

- ***Describe and understand the basic functions of the primary components of the digestive system.***
- ***Compare the functions and locations of the digestive organs in poultry, cows and man.***

What is the digestion?

The process by which large complex nutrient molecules are broken down into simpler molecules capable of being used by the organism for food. →→→

****Mechanical breakdown of food (chewing);***

****Chemical breakdown of food (Hcl , in the stomach - Enzymes);***

****Contractions of digestive tract.***

Animals are classified by the types of food they ingest to:

1- Carnivore → ***animal products:*** → ***Dogs & Cats.***

2- Herbivore → ***plant products:*** → ***Cattle, Sheep, Goats, Rabbits & Horses.***

3- Omnivore → ***combination of plant and animal products:*** → ***Humans & pigs.***

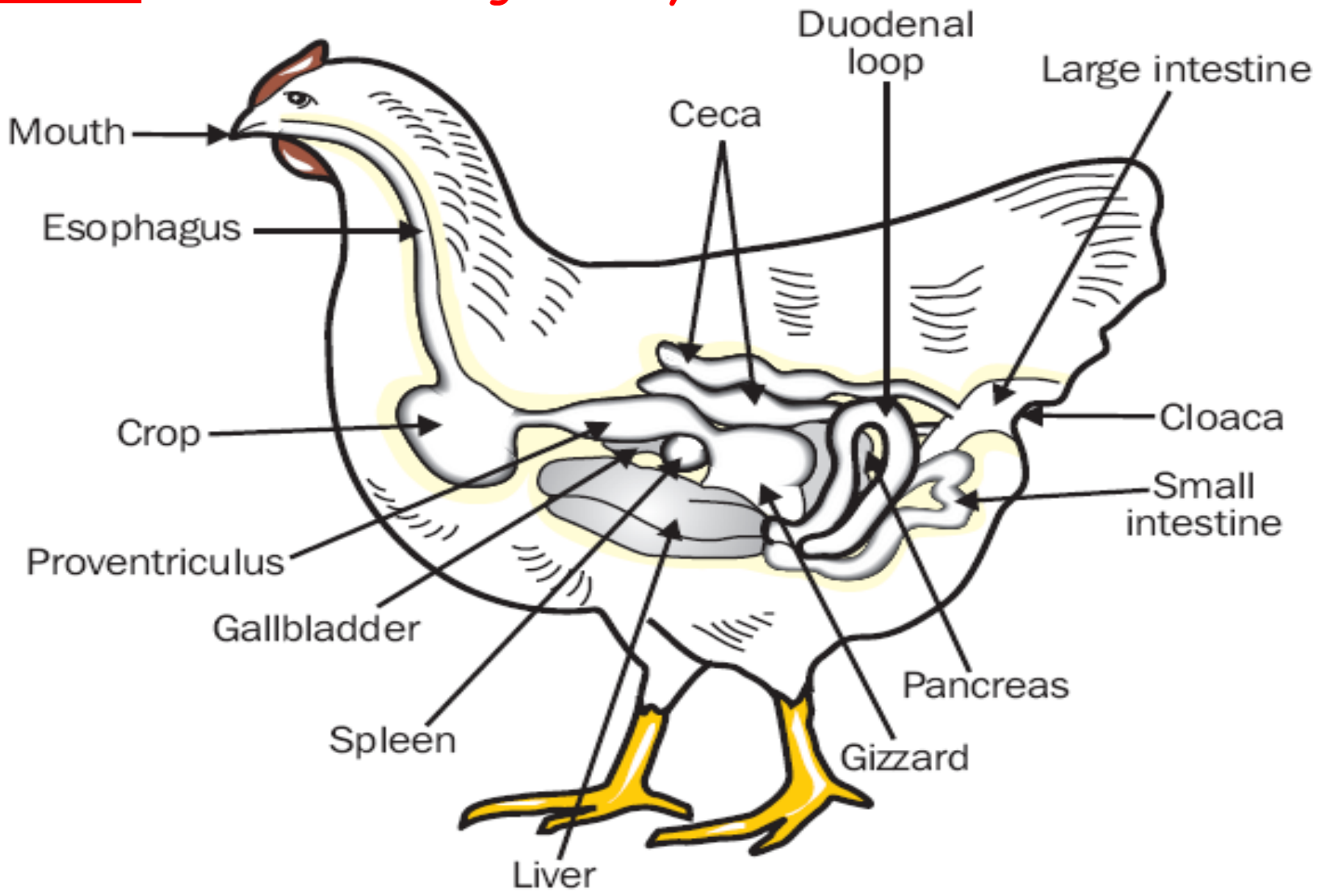
Animals are also classified by the type of stomach they have to:

1 -Simple stomach → *which is also known as a Mono-gastric* **or** ***non-ruminants*** *digestive systems* ***such as*** ***Humans, swine, rabbits, chickens and horses.***

2-Complex stomachs → *which are also known as ruminant digestive systems* ***such as*** ***Sheep, Cattle, Buffalo and goats.***

SCHEMATIC DIAGRAM OF CHICKEN DIGESTIVE SYSTEM

Known as a modified mono-gastric system



❖ Parts and functions of the mono-gastric avian digestive system:

Mouth/Beak: *Collect the feed (Since a bird has no teeth, no chewing is involved).*

Esophagus: *The esophagus empties directly into the crop.*

Crop: *Bottom of the esophagus forms a sac called crop where the food is stored and soaked.*

Proventriculus: *Glandular stomach (Hcl and gastric juices);enzymatic.*

Gizzard: *The gizzard is a very muscular organ (stomach),which normally contains stones or grit that grinds the food (mechanical breakdown).*
-Digestion in the avian system is very rapid.

Small Intestine:

* Functions of the small intestine:→
1-digestion of proteins, carbohydrates, and fats;
2-absorption of the end products of digestion.

Ceca: *Essentially non functioning in mono-gastric.*

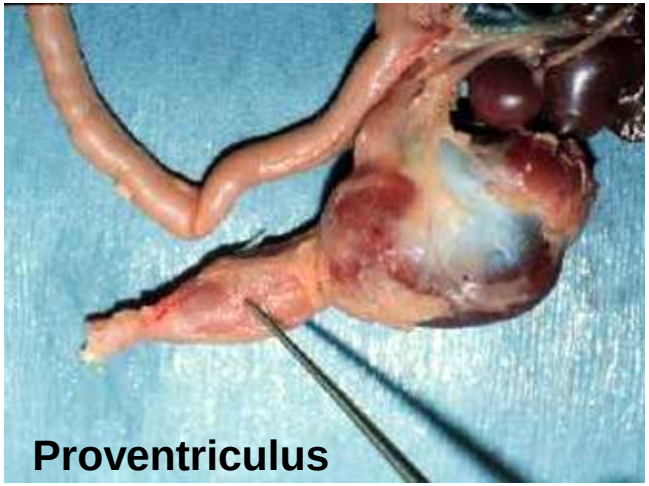
Large Intestine:

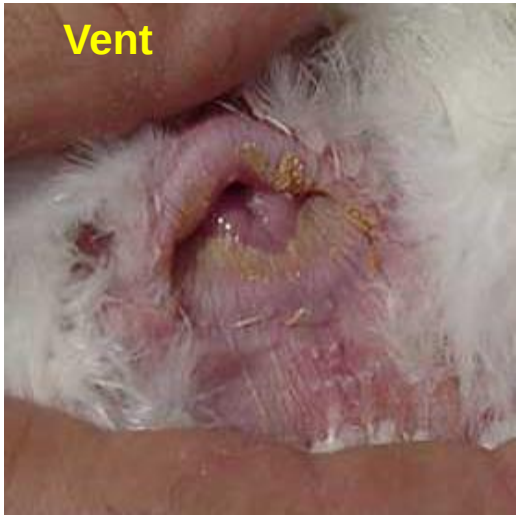
* Functions of the large intestine:→
1-bacterial activity.
2-water absorption.
3-waste storage.

Cloaca: *common chamber for gastrointestinal (GI) and urinary tracts.*

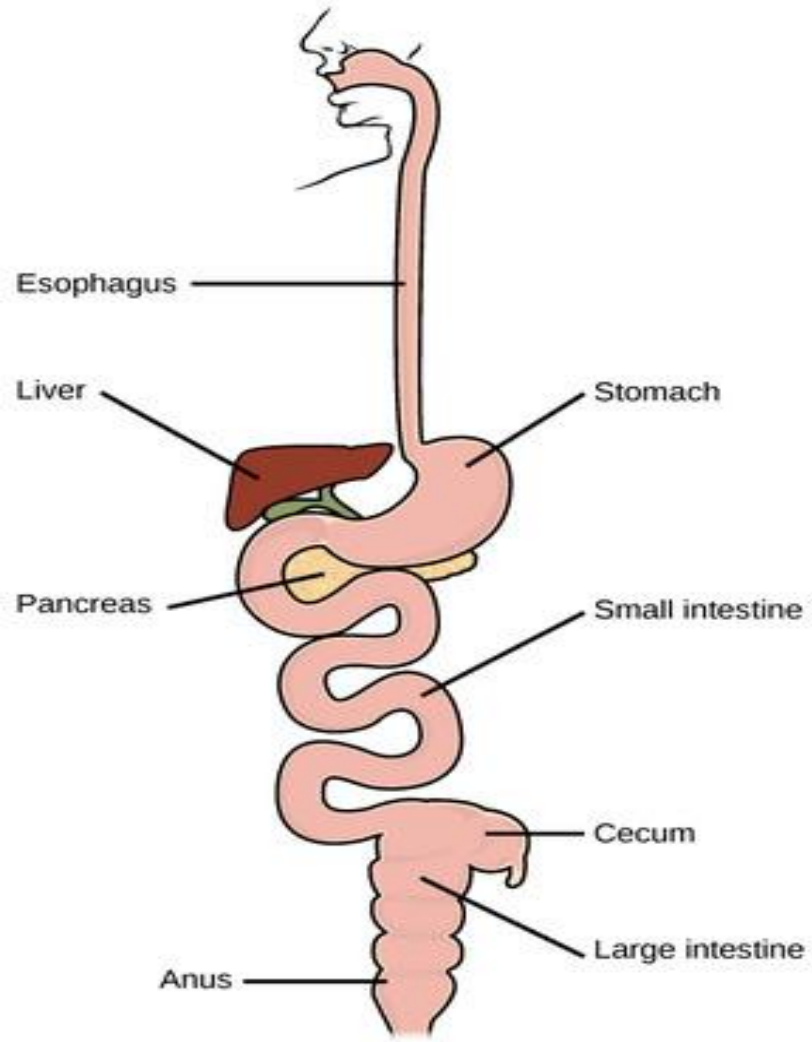
Vent: *-common exit for GI and urinary tracts.*

Specialized Poultry Organs

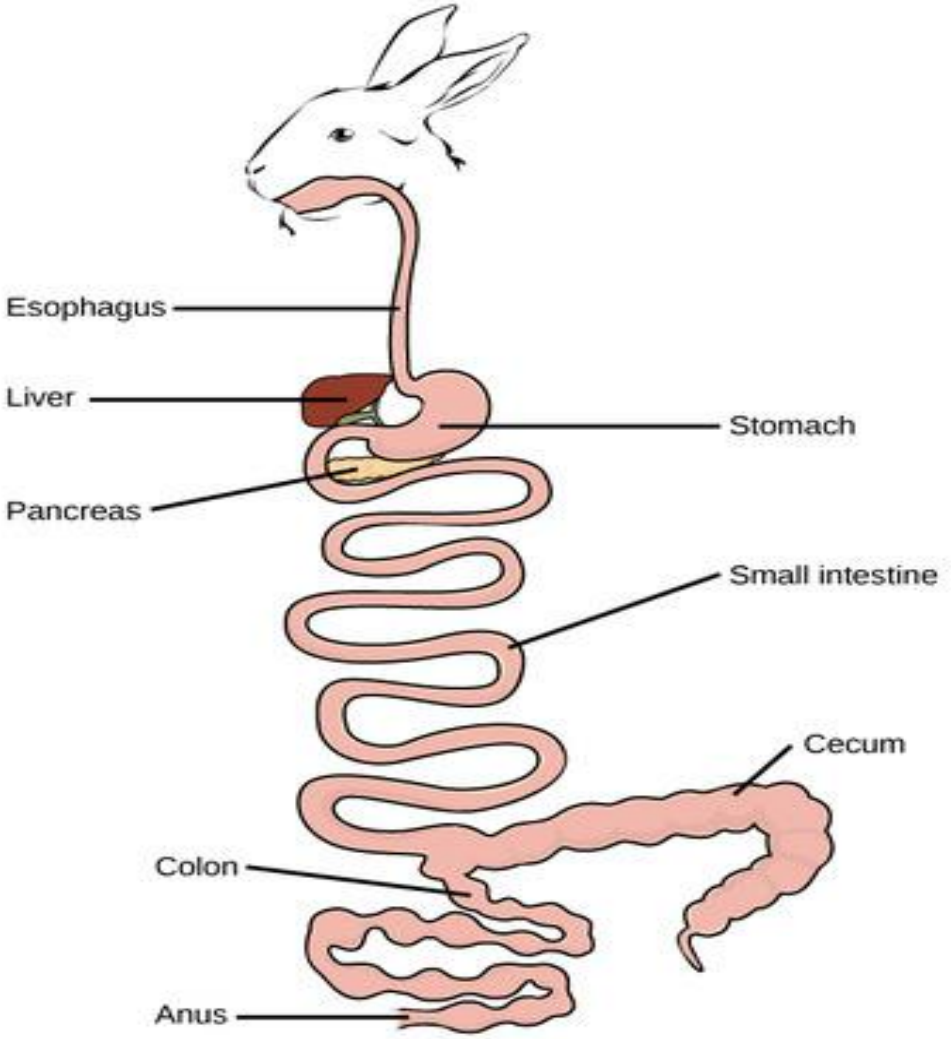




Digestive Tract of the Monogastric Mammal



(a) Human digestive system



(b) Rabbit digestive system

❖ Parts and functions of the monogastric mammal digestive system:

Mouth:

-gather(collect) and chew feed using tongue and teeth.

-salivary glands moisten feed to aid in swallowing.

-saliva begins the carbohydrate breakdown with salivary amylase.

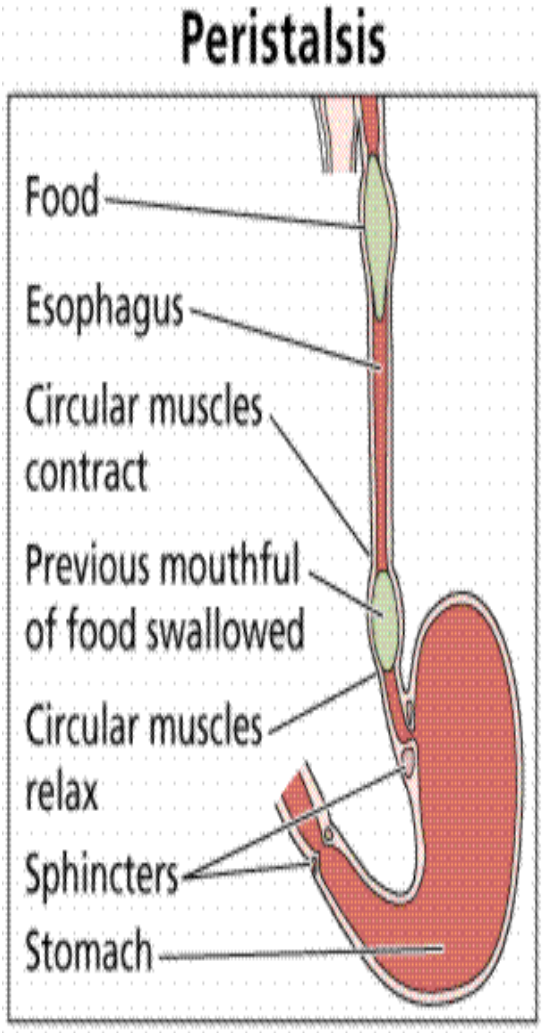
Esophagus:

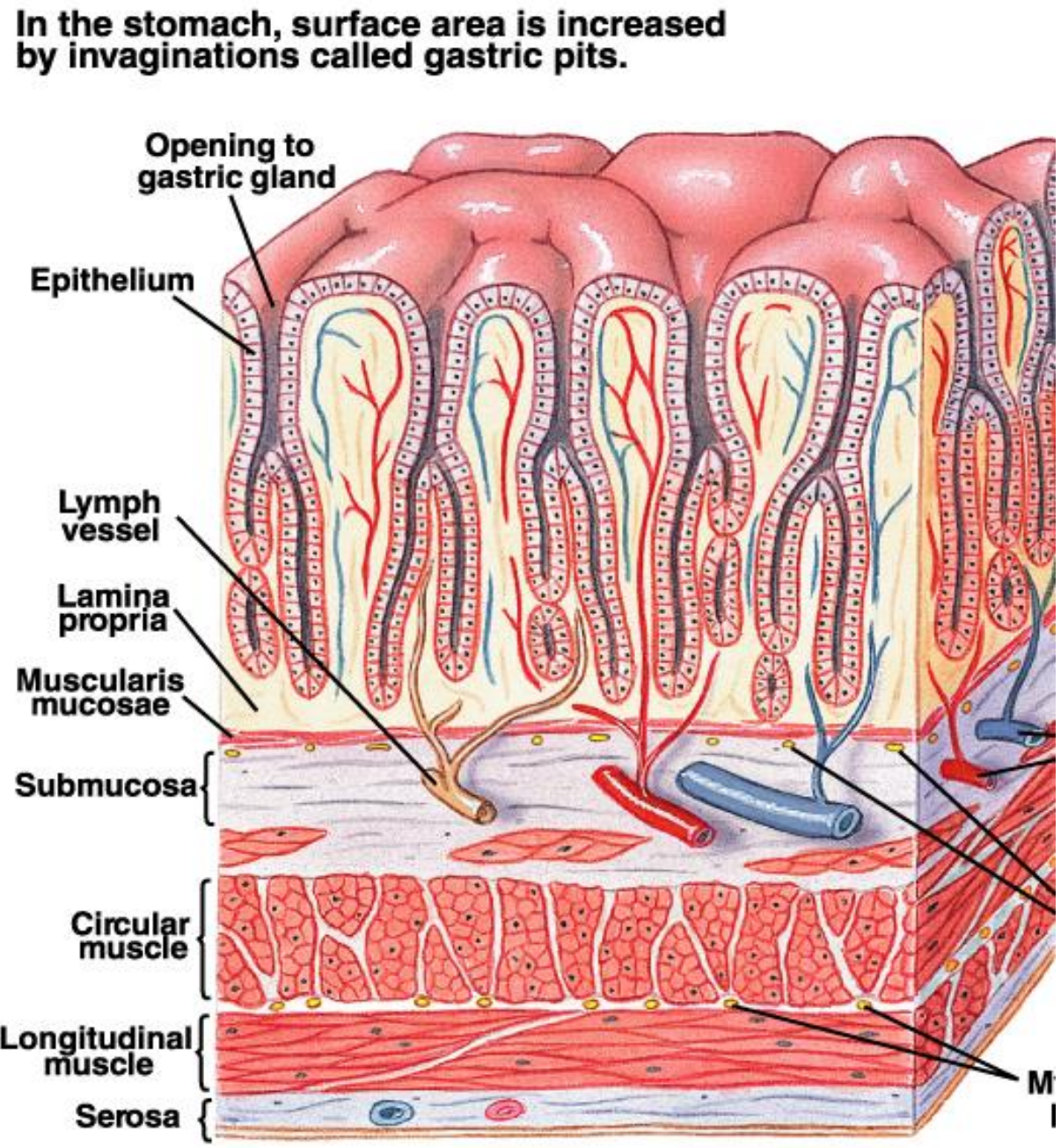
-tube from mouth to stomach that is open at the mouth end.

-separated from stomach by the esophageal sphincter.

Stomach:

-muscular gland lined sac that receives ingest from the esophagus and conducts both physical and chemical digestion →→





Gastric pits in gastric mucosa

- ***Gastric pits are openings to ducts into which gastric glands empty their secretions***

→→Stomach Secretions*

1. Gastrin:

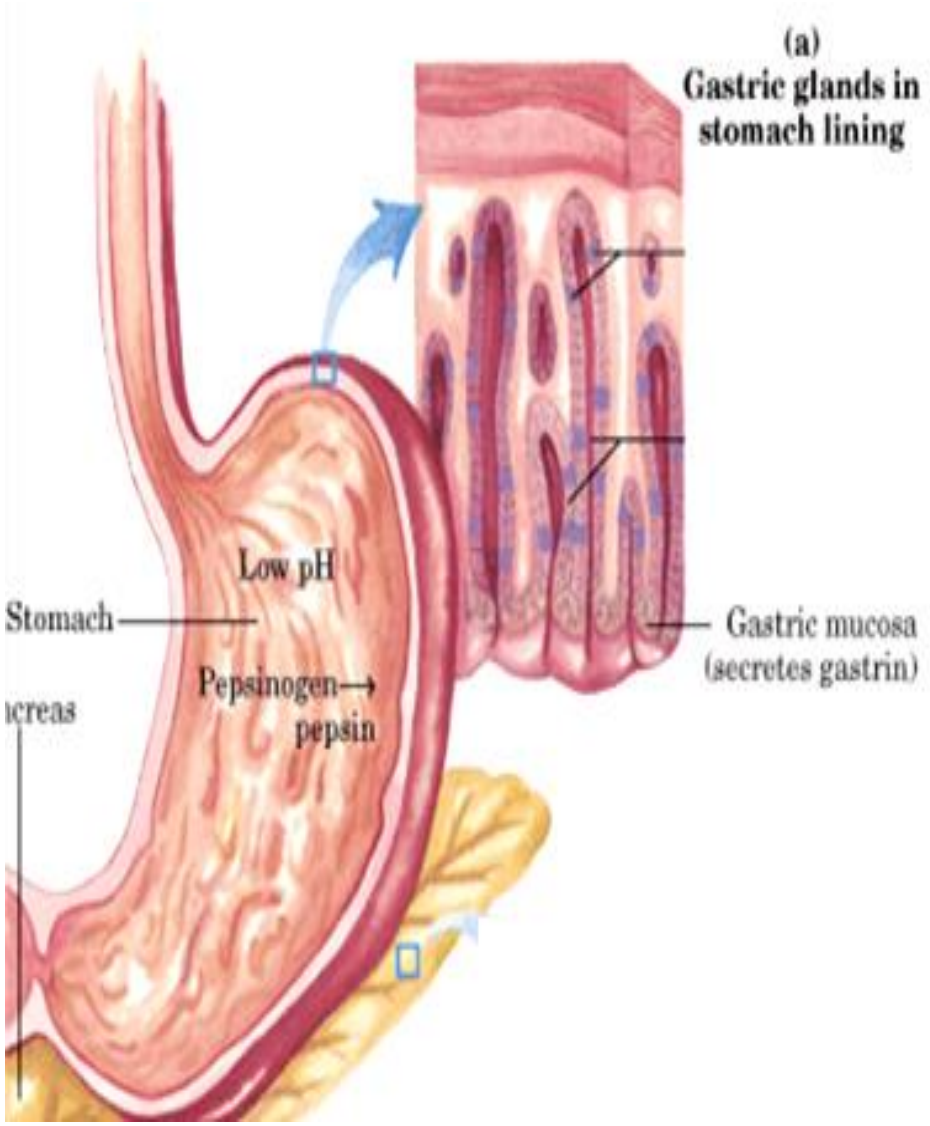
- *a polypeptide hormone secreted by the* pyloric glands *that stimulates production of HCL in the gastric glands.*

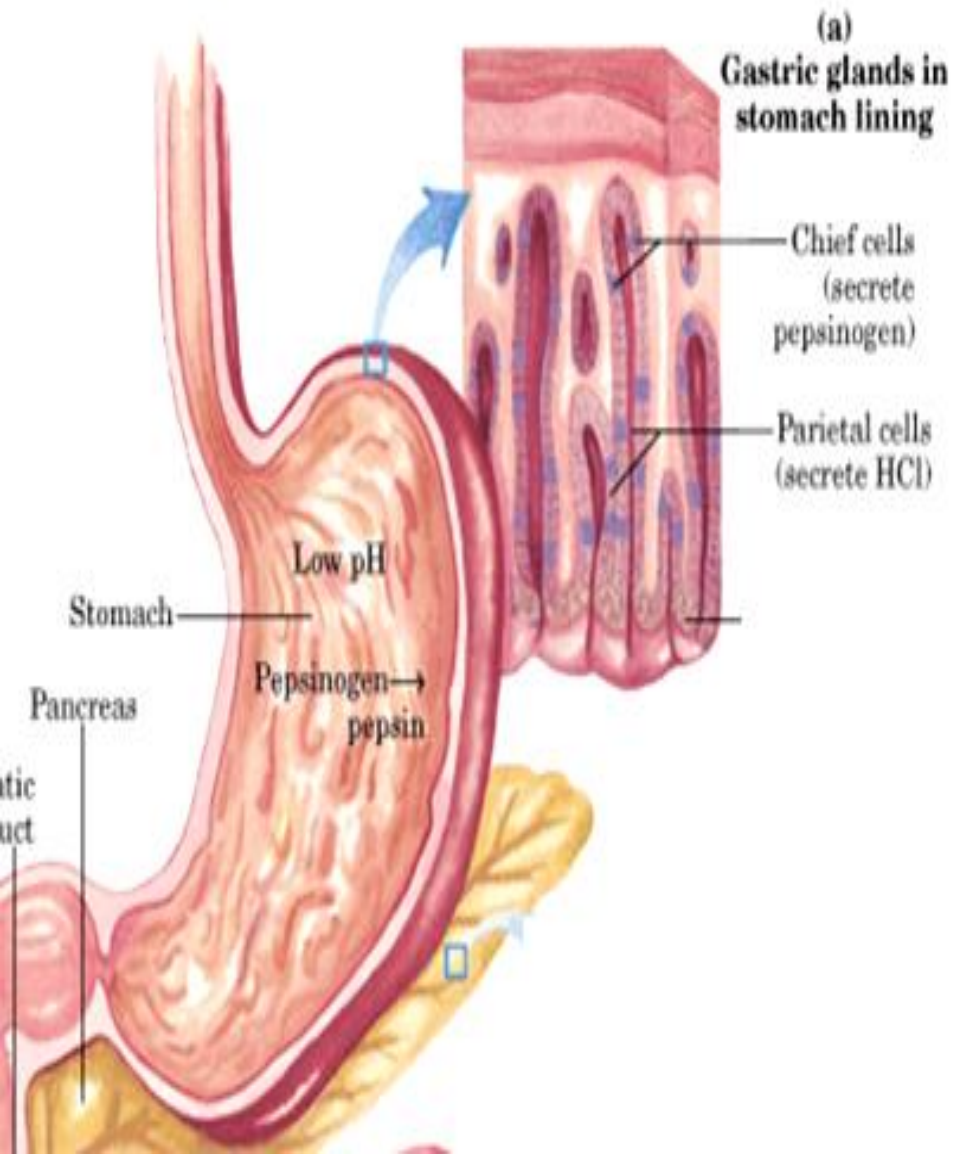
2. HCL (Gastric acid):

- *Decreases pH (~2-3).*
- *Denatured protein.*
- *Kills bacteria.*

3. Mucus:

- *Protects lining from acid and enzymes.* No "auto digestion".
- *Lubricant*





4. Pepsinogen (Zymogen):

- *Secreted by the* **chief cells** *of the gastric glands and converted into pepsin in the presence of HCL.*
- *Activated form is pepsin.*
- *Hydrolyzes protein(breaks down proteins into peptides).*

5. Chymosin (Rennin):

- *Secreted by* **chief cells** *of stomach (abomasum).*
- *Clots milk by converted casinogen to casein.*

6. Lipase:

- ***Some species.***

Small Intestine:

Functions of the small intestine:

1-digestion of proteins, carbohydrates, and fats;

2-absorption of the end products of digestion.

a-duodenum *-most digestion occurs here.*

b-jejunum *-some digestion and some absorption occur.*

c-ileum *-mostly absorption .*

- *Bile -made in liver, stored in gall bladder, active in the small intestine, emulsifies fat to aid in digestion.*

Cecum:

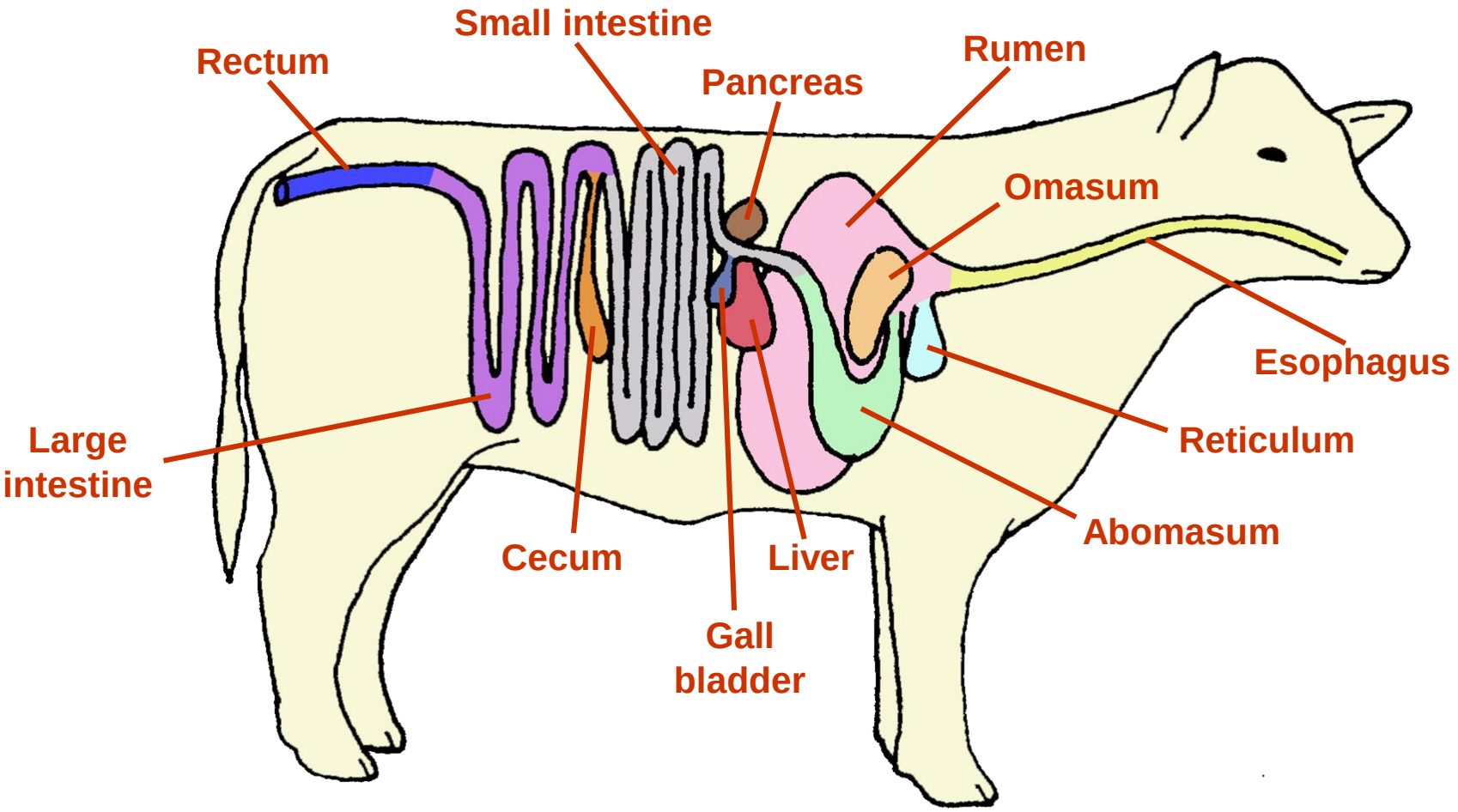
- Essentially non functioning in many monogastrics.
- Rabbits and horses have an enlarged cecum that acts like a rumen and is involved with microbial digestion(fermentation)

Large Intestine:

- Bacterial activity.
- Water absorption.
- Waste storage.

❖ Parts and functions of the ruminant digestive system:

***Ruminants** are characterized by having a stomach with four compartments.*



- **Mouth:**

  -contains dental pad, teeth, tongue and saliva.

  * Must produce large amounts of saliva. (150 L /day in cow and 10 L /day in sheep) → (1.5 L /day in human)

    →→ Used to feed microorganisms in the rumen.

  * saliva contains no salivary amylase

    -Food is ground down by teeth.

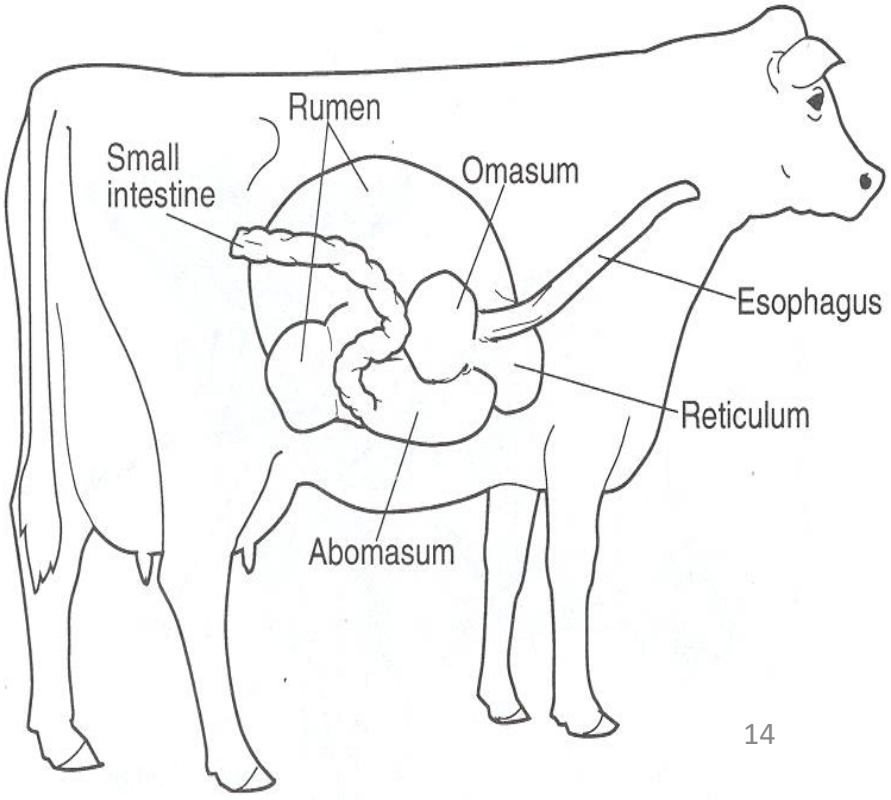
    -Also used to brake down the CUD.

- **Esophagus:**

  -tube from mouth to stomach.

  * Transport food to digestive tract.

  * Transport CUD to mouth.



- **Rumen:** *-large compartment (80% of capacity); Food is soaked, mixed,*
  - *-Microorganisms ferment the feed.*
  - *-anaerobic.*
  - *-Temperature = 39°C (103°F)*
  - *-saturated with gasses.*
  - *-constant motion .*
  - *-Carbohydrates are absorbed by the papillae (Small fingerlike that aid in absorption).*

Rumen Size

Species	Maximum	Normal Content
1000 lb cow	~55-60 gallons	25-30 gallons
150 lb ewe	~5-10 gallons	3-5 gallons

Lining of the rumen


Papillae in Rumen

❖ Rumen Microorganisms:

Bacteria and Protozoa:

- ***Rumen environment is moist, warm, and provides a constant supply of nutrients.***
- ***Entire population of organisms depending on the kind and quality of the feed. When they are washed out of the omasum into the abomasum the acidic environment kills the microorganisms. Provide amino acids and some enerav.***

Microorganisms in the Rumen

Protozoa	100,000 per gram of fluid
Bacteria	100 million per gram of fluid
Fungi	

- ***Functions of Microorganisms:***

-digest roughages to make Volatile Fatty Acids.
-make protein.
-make vitamins K and B complex.

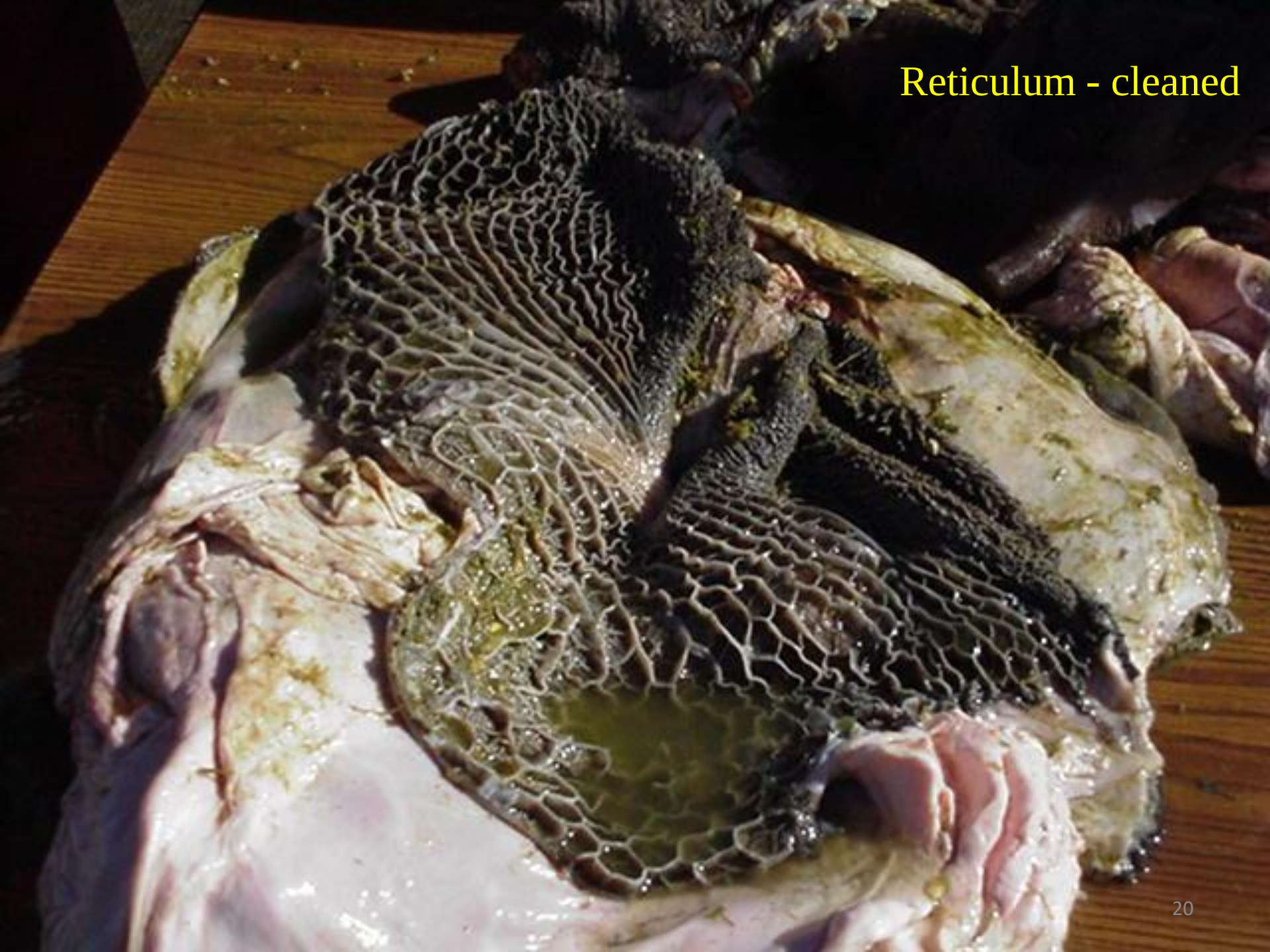
(Very similar to cecum of rabbit and horse)
The function of the rumen is to house microorganisms.

- **Reticulum:** - *"honeycomb shaped", 5% of capacity.*
  - -secrets mucus.
  - -houses microorganisms.
  - -catches hardware (ingested by animal).
  - -Regurgitation.
  - -houses the opening to the omasum.

- **Omasum:** *-Round – Soccer Ball; 7 % of capacity.*
  - -full of folded tissue – Like a round book
  - - Grinds the food as it passes through.
  - -water absorption.

- **Abomasum:** - *true stomach; 8% of capacity.*
  - -pepsin.
  - -HCl.

Reticulum - full


Reticulum - cleaned

Small Intestine:

- enzymatic digestion and absorption.

Functions of the small intestine:

1-digestion of proteins, carbohydrates, and fats;

2-absorption of the end products of digestion.

A-Duodenum.

B-Jejunum.

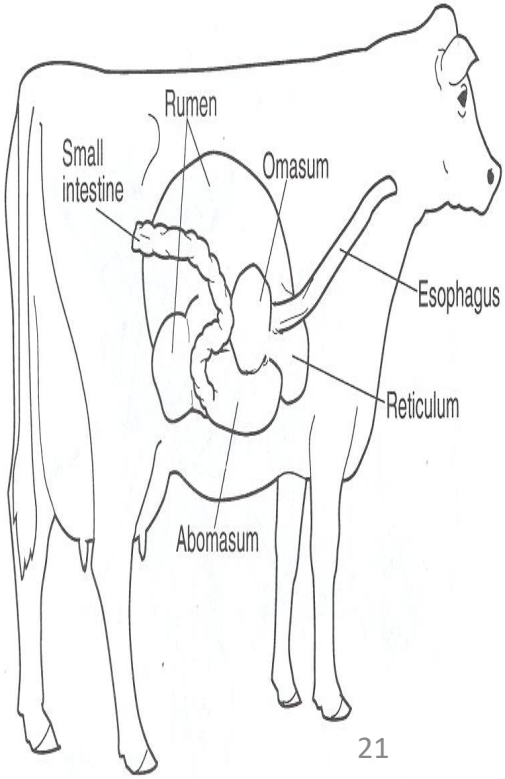
C-Ileum.

Cecum:- some microbial fermentation.

Large Intestine:

-water absorption.

-waste storage.

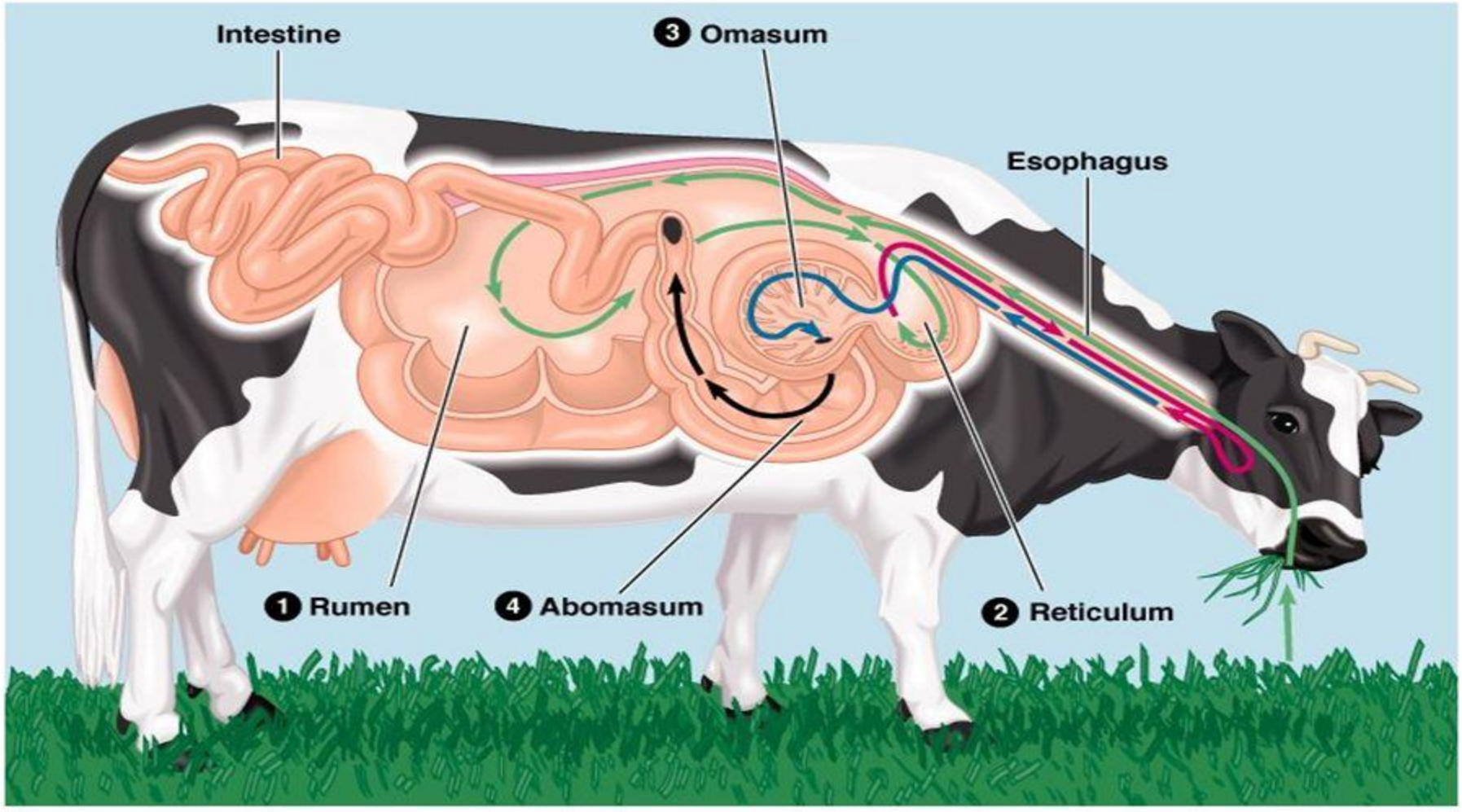


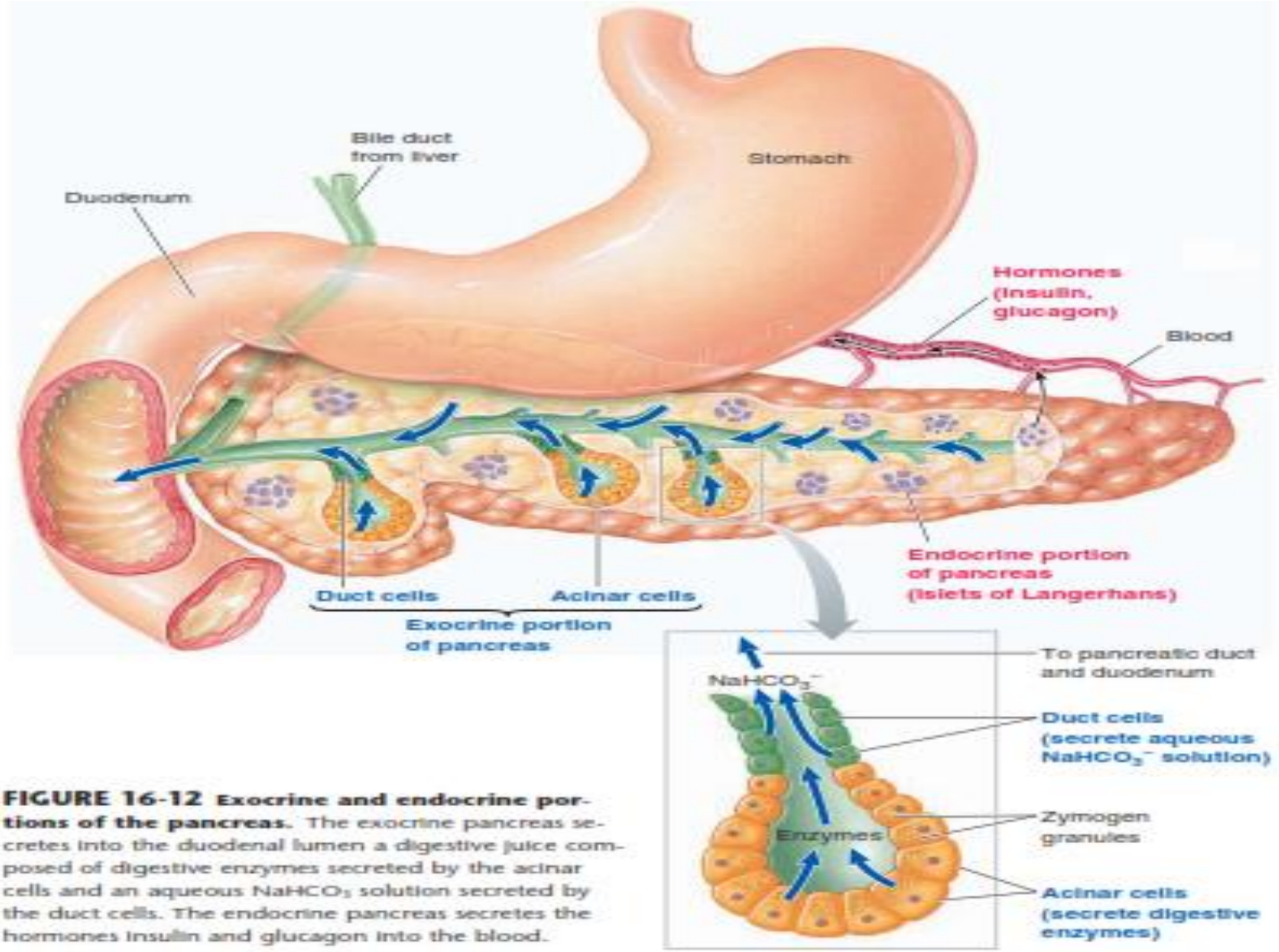
Rumination (regurgitation):*

- ***After rumen if full, it lies down to ruminate (chew its cud → mass of regurgitated ingesta; bolus).***
- ***Cattle spend from 5-7 hours ruminating, broken up into 6- 8 periods.***

Regurgitation is the process of forcing the feed back into the mouth for chewing. Done through a series of muscular contractions and pressure in the rumen and reticulum.

Rumination (regurgitation).....





● **FIGURE 16-12 Exocrine and endocrine portions of the pancreas.** The exocrine pancreas secretes into the duodenal lumen a digestive juice composed of digestive enzymes secreted by the acinar cells and an aqueous $NaHCO_3$ solution secreted by the duct cells. The endocrine pancreas secretes the hormones insulin and glucagon into the blood.

HORMONES INVOLVED IN DIGESTION:*

1- Leptin:

- *Produced by adipose cells.*
- *Increased amount of adipose tissue → increased levels of leptin → decreased appetite.*

2- Gastrin:

- *Produced by stomach* **(pyloric glands).**
- *Food triggers (activates) release of gastrin → returns to stomach wall → stimulates secretion of gastric juice.*

3- Secretin:

- *Produced by duodenum.*
- *Stimulates pancreas to release* **Na bicarbonate** *to neutralize chyme.*

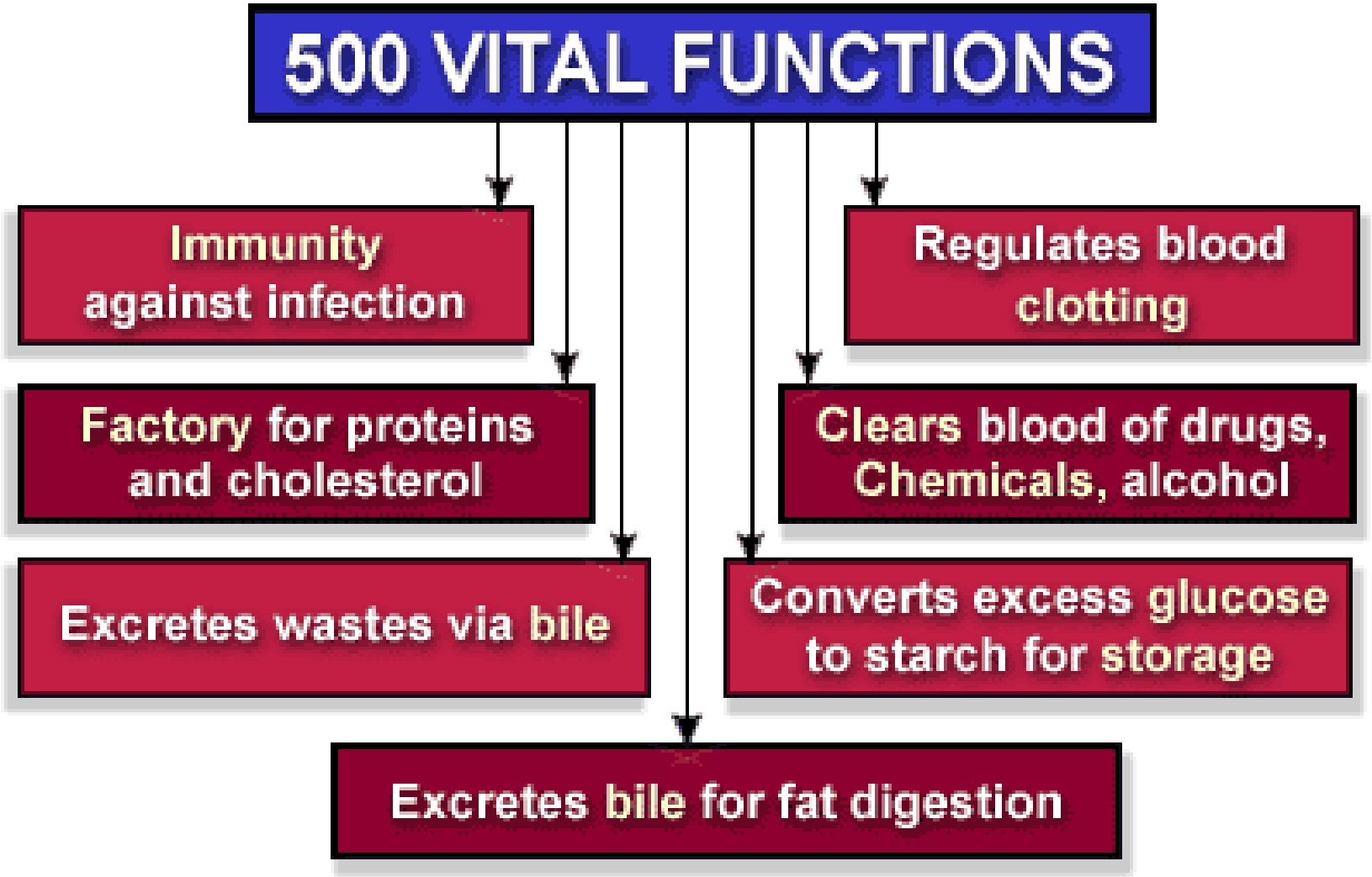
4- Cholecystokinin (CCK):

- *Produced by duodenum.*
- *Stimulates by presence of amino acids / fatty acids in duodenum → Triggers release of* **pancreatic digestive enzymes, bile** *from gall bladder.*

TABLE 16-6 Digestive Processes for the Three Major Categories of Nutrients

Nutrients	Enzymes for Digesting Nutrient	Source of Enzymes	Site of Action of Enzymes	Action of Enzymes	Absorbable Units of Nutrients
Carbohydrate	Amylase	Salivary glands	Mouth and (mostly) body of stomach	Hydrolyzes polysaccharides to disaccharides	
		Exocrine pancreas	Small-intestine lumen		
	Disaccharidases (maltase, sucrase, lactase)	Small-intestine epithelial cells	Small-intestine brush border	Hydrolyze disaccharides to monosaccharides	Monosaccharides, especially glucose
Protein	Pepsin	Stomach chief cells	Stomach antrum	Hydrolyzes protein to peptide fragments	
	Trypsin, chymotrypsin carboxypeptidase	Exocrine pancreas	Small-intestine lumen	Attack different peptide fragments	
	Aminopeptidases	Small-intestine epithelial cells	Small-intestine brush border	Hydrolyze peptide fragments to amino acids	Amino acids and a few small peptides
Fat	Lipase	Exocrine pancreas	Small-intestine lumen	Hydrolyzes triglycerides to fatty acids and monoglycerides	Fatty acids and monoglycerides
	Bile salts (not an enzyme)	Liver	Small-intestine lumen	Emulsify large fat globules for attack by pancreatic lipase	

What does the liver do?



❖ Metabolism:

***Metabolism** refers to all the chemical reactions that occur within the cells of the body. Those reactions involving the degradation, synthesis and transformation of the three classes of energy-rich organic molecules - protein, carbohydrate, and fat – are collectively known as fuel metabolism (Table 19-3).*

- *During the process of digestion, large nutrient molecules (macromolecules) are broken down into their smaller absorbable subunits as follows:*
- *Proteins are converted into amino acids, complex carbohydrates into mono-saccharides (mainly glucose), and triglycerides (dietary fats) into mono-glycerides and free fatty acids.*
- *These absorbable units are transferred from the digestive tract lumen into the blood, either directly or by way of the lymph.*

TABLE 19-3 Summary of Reactions in Fuel Metabolism

Metabolic Process	Reaction	Consequence
Glycogenesis	Glucose → glycogen	↓ Blood glucose
Glycogenolysis	Glycogen → glucose	↑ Blood glucose
Gluconeogenesis	Amino acids → glucose	↑ Blood glucose
Protein Synthesis	Amino acids → protein	↓ Blood amino acids
Protein Degradation	Protein → amino acids	↑ Blood amino acids
Fat Synthesis (Lipogenesis or Triglyceride Synthesis)	Fatty acids and glycerol → triglycerides	↓ Blood fatty acids
Fat Breakdown (Lipolysis or Triglyceride Degradation)	Triglycerides → fatty acids and glycerol	↑ Blood fatty acids

ANABOLISM AND CATABOLISM:

Anabolism ***is the buildup or synthesis of larger organic macromolecules from small organic molecular subunits. Anabolic reactions generally require energy input in the form of ATP. These reactions result in either:***

(1) the manufacture of materials needed by the cell, such as cellular structural proteins or secretory products; or

(2) storage of excess ingested nutrients not immediately needed for energy production or needed as cellular building blocks. Storage is in the form of glycogen (the storage form of glucose) or fat reservoirs.

Catabolism ***is the breakdown, or degradation, of large, energy-rich organic molecules within cells. Catabolism included*** two levels of breakdown:

(1) hydrolysis of large cellular organic macromolecules into their smaller subunits, similar to the process of digestion, except that the reactions take place within the body cells instead of within the digestive tract lumen (for example, release of glucose by the catabolism of stored glycogen); and

(2) oxidation of the smaller subunits, such as glucose, to yield energy for ATP production.

In an adult, ***the rates of anabolism and catabolism are generally in balance, so the adult body remains in a dynamic steady state.***

During growth, ***anabolism exceeds catabolism.***

Questions

First question:

1- List the parts and functions of the mono-gastric avian digestive system.

2- List the parts and functions of the ruminant digestive system.

3- List the enzymes involved in the digestion of each category of foodstuff. Indicate the source and control of secretion of each of the enzymes.

4- Summarize the vital functions of liver.

5- Summarize the functions of each of the gastrointestinal hormones.

Second question: Mention the followings:

1- Stomach Secretions

2- Hormones involved in digestion.

3- Rumen Microorganisms.

4- Rumination (regurgitation).

5- Metabolism.

6- Glycogenesis.

7- Glycogenolysis.

8- Gluconeogenesis.

9- Anabolism.

10- Catabolism

Best Wishes

- ***And***

- ***GOOD LUCK***