DIGESTIVE SYSTEM OF POULTRY

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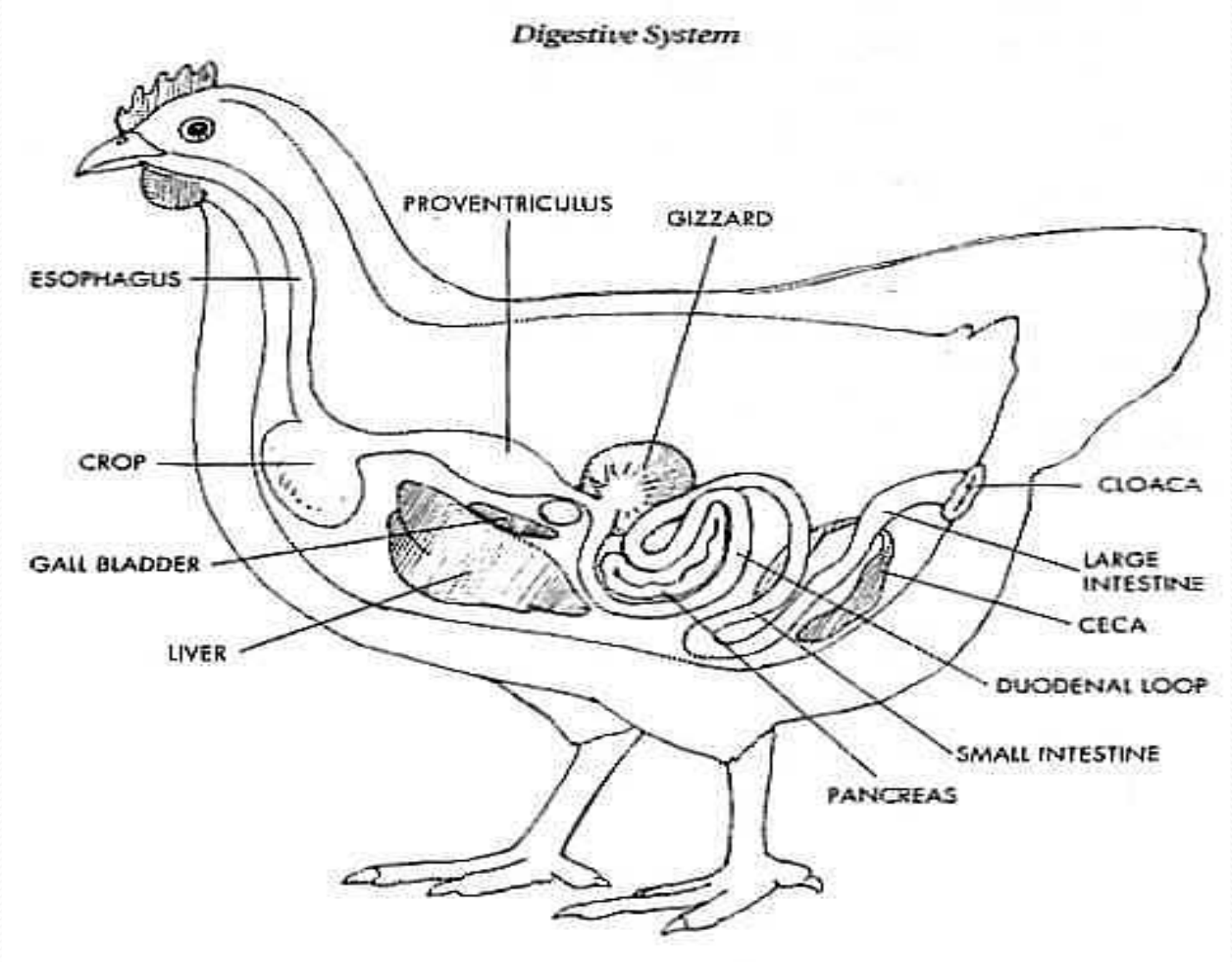
Digestive System

- This system is responsible for the break down of complex non absorbable components like
  - Carbohydrate
  - Protein
  - Fats

    Into relatively simplest and absorbable unit like glucose, amino acid and fatty acids respectively

TABLE 1 Dimensions of the Digestive Tract of Various Species of Birds[a]

Species	Body wt (kg)	Esophagus			Proventriculus and gizzard			Small intestine			Cecum		Rectum			Total	
		Length (mm)	Total %	Wt (g)	Length (mm)	Total %	Wt (g)	Length (mm)	Total %	Wt (g)	Length (mm)	Wt (g)	Length (mm)	Total %	Wt (g)	Length (mm)	Length/BW
Chicken																	
Leghorn	1.2	136	9.9	8.2	86	6.3	26.7	1082	78.9	29.5	127	5.2	68	5.0	2.3	1372	1.14
Broiler	3.0	140	6.4	16.8	101	4.7	43.5	1796	82.7	73.6	188	10.7	134	6.2	5.1	2171	0.72
Turkey	3.0	123	5.7	8.5	110	5.1	52.9	1853	85.7	85.3	278	20.1	75	3.5	4.4	2161	0.72
Japanese quail[b]	NA	75	11.5	—	38	5.8	—	510	78.1	—	100	—	30	4.6	—	653	—
Domestic duck[c]	2.2	310	11.7	—	130	4.9	—	2110	79.9	—	140	—	90	3.4	—	2640	1.20
Emu[c]	53.0	790	12.1	—	260	4.0	—	5200	79.4	—	120	—	300	4.6	—	6550	0.12
Rhea[d]	25.0		NA		310	—	—	1400	—	—	480	—	400	—	—	—	—
Ostrich[d]	122.0		NA		480	—	—	6400	—	—	940	—	8000	—	—	—	—
Cedar waxwing[e]	NA	51	16.2	—	36	11.4	—	171	54.3	—	0	0	57	18.1	—	315	—


Digestive System
PROVENTRICULUS
GIZZARD
ESOPHAGUS
CROP
CLOACA
GALL BLADDER
LARGE INTESTINE
CECA
LIVER
DUODENAL LOOP
SMALL INTESTINE
PANCREAS

- **Digestion is completed by the action of various enzymes secreted by the digestive system**
- **Digestive system is divided into following parts**
  1. **Mouth**
  2. **Pharynx**
  3. **Esophagus/gullet**
  4. **Crop**
  5. **Proventriculus**
  6. **Gizzard**
  7. **Small intestine**
  8. **Caeca**
  9. **Large intestine**
  10. **Cloaca**
  11. **Vent**

ACCESSORY DIGESTIVE GLANDS

- The glands which aid in the process of digestion are known as accessory digestive glands and are following
  1. Salivary glands
  2. Liver
  3. Pancrease

MOUTH

- Mouth is made up of upper mandible and lower mandible collectively known as beak
- The upper mandible is attached with skull and it is non-movable part of beak while the lower mandible is attached hinged and it is movable part of beak
- The roof of mouth is made up of hard palate that is divided by a long narrow slit in the center that is opened to the nasal passage
- While the soft palate is absent in the birds except pigeon
- The openings or slit in the hard palate and absence of soft palate make it impossible for the birds to create a vacuum to draw the water or feed into the mouth
- Thus birds have to scoop up the water when drinking elevates its head and then let the water run down the gullet by the action of gravity
- The base of mouth is made up of tongue and it has rough surface at the beak to help force the feed into esophagus or gullet. The base of the tongue has papilla, which contains very few numbers of taste buds. The taste buds help to taste the feed

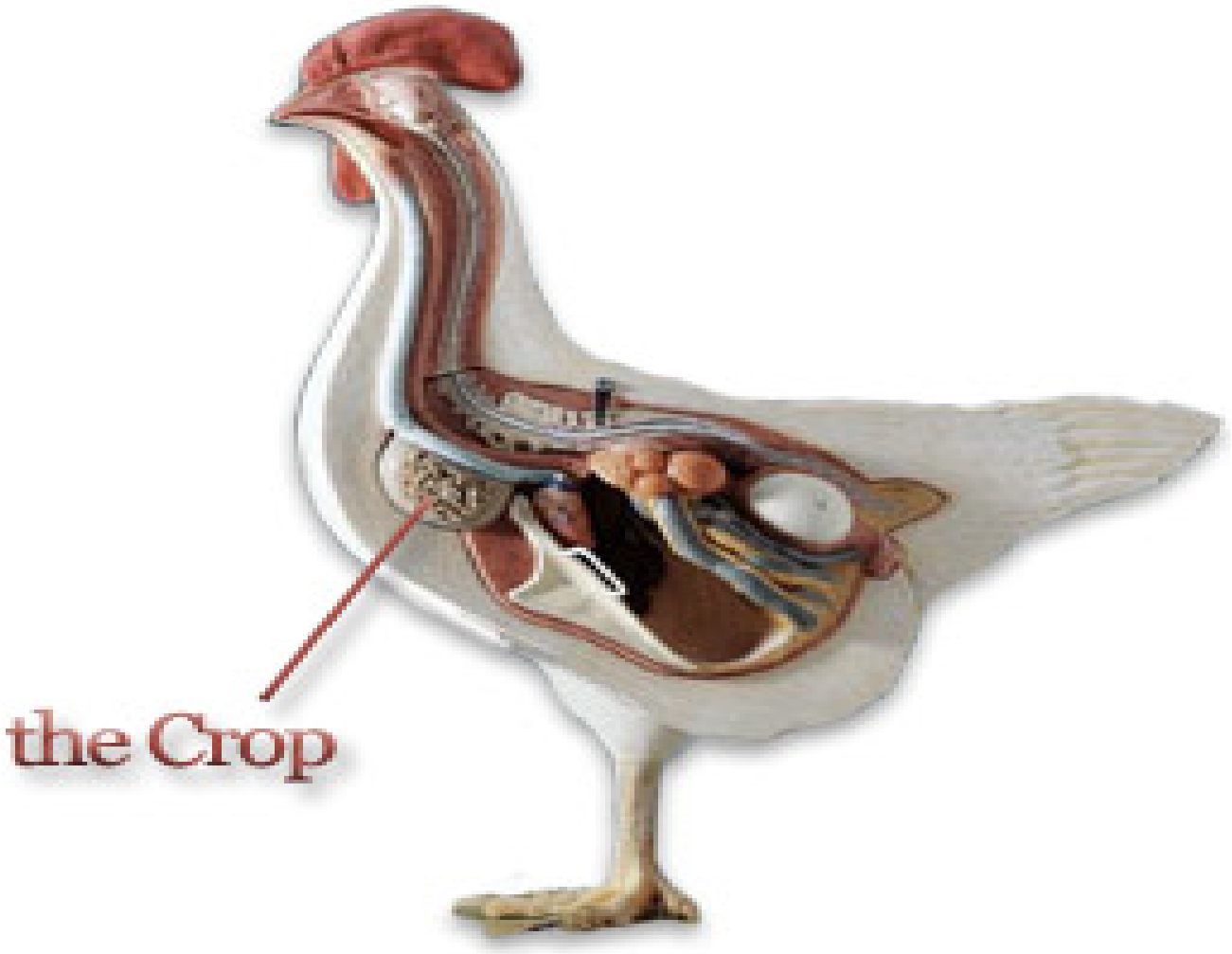
PHARYNX

- Pharynx is a common passageway for feed as well as for air and is divided into two parts.

1. Esophagus
2. Larynx

ESOPHAGUS

- Esophagus is a tube like structure that extends from mouth to Proventriculus
- It helps to carry the feed from mouth towards Proventriculus
- Major secretion is mucous
- In some species like greater flamingo and male Emperor penguin, a nutritive merocrine-type secretion is produced by the wall of the esophagus which is fed to the young


the Crop

CROP

- Crop is the extension of esophagus located in the neck region
- Cropectomy has no effect on growth rate of ad-libitum fed chickens
- It is responsible for the storage of feed but when the Proventriculus or gizzard is empty the feed by pass the crop
- Little digestion takes place with the action of salivary amylase
- Amylase activity at this site comes from either salivary secretions, intestinal reflux, or plant and/or bacterial sources
- Starch is hydrolyzed within the crop where it can either be absorbed, converted to alcohol, lactic or other acids

Cont…

- In pigeons and doves, "crop-milk" is produced during the breeding season under the influence of prolactin
- Crop milk contains 12.4 % protein, 8.6% lipids, 1.37% ash, and 74% water
- Rich in protein and essential fatty acids and is devoid of carbohydrates and calcium

PROVENTRICULUS

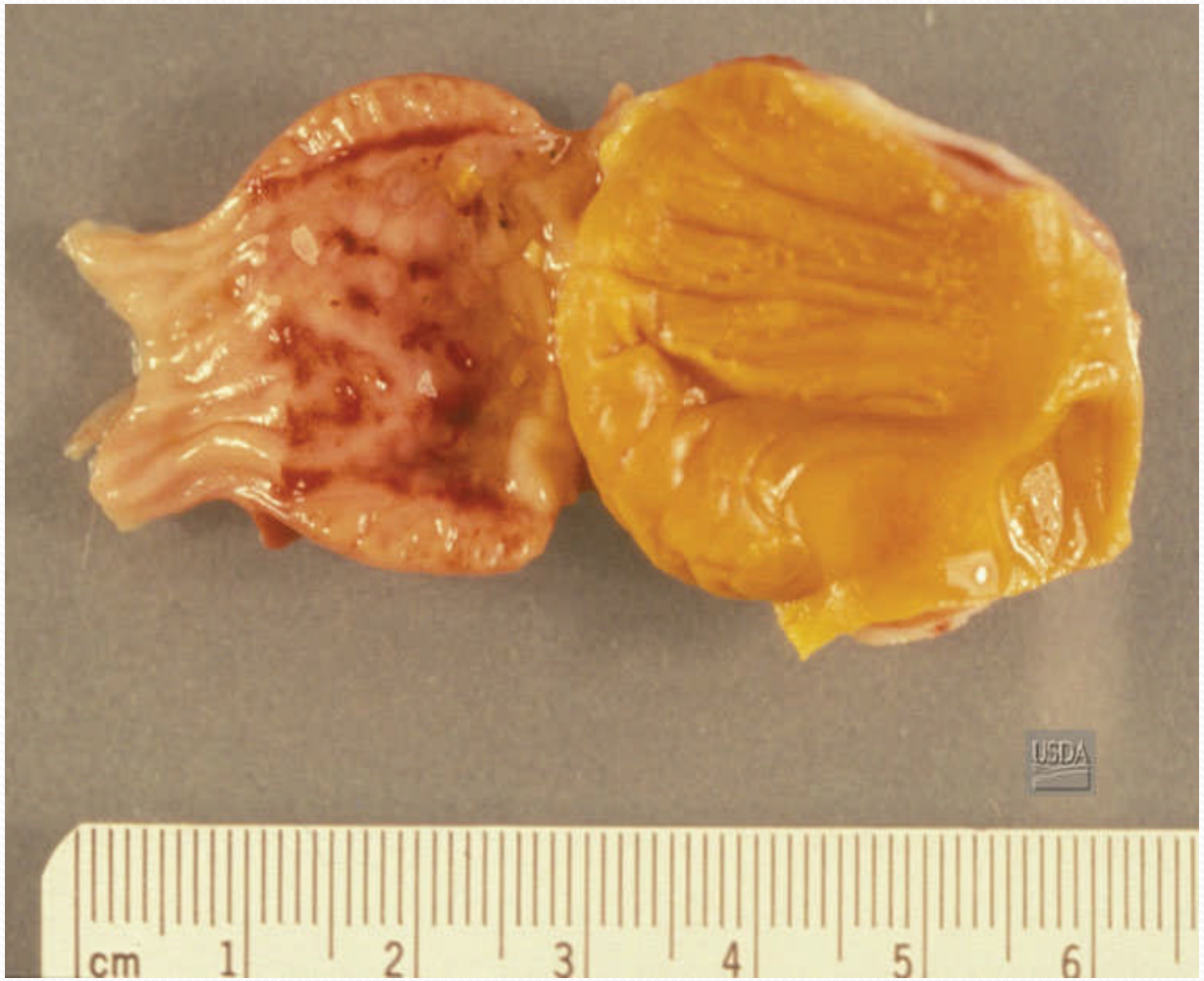
- Also called glandular stomach or true stomach
- It is a specialized enlargement of the gullet just before entry into the gizzard
- Responsible for the production of gastric juice
- Gastric juice is made up of the proenzyme known as pepsinogen and hydrochloric acid
- The oxynticopeptic cells found in birds secrete both HCl and pepsinogen
- Gastric juice produced in response to protein content in diet
- The basal gastric secretory rate is 15.4 ml/hour and contains 93 mEq/liter of acid and 247 Pu/ml of pepsin
- Acid secretion of chickens is high relative to mammals
- Amylolysis occurs in the crop, it is not evident in the ventriculus

TABLE 5 The Ph of Contents of the Digestive Tract of Avian Species[a]

	Chicken	Pigeon	Pheasant	Duck	Turkey
Crop	4.51	6.3[b]	5.8	4.9	6.0
		4.28			
Proventriculus	4.8	1.4[b]	4.7	3.4	4.7
		4.8			
Gizzard	4.74[c]	2.0	2.0	2.3	2.2
	2.50				
Duodenum	5.7–6.0	6.4[b]	5.6–6.0	6.0–6.2	5.8–6.5
	6.4[c]	5.2–5.4			
Jejunum	5.8–5.9	5.3–5.9	6.2–6.8	6.1–6.7	6.7–6.9
	6.6[c]				
Ileum	6.3–6.4	6.8[b]	6.8	6.9	6.8
	7.2[c]	5.6			
Rectum	6.3	5.4	6.6	6.7	6.5
		6.6[b]			
Ceca	5.7		5.4	5.9	5.9
	6.9[c]				
	5.5–7.0[d]				
Bile	7.7[c]		6.2	6.1	6.0
	6.6[c]				
	5.9				

TABLE 7 Gastrointestinal Hormones in the Domestic Fowl

Hormone	Site of origin	Biological actions
Gastrin	Proventriculus	Stimulates gastric acid and pepsin secretion
Cholecystokinin	Duodenum, jejunum	Stimulates gall-bladder contraction and pancreatic enzyme secretion and gastric acid secretion; inhibits gastric emptying; potentiates secretin-induced stimulation of pancreatic electrolyte secretion
Secretin	Duodenum, jejunum	Stimulates bicarbonate secretion by pancreas
Vasoactive intestinal peptide	Duodenum, jejunum	May be a more potent stimulator of pancreatic electrolyte secretion than secretin; inhibits smooth muscle contraction
Pancreatic polypeptide	Pancreas, proventriculus, duodenum	Stimulates gastric acid and pepsin secretion
Gastrin-releasing peptide (bombesin)	Proventriculus	Stimulates pancreatic enzyme secretion; stimulates crop contraction
Somatostatin	Pancreas, gizzard, proventriculus, duodenum, ileum	Inhibits secretion of other gut hormones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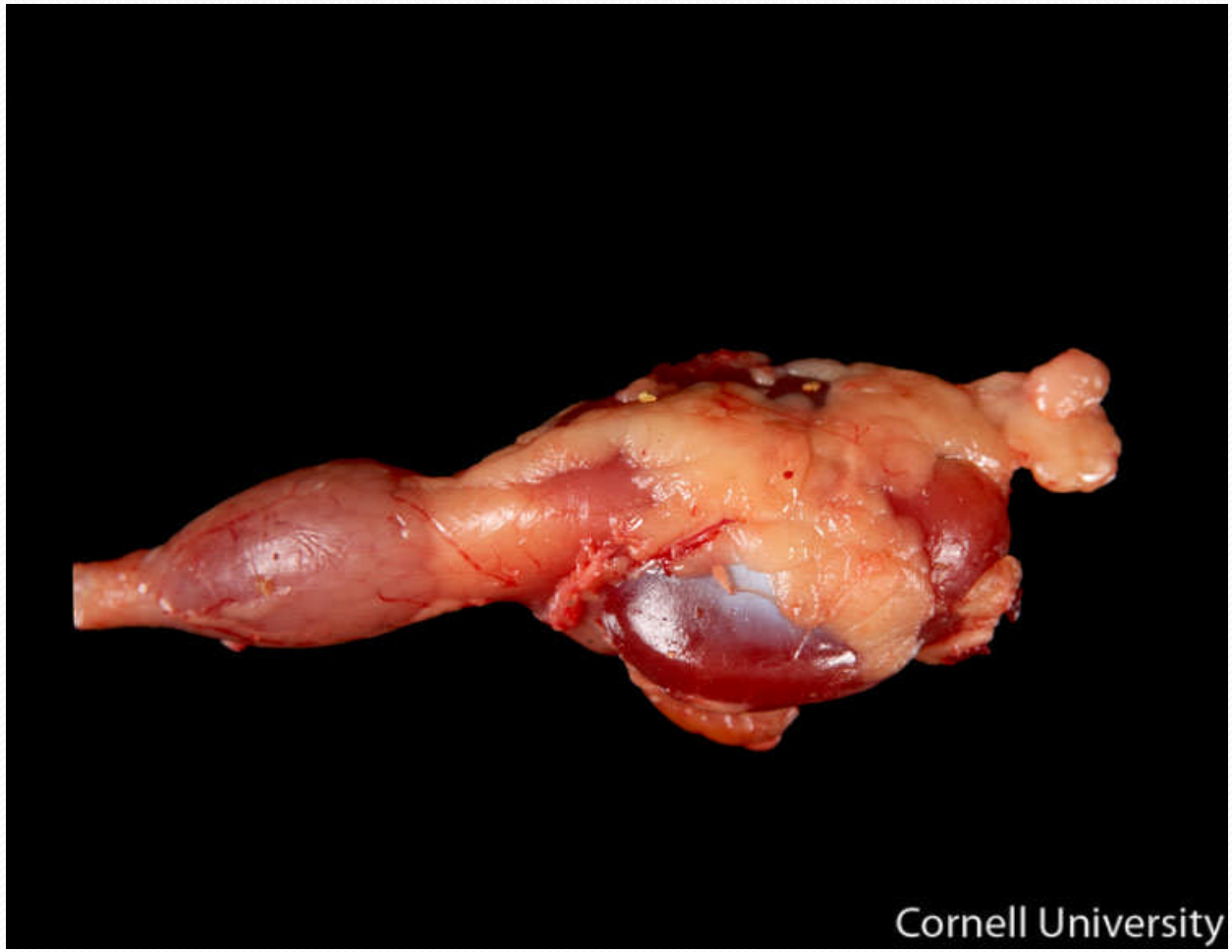
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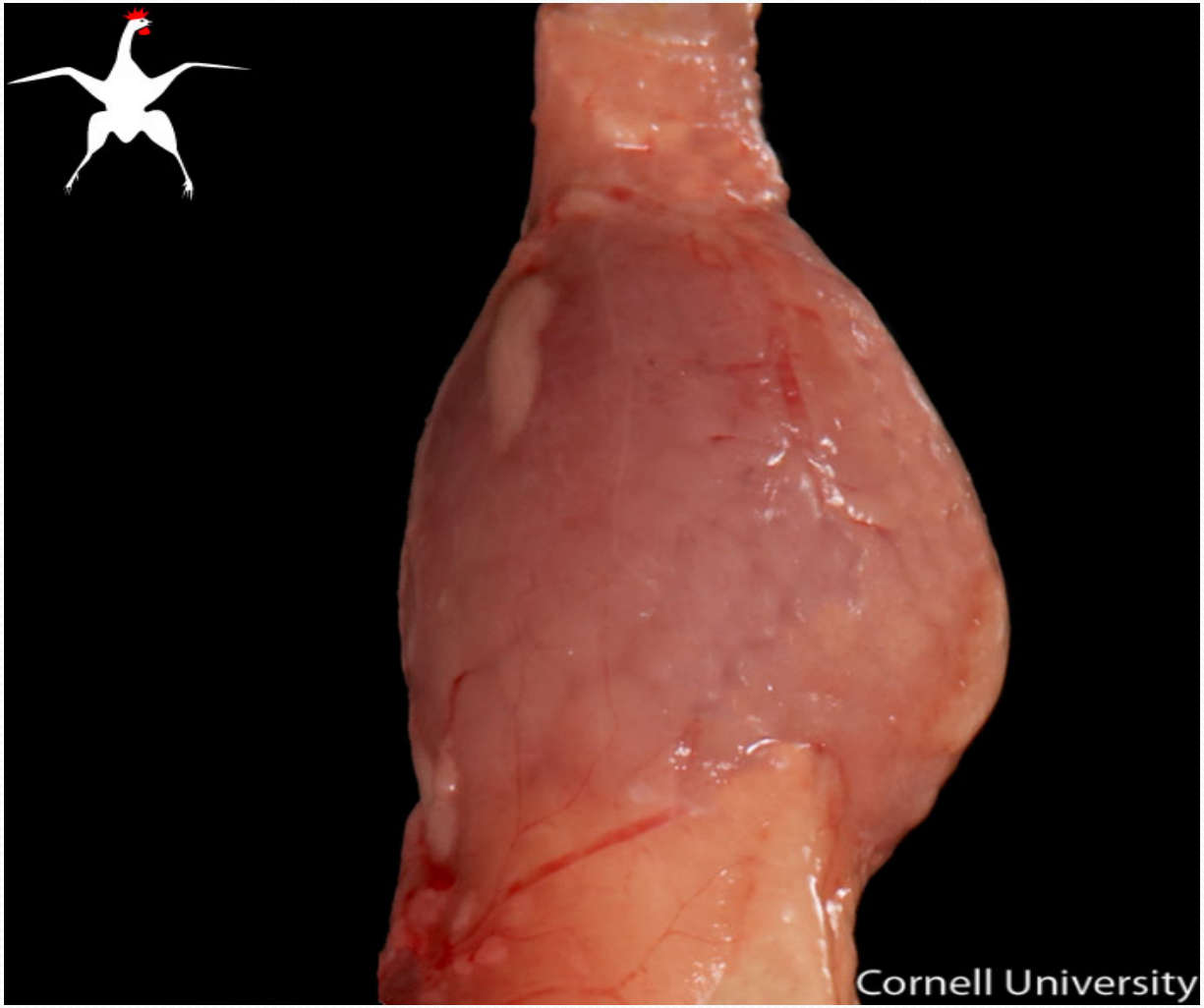
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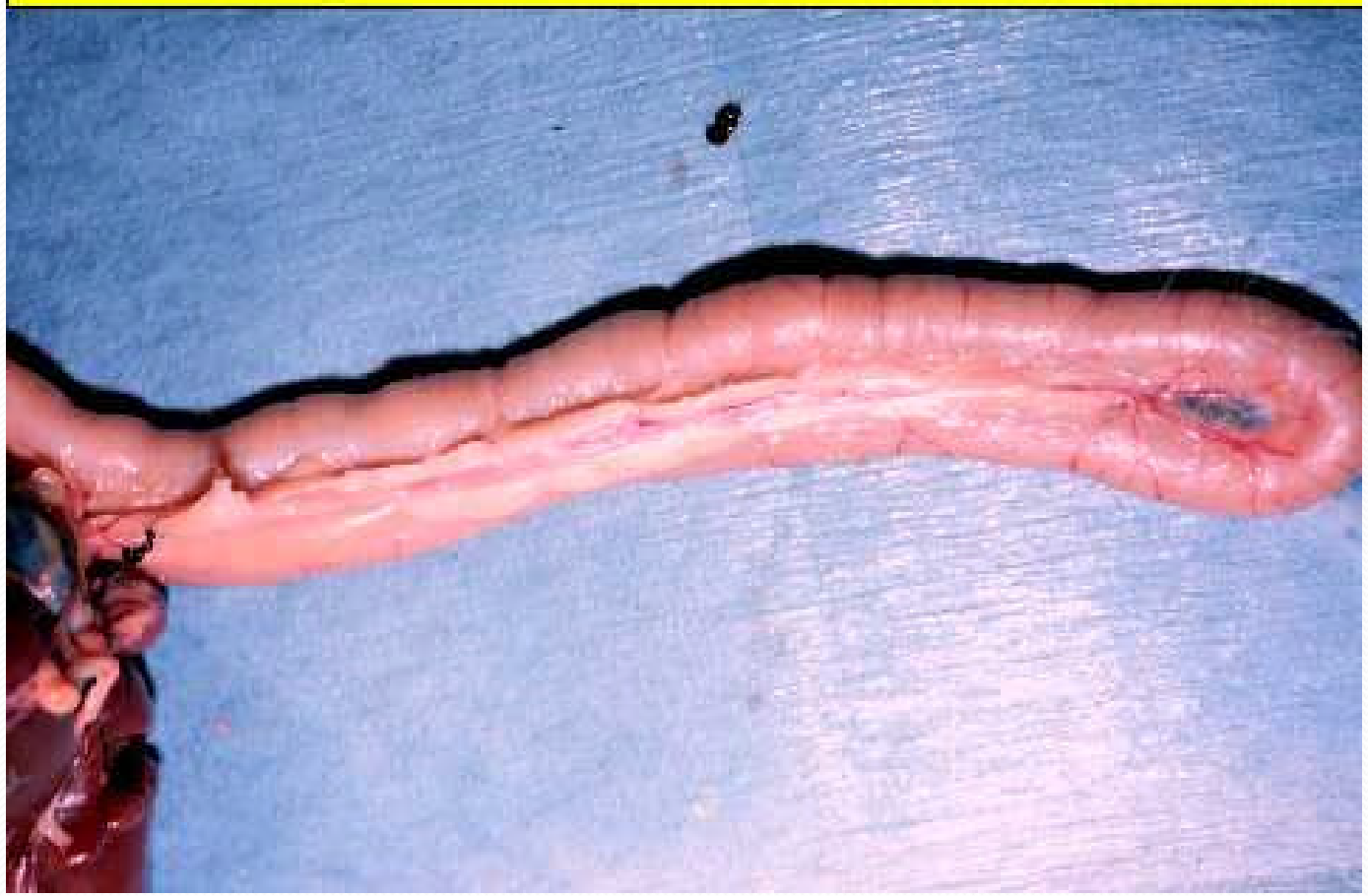
Gizzard

- Also called Muscular Stomach or Ventriculus
- It is made up of two pairs of powerful muscles capable of crushing and grinding the feed particle
- (The tunica muscularis of gizzard is made up of two layers of smooth muscles, inner circular & outer longitudinal)
- It performs powerful muscular contraction, which ultimately leads to crushing and grinding of the particles
- This process is aided by the presence of grit or rocks present in the gizzard
- The gizzard performs 2-5 contractions per minute according to the consistency of the feed particle

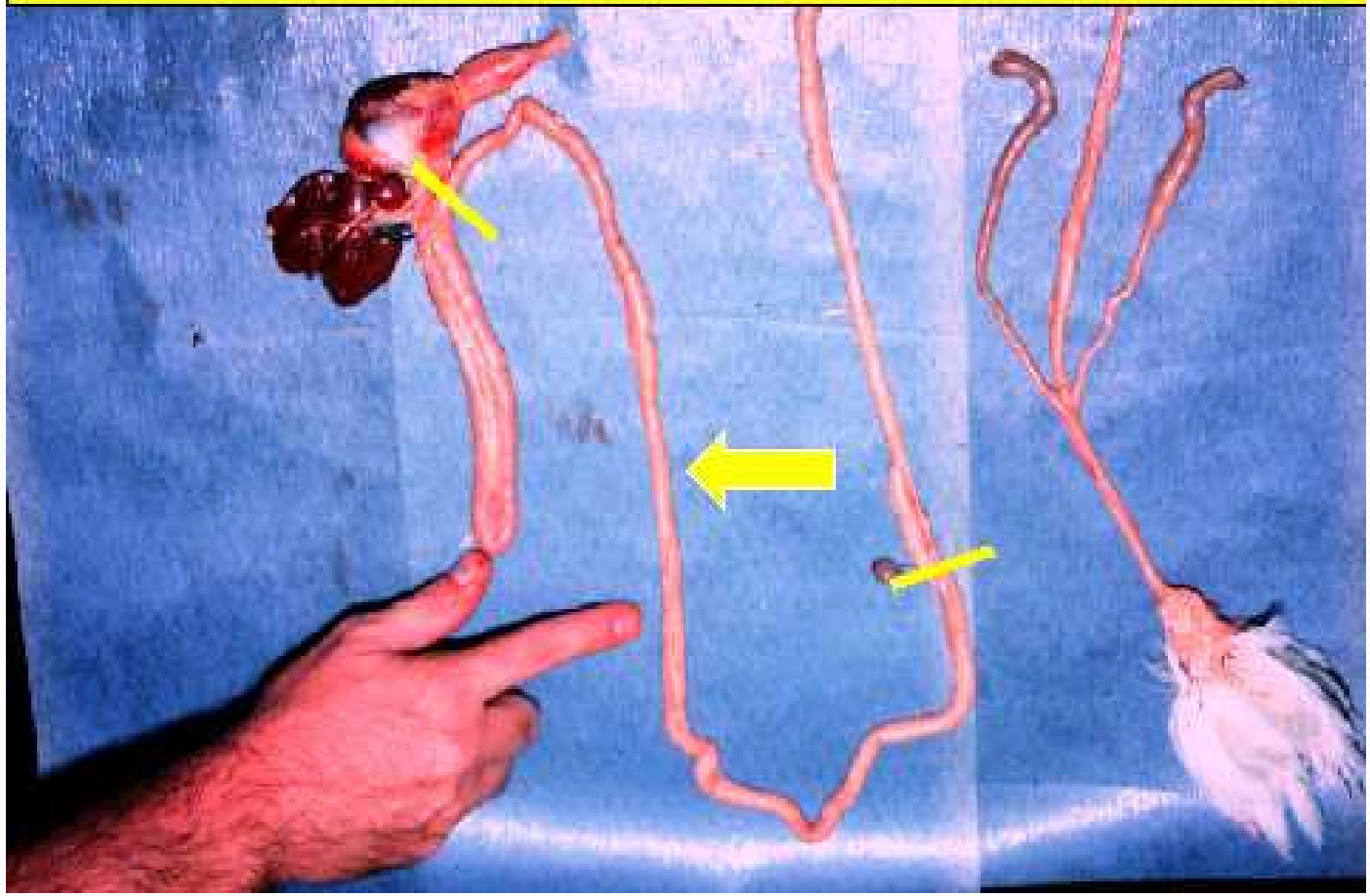
Small Intestine

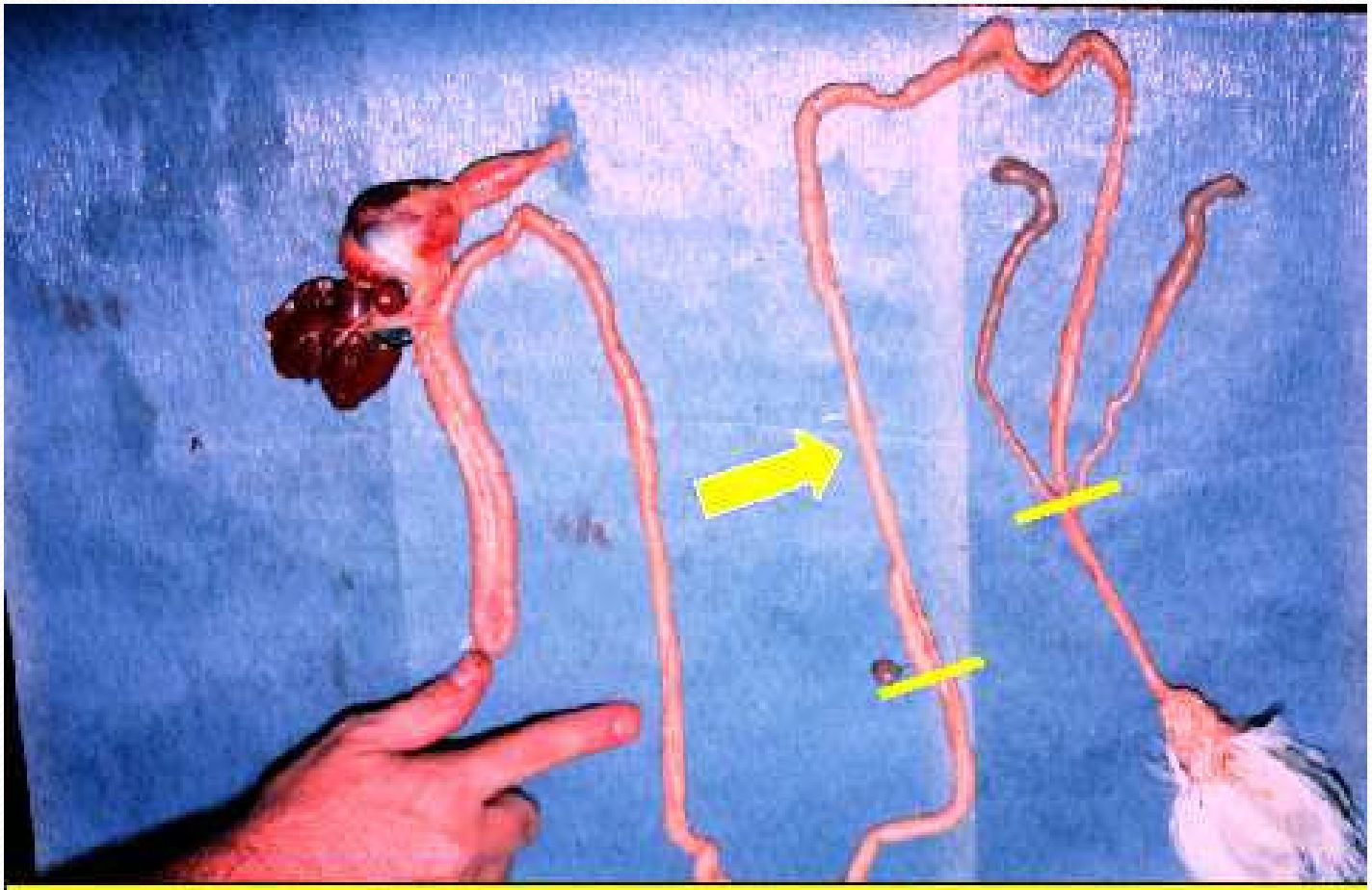
- **Small intestine is 62 inch (1.5 metre) long in the adult bird**
  - **It has three parts.**
  - **1) Duodenum**
  - **2) Jejunum**
  - **3) Ileum**
- **Duodenum makes the loop known as duodenal loop which contain the pancrease**
- **Digestion of carbohydrates, protein, and fat take place in the small intestine with the help of intestinal juice, pancreatic juice, and secretion of liver known as bile**

Duodenum and Pancreas



Small Intestine (Jejunum)





Small Intestine (Ileum)

- **Intestinal juice contains variety of enzymes such as amylase , invertase , and trypsin**
- **The first two enzymes are responsible for the break down of complex carbohydrates into simple sugars such as glucose , maltose etc**
- **While trypsin is responsible for break down of intermediate proteins like proteoses, peptoses into aminoacids**
- **Similarly, pancreatic juice contain variety of enzymes that do take part in digestion of carbohydrates , protein and fat**

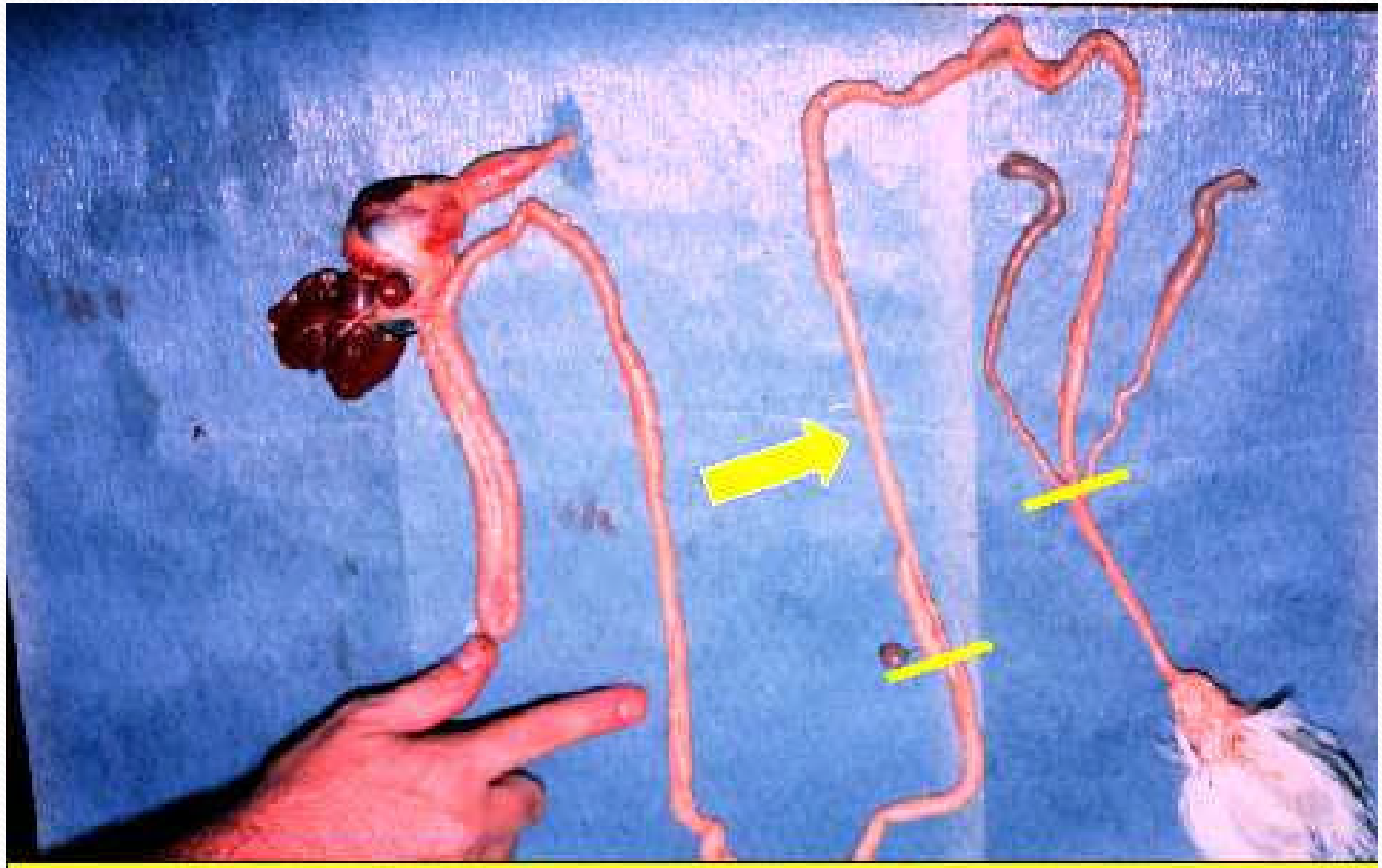
TABLE 8 Enzymes Secreted by the Intestines

Enzyme	Substrate	Product or function
Maltase	Maltose	Glucose
Isomaltase	Dextrins	Glucose
Sucrase	Sucrose	Glucose, fructose
Enterokinase	Trypsinogen	Trypsin
Lipase	Monoglycerides	Glycerol, fatty acids
Peptidases	Di- and tripeptides	Amino acids

- **The bile produced from the liver is responsible for emulsification of fat which is then digested by variety enzymes**
- **After completion of digestion the end product of carbohydrate (glucose) protein (amino acid) fats (fatty acid) are absorbed by the finger like projections of small intestine known as villi**
- **The amino acid and fatty acids and glycerol are absorbed into the lymphatic vessels**
- **These end products are ultimately reached to the liver via portal vein**

Caeca

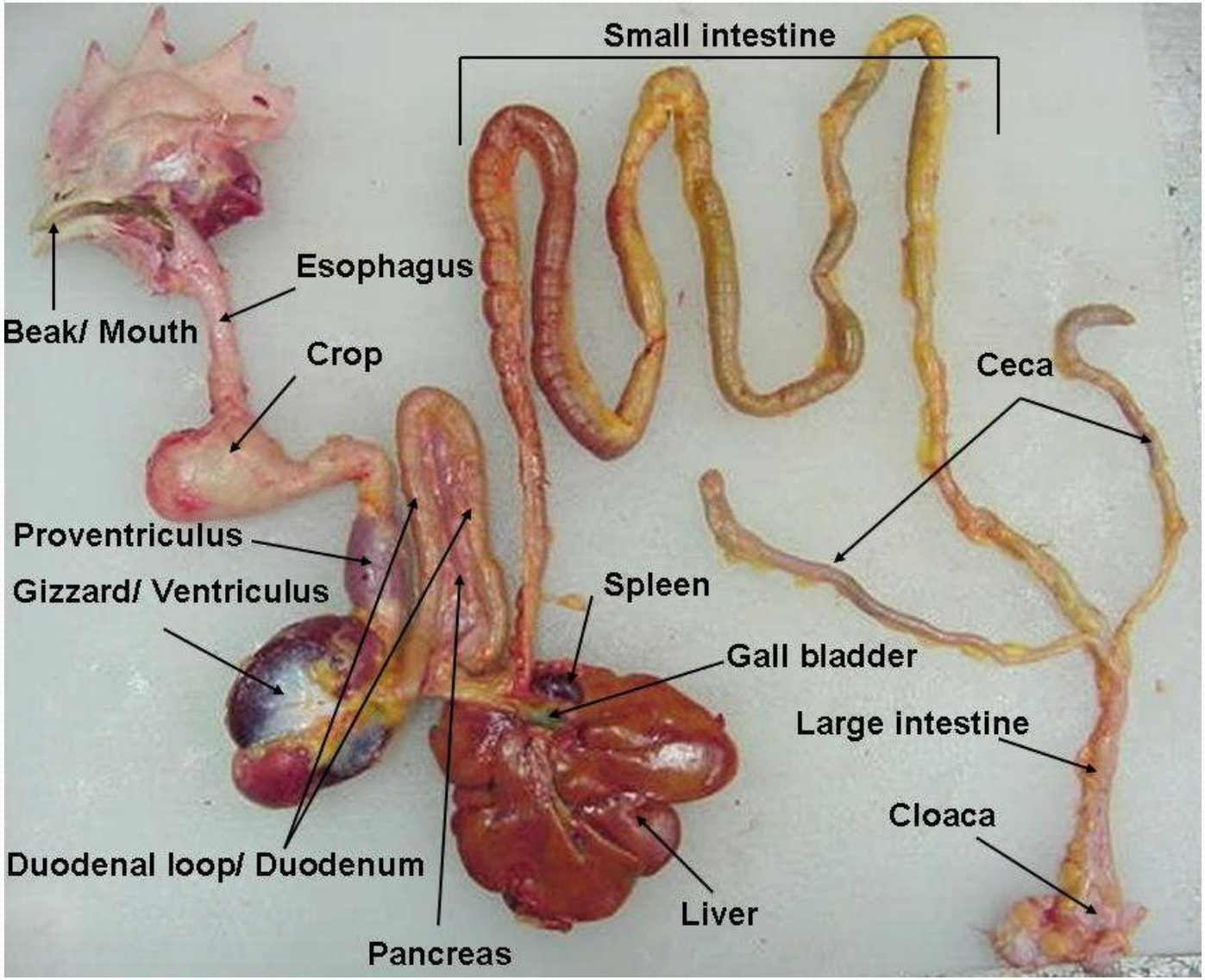
- **These are two blind pouches located between the small intestine and large intestine having a length of 6 inches (1.5 cm)**
- **The function of Caeca is not clear**
- **It is thought that it takes part in digestion of carbohydrate, proteins, and crude fiber with the help of bacterial action**



Small Intestine (Ileum)

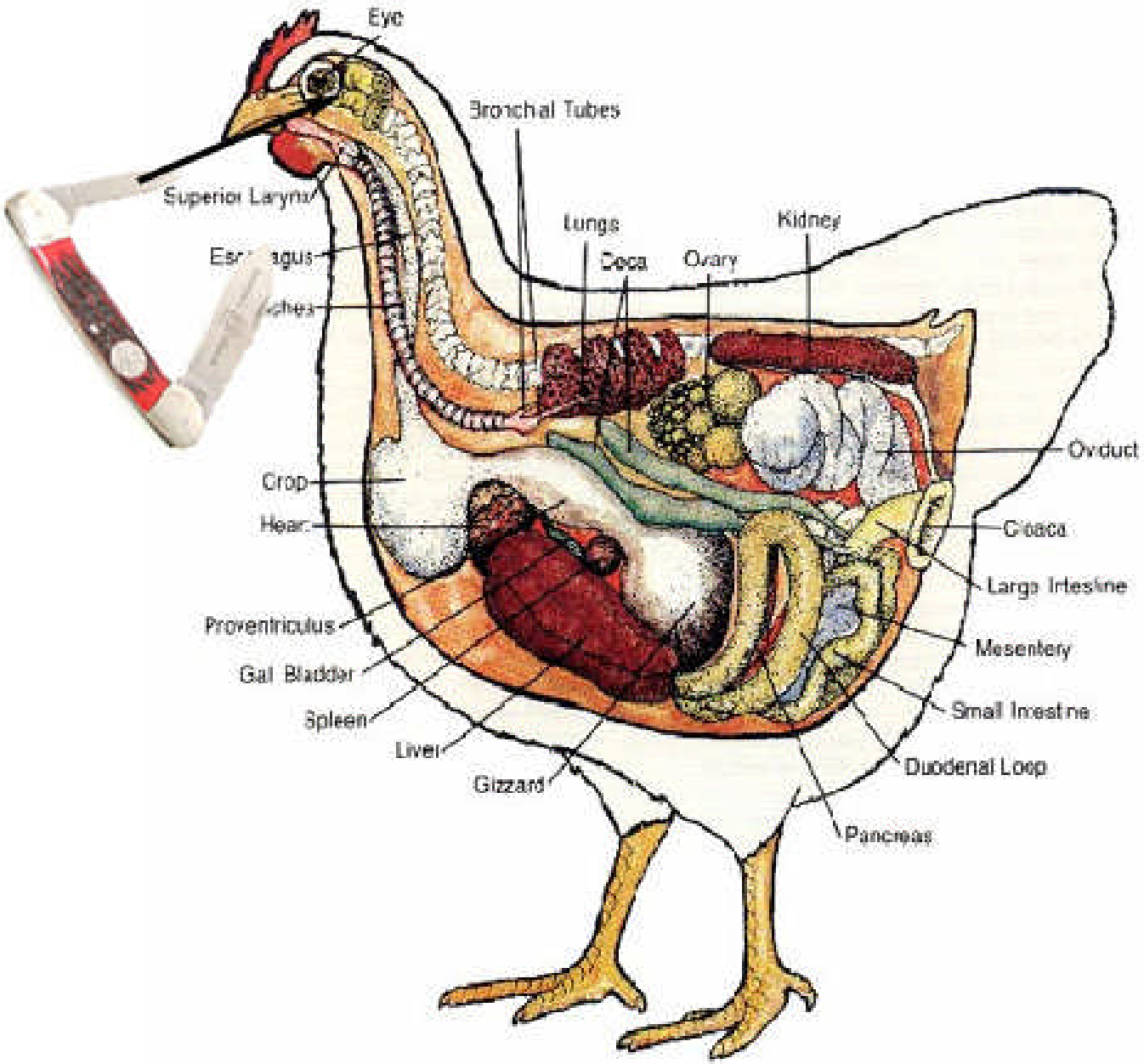
Large Intestine

- **Large intestine is much smaller as compared to small intestine and caecum**
- **The length of large intestine is 4 inches (10 cm)**
- **The diameter is twice the diameter of small intestine**
- **It extends from small intestine to cloaca**
- **It helps to maintain water balance by water absorption.**

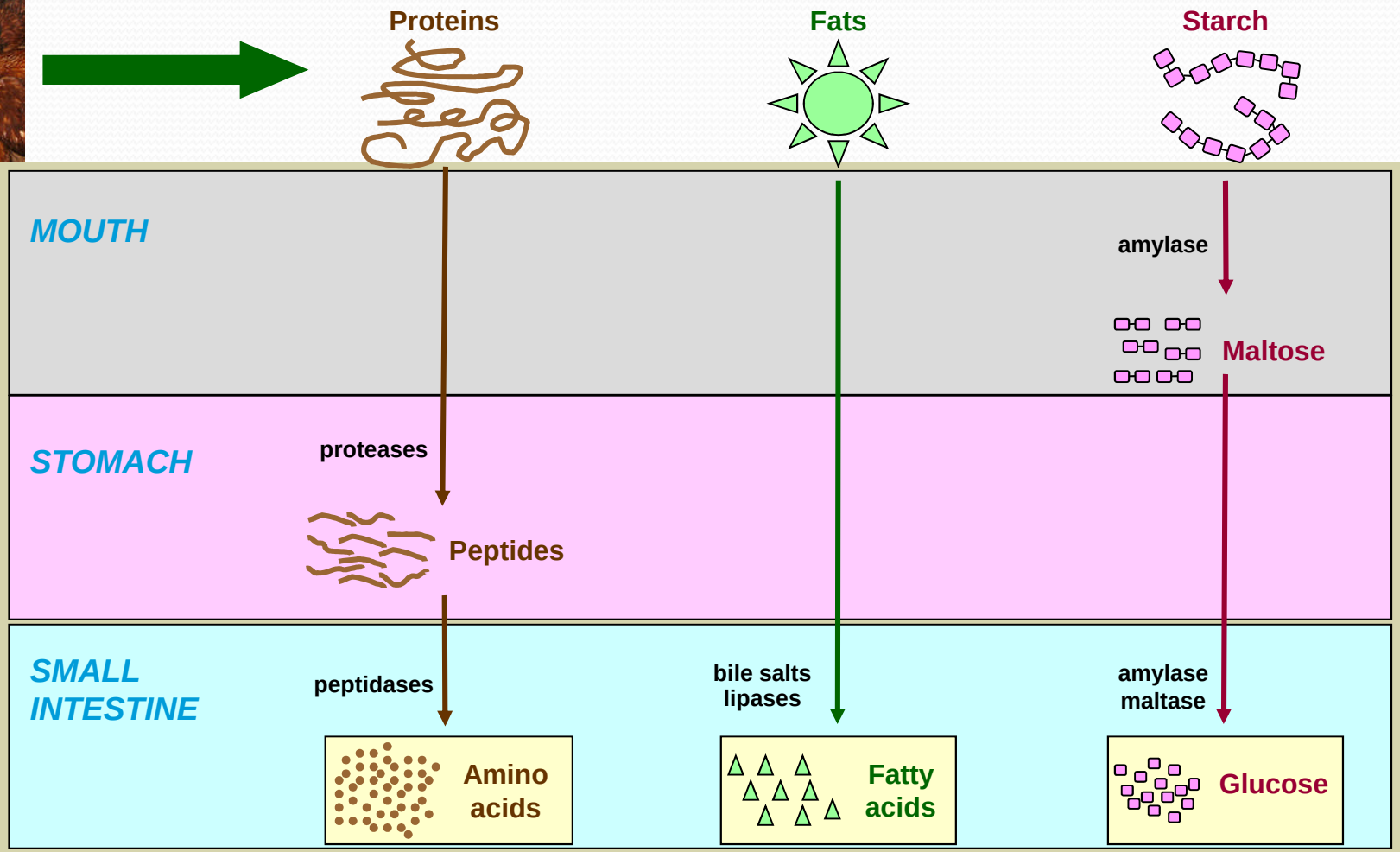

Small intestine
Esophagus
Beak/ Mouth
Crop
Ceca
Proventriculus
Gizzard/ Ventriculus
Spleen
Gall bladder
Large intestine
Cloaca
Duodenal loop/ Duodenum
Liver
Pancreas

Cloaca and Vent

- It is the bulbous/enlarged area located at the end of large intestine
- It is also known as common sewer because it receives the openings from digestive system, reproductive system and urinary system
- External opening of the cloaca is known as vent and its size is variable depending upon the productivity of the birds


Eye
Bronchial Tubes
Superior Larynx
Lungs
Kidney
Ceca
Ovary
Crop
Heart
Oviduct
Cloaca
Large Intestine
Proventriculus
Mesentery
Gall Bladder
Small Intestine
Spleen
Liver
Duodenal Loop
Gizzard
Pancreas

Digestive Process in Poultry



ACCESSORY DIGESTIVE GLANDS AND THEIR FUNCTIONS

- **There are three types of accessory digestive glands which play a vital role in the process of digestion**

1. **Salivary Glands**
2. **Pancreas**
3. **Liver**

1- SALIVARY GLANDS

This gland is responsible for production of saliva. Amylase is not present in the saliva of Gallus and Melecigris. Its secretions ranges from 7 to 25 ml.

The saliva has following functions

- Saliva causes the lubrication of the feed
- Saliva has a enzyme known as salivary amylase or ptyalin. It is responsible for the break down of glycosidic linkage and thus it splits carbohydrates molecule. This enzyme acts on starch and converts into maltose
- Saliva acts as a buffer because it contains bicarbonate and other salts
- It also helps in tasting the feed
- It protects the mucous membrane and keeps it moist
- It helps regulate the body temperature
- Saliva contain enzyme known as muramidase which is bacteriosidal in nature and thus it produces the local immunity

2- PANCREAS

- **Pancreas produces a pancreatic juice having a pH of 6.9 and is released in the distal end of the loop of duodenum**
- **<u>Composition of Pancreatic juice</u>**

Pancreatic juice contains four kinds of enzymes

1. **Proteolytic Enzymes**
2. **Lipolytic Enzyme**
3. **Carbohydrate splitting Enzymes**
4. **Nucleolytic Enzymes**

A- Proteolytic Enzymes

- There are five different kinds of proteolytic enzymes
  1. Trypsinogen
  2. Chymotrypsinogen A
  3. Chymotrypsinogen B
  4. Procarboxy peptidase A
  5. Procarboxy peptidase B
- These enzymes are responsible for the break down of protein molecules into simpler units

B- Lipolytic Enzyme

- There are three type of lipolytic enzymes which are produced by the pancreas
  1. Phospholipase
  2. Pancreatic lipase
  3. Cholesterol esterase
- The first two enzymes are responsible for the break down of lipids while third enzyme is responsible for esterification of cholesterol

C- Carbohydrate splitting Enzymes

- **These consist of**
  1. **Pancreatic amylase**
  2. **Invertase**

- **Pancreatic amylase acts on the starch and converts it into simpler units while invertase acts on the sucrose and convert them into simpler sugars**

D- Nucleolytic Enzymes

- There are two kinds of nucleolytic enzymes
  1. Ribonuclease
  2. Deoxyribonuclease
- Besides enzymes pancreatic juice also contains cations and anions.
- Cations: Na+, K+, Mg++, etc.
- These act as buffer, cofactors, and osmotic regulators.
- Anions: HCO_3
- These mainly act as buffer and osmotic regulators

3- LIVER

- **Liver is a bilobed structure and it perform the following functions**

1. **After the digestion of feed the feed is taken up by the villi of small intestine which then enters in the hepatic portal circulation and mobilized towards the liver**
2. **The feed is detoxified by the liver and then distribute to the entire body**
3. **It also act as a store house for the vitamins and carbohydrates The carbohydrates are stored in the form of glycogen**
4. **The liver is responsible for the formation plasma protein like albumin and globulin**
5. **It activates and inactivates the protein and peptide hormones**
6. **Liver is a site for the destruction of old RBCs which ultimately leads to the formation of bile, which is responsible for the emulsification of the fat**

Composition of Intestinal Juice

- **<u>Composition of Intestinal Juice</u>**
- **Intestinal juice is composed of following.**

1. **Peptidase (Erepsin)**
2. **Sucrase (invertase)**
3. **Maltase**
4. **Lactase**
5. **Nucleotidase**
6. **Polynucleotidase**

MECHANISM OF ENZYME PRODUCTION AND ACTIVATION

- **The activities of gastrointestinal tract are controlled**

1. **Nervous system**
2. **Endocrine system**

- **In case of nervous system autonomic nervous is responsible for controlling the activity of gastrointestinal tract**
- **This system has two parts**

1. **Parasympathetic nervous system**
2. **Sympathetic nervous system**

- **The parasympathetic nervous system activates the gastrointestinal tract while sympathetic nervous system activates as well as deactivates the gastrointestinal tract**
- **When the feed enter the oral cavity, the visual stimuli, smell and taste stimulate the parasympathetic which ultimately leads to the production saliva**
- **Similarly when feed enters the Proventriculus the walls are stretched leading to the release of a hormone known as gastric juice**
- **When the feed enters small intestine the duodenum produces the secretin which stimulate the pancreas to produce pancreatic juice**
- **In response to the fats, the duodenum produces another hormone known as cholecystokinin, which causes the stimulation of gall bladder and the release of bile**

ACTIVATION OF ENZYMES

- **The enzyme present in the gastric juice i.e. pepsinogen is stimulated by HCl or pepsin into the active form known as pepsin.**
- **The proteolytic enzymes present in the pancreatic juice are released in inactive form the trypsinogen is activated by another enzyme known as enterokinase, which is released from duodenum**

Carboxy peptidase ← Procarboxy Peptide

- **Enterokinase → trypsinogen → trypsin↑↓**

Chymotrypsin← Chymotrypsinogen

TABLE 1.1 Digestive enzyme activity

Location	pH	Enzyme (or secretion)	Substrate	Product
Mouth	7.0 to 7.5	Saliva	Lubricates and softens feed	
		Amylase (ptyalin)	Starch	Dextrin
			Dextrin	Glucose
Crop	4.5	Mucus	Lubricates and softens feed	
Gizzard and proventriculus	2.5	HCl	Lowers digesta pH, initiates protein cleavag	
		Pepsin	Protein	Polypeptides
		Lipase	Triglyceride	Fatty acids, monoglycerides
Duodenum	6.0 to 6.8	Amylase (amylopsin)	Starch Dextrin	Maltose Glucose
		Trypsin, chymotrypsin and Elastases	Proteins, peptides	Peptides, amino acids
		Carboxypeptidases Collagenase	Peptides Collagen	Amino acids Peptides
		Bile	Emulsification of fats	
		Lipase	Fat	Fatty acids, monoglycerides, diglycarides
		Cholesterol esterase	Cholesterol Esters	Fatty acids, Cholesterol
Jejunum	5.8 to 6.8	Maltase and Isomaltase	Maltose Isomaltose	Glucose Glucose
		Sucrase	Sucrose	Glucose, Fructose
		Lactase	Lactase	Glucose, Galactose
		Peptidases	Peptides	Dipeptides, Amino acids
		Polynucleotidase	Nucleic acids	Mononucleotides
Ceca	5.7 to 5.9	Microbial activity	Cellulose, polysaccharides, starches, sugars	Volatile fatty acids, vitamin K, B-vitamins

Regulation of Feeding

- **There are different factors affecting the regulation of feeding in birds which are as followings**

1. **Size**
2. **Sex/gender of the bird**
3. **Age of the bird**
4. **Body temperature & ambient temperature**
5. **Activity**
6. **Reproductive stage**
7. **Appearance and taste of feed**
8. **Energy contents of feed**

Mechanism of Hunger

- There are two systems or centers located in the brain or liver which controls the feeding behavior of animals
  1. Satiety center
  2. Appetite center
- The stimulation of statiety center leads to the ceasation of feed in take and is activated by the elevated level of glucose in the blood
- This center is located in the liver of the chicken while in other animals it is located in the brain
- This center is also known as glucostatiey Centre
- The stimulation of this Centre results in feed intake or hunger. This centre is stimulated by low concentration of glucose in the blood. This is located in the brain.

Details

- Vagus, the tenth cranial nerve, arises from the medulla and carries both afferent and efferent fibers
- Cholinergic drugs are medications that produce the same effects as the parasympathetic nervous system.