Dr. Muna H. AL-Saeed

Physiology

Digestive system:-

The organs of the digestive system include the mouth, pharynx, esophagus, stomach, small intestine and large intestine.

Digestion:- Mean the change of the food (breakdown) into the simple form and makes easily absorbed into blood stream, for instance.

Digestion:- is a form of catabolism (breakdown) of large food molecules to smaller ones.

In most vertebrates, digestion is a multi-stage process in the digestive system, starting from ingestion in mouth until the large intestine.

Ingestion will include some type of physical (mechanical) and chemical processing.

Digestion is separated into four steps:-

1- Ingestion: placing food into the mouth (entry of food in the digestive system).
2- Mechanical and chemical breakdown: mastication and mixing of the resulting bolus with water, acids, bile and enzymes in stomach and intestine to breakdown complex molecules into simple structures.
3- Absorption: of nutrients from the digestive system to the circulatory and lymphatic capillaries through osmosis, active transport, and diffusion.
4- Egestion (Excretion):Removal of undigested materials from the digestive tract through defecation.

The digestion in the mouth:-

In animals, digestion in oral cavity, otherwise known ″ Buccal Cavity″ where food chewed, its digestion starts by process of mastication , a form of mechanical digestion in mouth take place by action of teeth and assistance by tongue and saliva which play very important part by it physical action in moisten the food. Saliva is secreted in large amounts (1-1.5 L / D) by three pairs of exocrine salivary gland (parotid, submandibular and sublingual) in the oral cavity, and is mixed with the chewed food by the tongue. The chemical digestion in mouth will occur by the action of saliva.

The saliva has the many function as well as the chemical digestion these are:-

1-It moisten the food.

2- It clean the mouth from the small particles of food.

3-It will prevent the growth of bacteria and it is action in keeping the pH of mouth constant.

4-It will act as secretary organ because will assist in excreted many organic and inorganic compound.

There are four types of salivary gland:-

1- Tiny cells in the surface of the mouth and pharynx which secret saliva rich with mucous.
2- Sub-lingual salivary gland:- These are presence under tongue and secreted saliva rich mucous.
3- Parotid salivary gland:- These are presence in the side of face under the ears. They secret watery saliva a rich with enzyme.
4- Sub-mandibular salivary gland:- These are presence under the jaw excrete saliva contain mixed a mucous and watery enzyme.

- **The chemical digestion in the mouth occur by action two enzymes present in the saliva these enzymes are:-**

1- The saliva amylase (ptyalin):-

Which are on the complex carbohydrate (polysaccharides) eating such as starch(large molecules) and change it into (disaccharides) such as maltose.

2- Maltase:- which present in a small amount and it will act on maltose and change it into glucose but action of these enzymes in the mouth is very a few because the food will not remain in the mouth for long time, but the first enzyme will continuous action in the stomach about an hour until the acidity of stomach became high because the action of hydrochloric acid. Which stop the action of the enzyme. The saliva also contain some other substance such as sodium, potassium, chloride.

Regulation of salivary secretion

The salivary secretion regulated by two ways:-

1- Nerves Control:- Which depend on smell of food. This will stimulate the secretion of saliva before the entering of food into the mouth. This will occur as a reflex controlled by the brain.

2- Adirect stimulation of food when inter the mouth:-

This will directly stimulate the saliva in order to increase. Its secretion or it ingest stimulate especial receptor presence in the mouth cavity (buccal) these receptor will send information to the brain in order to increase the saliva secretion. Some kinds of food such as biters, acids and salt food will increase the salivary secretion more than the other kind of food.

The esophagus has no digestive function but it is only work as passage for the food from the mouth to word stomach.

The digestion in the stomach (Simple Stomach).

The most important process in the stomach is the chemical digestion. The stomach contain in its wall glands for (the gastric glands). These gland secrete a juice known as a gastric juice. These gland found as a sac in the wall of the stomach it contain 3 kinds of cells.

known

These are cells

1- Neck Cells:- These cells are found in the neck of gland and they secrete mucous substance is very important because it protective connect the wall of stomach from the action of the acid and digestive enzymes. It will lined the stomach wall from the inside and form a protective layer.

2- The Parietal Cells :- These are flat cells found near the wall of gland it secrete a hydrochloric acid.

3- The Chief Cells:- These form the major part of the gastric gland and they are bigs size and the secrete the digestive enzymes of the stomach.

They secrete two enzymes

A-The pepsin:- which is stored and secreted in inactive form called (pepsinogen) in order to prevent the digestive action of the enzyme on the cells of the gland or the alter part of stomach. The pepsinogen will be transported from the inactive form to active form by the action of HCL (hydrochloric acid) and properly the pepsin which form will activate to other pepsinogen to pepsin.

B- Renin(milk curding enzyme):- This enzyme is secreted by the gastric gland during the first years old age and assist in the digestion of milk.

Control of Gastric Secretion

The control of gastric secretion will be classify into three phases:-

1- **Cephalic phase:-** The gastric secretion depend on direct stimulation by the nervous system on the gastric gland in order to increase the gastric secretion. This stimulation is mediate by sense organs related to the digestive system the smell, the taste, the site and even hearing of food preparation will stimulate the gastric secretion.

2- **Gastric Phase:-** In this phase the secretion of gastric juice depend on the entrance of food into the stomach and this will occur by one of three ways.

A- The entrance of the food in the stomach will stimulate directly the mucus membrane of the stomach and this will increase the secretion of gastric gland specially the mucus substance.

B- The entrance of the food in the stomach will stimulate special receptor in the wall of the stomach called nervous plexuses. These receptors will send the information toward the brain who will stimulate the secretion of the gastric juice via the vagus nerve.

C- Hormonal stimulation of the secretion of gastric gland:-
There is a special hormonal called (gastrin) which is secreted from (G) cells of the pyloric antrum of the stomach due to the entrance of food in the stomach. This hormone will stimulation of gastric acid secretion and stimulation of growth of the gastric mucosa.

3- **The intestinal phase:-** The gastric juice increase or regulated due to entrance food into duodenum and this is pyloric to hormones secreted from this part small intestine.

The action of Gastric juice:-

Normal gastric secretions contain (a glycoprotein) called intrinsic factor, secreted by the same parietal cells that secrete hydrochloric acid. Intrinsic factor must be present for adequate absorption of vitamin B_{12} from ileum. That is, intrinsic factor combines with vitamin B_{12} in the stomach and protect it from being digested and destroyed as it passes into the small intestine. Then, when the intrinsic factor-vitamin B_{12} complex reaches the terminal ileum, the intrinsic factor binds with receptors on the ileal epithelial surface. This in turn makes it possible for the vitamin B_{12} to be absorbed. In

the absence of intrinsic factor, an adequate amount of vitamin B_{12} is not made available from foods to cause young, newly forming red blood cells to mature in the bone marrow. The result is *pernicious anemia*. The *pernicious anemia* is common accompaniment of gastric atrophy and achlorhydria.

1- The mucus is a protective substance of forming a thin layer an inner surface of the stomach which protective enzyme and also against the irritation produce by acid and digestive enzyme and also against a irritating substance which enter to stomach from outside in the food. The mucus also neutralize the medium of stomach.
2- The pepsin enzyme will act on the big molecules of protein and change it into polypeptides. This enzyme started the digestive of protein.
3- The Renin will present the casein (milk protein) in order to give para casine which in present of Ca ion will change into Ca para casein.
4- Gastric lipase is present in very small and will started the digestion of fat and lipase change it into fatty acid and triglycerides.
5- HCL:-This acid is very important because it will provide the necessary medium form the digestion of carbohydrate, protein and lipids in the stomach. It also activate the pepsinogen and change it into pepsin(It has a pH of 2, which is perfect for proteases such as pepsin to break down proteins as effectively as possible). It also prevent growth of many infected bacteria in stomach(It sterilizes food by killing pathogens and other microbes).

Mechanical digestion of the stomach:-is complete by movement of stomach the peristalsis movement of stomach which is useful beginning breaking down big molecules of food into smaller amount and give ability of enzymes to work on these particles. It also assist in moving the food particles along the stomach. The movement also assist in mixing the food together with the gastric juices. The other kind of movement is the shivering movement. This movement noticed in empty stomach more than fill stomach it also assist in the mixing of food with the gastric juices. The move of stomach inhibited by the action of hormone called entrogastrone (secreted from the duodenum)which make other function inhibit the gastrin.

Digestion in the Small Intestine:-

The chemical digestion:- In the small intestine will occur by the secretion of two juices.

1- <u>Pancreatic juice</u>:- This is a very important mixture which is secreted by the pancreas because this juice is a complete digestive . The juice is contain four types of enzymes.

a- **<u>The proteolytic enzymes</u>**:- This group contain three enzymes act on the protein these are:-

1-**Trypsin** which is stored and secreted by the pancreas into as inactive trypsin known (Trypsinogen) this activated by another enzyme called entrokinase which transported the trypsinogen into trypsin the action of trypsin is on the big molecules protein to breakdown it into polypeptidase.

2-**Chemotrypsin** It is also stored and secreted from the pancreas as in active phase called chemotrypsinogen which activated into entrokinase which also break down big molecules of protein into polypeptidase.

3-**Carboxypolypeptidase**:- This enzyme will act on the polypeptide and change into tripeptide and dipeptide.

b-**amylolytic enzyme (pancreatic amylase):-** This enzyme act on carbohydrate (starch) and change it into maltose it is similar the salivary enzyme similar function but it only different that of enzyme alkaline median but the first one acid median.

c-**Lipolytic enzyme (pancreatic lipase):-** This enzyme is act on lipid and convert it into glycerol and fatty acid. It complete the digestion of lipid in the intestine which is start by the gastric lipase this enzyme is highly activated by bile salts and it becomes three times its normal action is present in bile salts moreover the bile salts will emulsify the fat and convert it into emulsion and by this process the surface area will be increase and enzyme will act better.

d-**Two enzyme which act on ribonuclease and deoxyribonuclease**:- There enzymes will act on RNA and DNA and convert them into mononucleotides.

<u>The Control of Pancreatic Secretion:-</u>

This secretion pancreas juice is control by nervous factor because the stimulation of vagus nerves will increase the secretion of the pancreas and also it is control by hormonal factor which is more important than the nerve factor.

The hormonal control contain 2 hormones secreted by intestinal cells and absorbed to the blood and when it reach the pancreatic cells it will increase the secretion of pancreatic juice these hormones are:-

1- **Secretin Hormone**:-This hormone increase secretion of pancreas juices rich with bicarbonate and poor with enzyme.

2- **Pancreozymine [cholycystokinin (CCK)]**:- This hormone will act on duodenum increase secretion of a pancreatic juice rich with enzymes. So the bicarbonate are substance which secreted from assist in neutralize the intestinal median.

2-**The Intestinal Juice:-** The wall of the intestine contain types of glands there are:-

a-**Brunner glands:-** These gland present in the wall of the intestine is specific in its secretion it secret mainly mucus which assist in coating the intestinal wall and protective from the action of acidic chymose which comes from stomach and also a little assist in neutralize the intestinal medium.

b-**Crypts of Lieberkuhn**:- These gland secrete the intestinal juice which is also called succus entericus which is rich in many enzymes.

The most important enzyme secreted by the crypts of Lieberkuhn are:-

1- **The enterolipase** which is a very important enzyme in the activation of protolytic enzyme.

2- **The enzymes act on the protein** This group of enzyme include three enzymes which act on protein and these are:-

a- Aminopolypeptidase which is similar to carboxy polypeptidase which secreted from pancreas. This enzyme act on the polypeptide conversion into tripeptide and dipeptide.

b- Tripeptidase which act on tripeptide conversion into dipeptide.

c- Dipeptidase which act on dipeptide conversion into amino acids. This group enzyme complete the digestion of protein and conversion it into a simple form. These enzymes is not secreted into the lumen of intestine but it is present in the cells of the mucus membrane so it will act on the sometime of the absorption process.

3-**Group of enzymes which act on carbohydrate**:-

This group include three enzymes are:-

a-**maltase** :- which act on maltose and convert it into glucose.

b- **Sucrase**:- which act on sucrose and convert it into glucose.

c-**Lactase** :- which act on lactose convert it into glucose.

4-**The Enzymes which act on the nucleic acid**

There are two enzymes secreted by the crypts of lieberkuhn these enzymes are :-

a-**Nucleotidase**:- which act on nucleotide and convert it into nucleoside.

b-**Nuclosidase**:- which act on nucleoside and convert it into ribose are deoxyribose and nitrogen base.

Control of Secretion of intestinal gland

The secretion of intestinal gland is controlled by

1- **A simple reflex action** :- which is bed on intestinal wall when enter of food into the first part of duodenum this will directly stimulation secrete to intestinal gland specially Bunner gland.
2- **The vagus nerve**:- Also has effect on fold mucosa of intestine and lead to excitation of intestinal gland and increase secretion of intestinal gland. This is enhanced by the entrance of food into the first part of duodenum. This will increase the secretion of intestinal juice rich with enzymes.
3- **The entrance of the acidic chyme from the stomach to the intestine:-** will stimulate the mucus membrane of duodenum to release the hormone called cholecystokinin. This hormone flow by the blood and when reach intestine gland will increase secretion that to say increase the intestinal juice.

Bile Juice:- The bile juice is synthesis by the liver and store in a sac called gall bladder. Bile is secreted in two stages by liver: 1) The initial portion is secreted by the principal functional cells of the liver , the hepatocytes;this initial secretion contains large amounts of bile acids, cholesterol, and other constituents. It is secreted into minute bile canaliculi that originate between the hepatic cells. 2) The bile flows in the canaliculi toward the interlobular septa, where the canaliculi empty into terminal bile ducts and then into progressively larger ducts, finally reaching the hepatic duct and common bile duct. From these the bile either empties directly into the duodenum or is diverted for minutes up to several hours through the cystic duct into the gall bladder and this sac will open by a duct which guards by a sphincter of Oddi. This sphincter control or regulate on the entrance of the bile juice and the pancreatic juice to the small intestine. It is situated about 12cm from the beginning of duodenum. The bile juice composition of water, bile salts, bilirubin, cholesterol, fatty acid, lecithin and usual electrolytes (Na, K, Ca, Cl and HCO_3). The contain of bile juice not present enzymes. The most important substance of the bile juice which assist in digestion is bile salts. These salts have two important actions in the intestinal tract:

First, they have a detergent action on fat particles in the food. This decreases the surface tension of the particles and allows agitation in the tract to break the fat globules into minute sizes. This is called the emulsifying or detergent function of bile salts.

Second, and even more important than the emulsifying function, bile salts help in the absorption of 1) fatty acids, 2)monoglycerides, 3)cholesterol and 4) other lipids from the intestinal tract. They do this by forming very small physical complexes with these lipids; the complexes are called micelles, and they are semi-soluble in chyme because of electrical charges of bile salts. In order to increase the surface area which make the action of enzymes easy her and also these salts will increase the activity of pancreatic lipase three times from normally activity. The intestinal lipids are (ferried) in this form to the intestinal mucosa, where they are then absorbed into blood.

The Control of the Secretion and Synthesis of Bile Juice by Liver :-

1-The entrance of food contain lipids will stimulate the liver to synthesis bile juice specially bile salts.

2-The present of a big amount of bile salts in the blood and the retention this salts to the liver will stimulate the liver cells to synthesis and secretion the bile juice.

The Control of Secretion of bile Juice from the Gall Bladder to Intestine:-

1- **The entrance of the acidic chymes a rich with lipids to the intestine** will stimulate the gall bladder to contract at the sometime will stimulate the sphincter of Oddi to be relaxed and then bile juice will be secreted into the intestine. The vagus nerve play a very important role in this mechanism of secretion.

2- **Hormonal Factor:-**Which enhance by secreted hormone from the duodenum. This hormone is known as cholecystokinin. This hormone will absorb to the blood and when reach the gall bladder it will stimulate to be contracted and stimulate sphincter to be relaxed for empty of bile juice into the intestine . It's also suggested that this hormone will also stimulate the liver cells to the synthesis and secrete bile juice.

Mechanical Digestion in the Small Intestine:-

This will occur in the small intestine because the presence two types of the movements in small intestine.

1- **Segmental movement**:-which is responsible for mixing of the food together and with the digestive enzymes along the intestine and its moreover thin moreover thin movement also assist in moving food masses from the beginning of intestine toward the end.

2- **The Peristaltic movement** :- It is a movement appear like wave and it is responsible mainly about the movement of food masses along the small intestine.

Digestion in the Large intestine:-

There is no chemical digestion in the large intestine because mainly wast product will reach to the large intestine. There are only two processes occur in this part these are:-

1- **Putrefaction Process:-** It is a processes occur on the indigestive protein which reach the large intestine and this putrefaction occur by microflora which present in the large intestine. The end product of this process is indol and acetic acid.

2- **Fermentation Process**:- It is a process take place on cellulose by the micro flora and this break down the cellulose and there will be many gases product such as methane, CO_2 and other gases. These gases may be sometime very painful to the animal when they are accumulated, moreover there are some microorganism in the large intestine which produce some vitamins such as B complex and B_{12}.

Absorption:-

The Stomach:- There will be absorption amount of water, alcohol and some other chemical such as Salicylic acid (penicillin) and this muco retention o the wall of stomach specially if it is empty to food and this will give rise gastric ulcer.

The Small Intestine:- All kinds of food compound will be absorb across the intestinal membrane. The main reason for the occurance of absorption in the small intestine it is:-

1-Presence of projections called the villi:- These projection gives a finer projection called microvilli these projection have supply of blood vessels and lymphatic cannel this will make these papillae a typical side for absorption.

2-These projection will increase the surface contact will food particles and this will assist in absorption.

3- **The long distance:-** For the food pass thought will give enough time for absorption process.

4- **The chemical digestion of food :-** will be finished in the first half of the small intestine and it will be ready for absorption.

Some types of material need a specially mechanism for absorption there are:-

1- **Vit. B_{12} :-** This Vit. will not absorbed freely except in the presence of a special protein called the intrinsic factor which secreted in the stomach and will adhere with vit. molecules and when reach the ileum it will adhere to the wall of ileum the vit. B_{12} will be absorbed while the intrinsic factor leave freely.

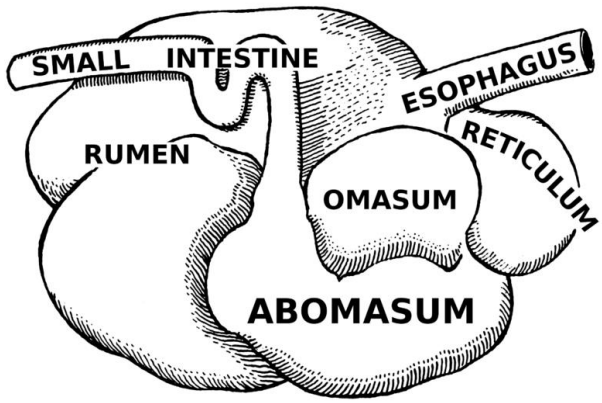
2- **The Iron**

3- **Calcium**
4- **Fat Soluble Vitamin:**A,D,E and K.
5- **Strychnin:-** Absorbed in mouth

Dr. Muna H. AL-Saeed

Digestive System in Ruminant

A **ruminant** is a mammal that digests plant-based food by initially softening it within the animal's first compartment of the stomach, principally through bacterial actions, then regurgitating the semi-digested mass, now known as cud, and chewing it again. The process of rechewing the cud to further break down plant matter and stimulate digestion is called "ruminating. There are about 150 species of ruminants which include both domestic and wild species. Ruminating mammals include cattle, goats, sheep,deer, camels. Therefore, the term 'ruminant' is not synonymous with Ruminantia. The word "ruminant" comes from the Latin *ruminare,* which means "to chew over again".



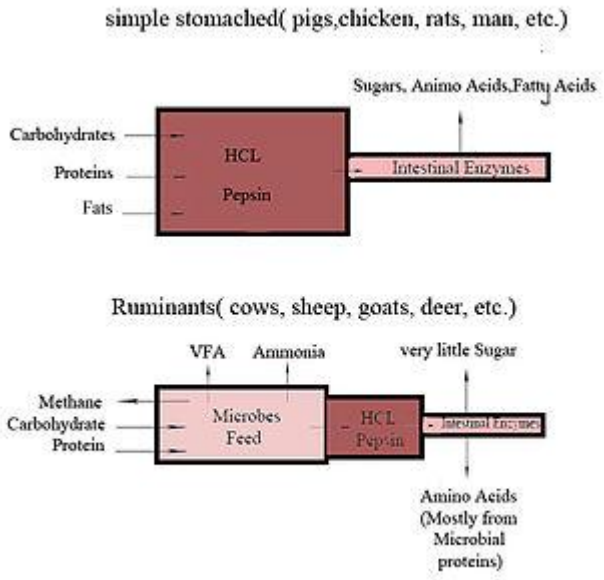
The primary difference between a ruminant and non-ruminant (called monogastrics, such as humans, dogs, and pigs) is that ruminants have a four-compartment stomach. The four parts of the stomach are rumen, reticulum, omasum, and abomasum. In the first two chambers, the rumen and the reticulum, the food is mixed with saliva and separates into layers of solid and liquid material. Solids clump together to form the cud or bolus.

The cud is then regurgitated and chewed to completely mix it with saliva and to break down the particle size. Fiber, especially cellulose and hemi-cellulose, is primarily broken down into the three volatile fatty acids (VFAs), acetic acid, propanoic acid and beta-hydroxybutyric acid, in these chambers by microbes (mostly bacteria and well as some protozoa, fungi and yeast). Protein and non-structural carbohydrate (pectin, sugars, starches) are also fermented.

Even though the rumen and reticulum have different names they represent the same functional space as digesta can move back and forth between them. Together these chambers are called the reticulorumen. The degraded digesta, which is now in the lower liquid part of the reticulorumen, then passes into the next chamber, the omasum, where water and many of the inorganic mineral elements are absorbed into the blood stream.

After this the digesta is moved to the true stomach, the abomasum. The abomasum is the direct equivalent of the monogastric stomach (for example that of the human or pig), and digesta is digested here in much the same way. Digesta is finally moved into the small intestine, where the digestion and absorption of nutrients occurs. Microbes

produced in the reticulorumen are also digested in the small intestine. Fermentation continues in the large intestine in the same way as in the reticulorumen.
Only small amounts of glucose are absorbed from dietary carbohydrates. Most dietary carbohydrates are fermented into VFAs in the rumen. The glucose needed as energy for the brain and for lactose and milk fat in milk production, as well as other uses, comes from non-sugar sources such as the VFA propionate, glycerol, lactate and protein. The VFA propionate is used for around 70% of the glucose and glycogen produced and protein for another 20% (50% under starvation conditions).
grass/roughage eaters, with the assumption that feeding habits in ruminants cause morphological differences in their digestive systems, including salivary glands, rumen size, and rumen papillae.
There are also pseudo-ruminants having three-compartment stomach instead of four like ruminants. Monogastric animals such as Guinea pigs, horses and rabbits are not ruminants as they have a simple single-chambered stomach and digest cellulose in an enlarged cecum allowing the easy digestion of fibrous materials. Such animals are lack the ability to hydrolyse beta [1-4] glycosidic bond of plant cellulose due to the lack of an enzyme cellulase. Thus ruminants must completely depend upon the microbial flora, present in rumen or hindgut, so as to digest cellulose. Digestion of food in rumen is primarily carried out by the rumen microflora which contain dense populations of several species of bacteria, protozoa, sometimes yeasts and fungi. It is estimated that 1 mL of rumen contains 10-50 billion bacteria, 1 million protozoa and several yeasts, fungi.
As the environment inside a rumen is anaerobic, most of these microbial species are obligate or facultative anaerobes which can decompose complex plant material such as cellulose, hemicelluloses, starch, proteins. Hydrolysis of cellulose results in sugars which are further fermentated to acetate, lactate, propionate, butyrate, carbon dioxide and methane.
During grazing, ruminants produce large amount of saliva. Estimates are within 100 to 150 litres of saliva per day for an adult cow. The role of saliva is to provide ample fluid for rumen fermentation and as a buffering agent. Rumen fermentation produces large amounts of organic acids and thus maintaining the appropriate pH of rumen fluids is a critical factor in rumen fermentation. called hindgut fermenters



Food digestion in the simple stomach of non-ruminant animals versus ruminants

Avian digestive system

The digestive tract of any animal, including chickens, is important in converting the food the animal eats into the nutrients their body needs for maintenance, growth, and production(such as eggs). Once food is eaten, it must be broken down into its basic components. This is done through both mechanical
and chemical means.

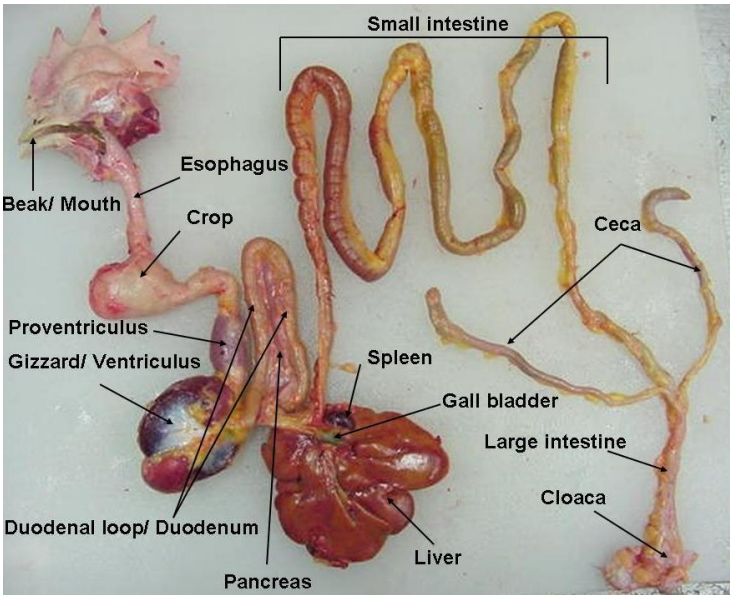
Mechanical action typically involves chewing, but since birds don't have teeth other mechanical methods are used and will be discussed later in this publication.

Chemical action includes the release of digestive enzymes and fluids from the stomach, pancreas and liver.

Once the nutrients have been released from food during digestion, they can be absorbed and distributed throughout the animal's body. The digestive tract is also referred to as the gastro-intestinal or GI tract. Which ever term is used, in chickens it begins at the **mouth** and ends at the **cloaca** and has several important organs in between.

Beak / Mouth: Chickens, as with most birds, obtain feed with the use of their **beak**. Food picked up by the beak enters the mouth. As previously mentioned, chickens do not have teeth so they are not able to chew their food. The mouth does contain glands which secrete saliva which wets the feed to make it easier to swallow. The saliva also contains some enzymes which start the digestion of the food eaten. The chicken's **tongue** is then used to push the feed to the back of the mouth so that it can be swallowed.

Esophagus: The esophagus is a flexible tube that connects the mouth with the rest of the digestive tract. It carries food from the mouth to the crop and from the crop to the proventriculus.



Crop: The crop is an out-pocketing of the esophagus and is located just outside the body cavity in the neck region. Any swallowed feed and water is stored in the crop

until it is time to pass it on to the rest of the digestive tract. When the crop is empty, or nearly empty, it sends hunger signals to the brain so that the chicken will eat more. Although salivary glands of the mouth secrete the **digestive enzyme** amylase very little digestion actually takes place in the crop – it is simply a temporary storage pouch. The crop evolved for birds that are typically hunted by other animals but which need to move to the open to find feed. These birds are able to consume relatively large amounts of food quickly and then move to a more secure location to digest the food they consumed. Occasionally the crop becomes impacted or 'backed up' (**crop impaction**, also referred to as **crop binding** or **pendulous crop**). This may occur when chickens go a long time without feed. This will cause the chickens to eat too much too fast when the feed becomes available again. A crop may also become impacted in a chicken that is free-ranged on a pasture of tough, fibrous vegetation. Crop impaction can also result when the chickens eat a long piece of string. With a crop impaction, even if a chicken continues to eat, the feed can not get past the impacted crop. The swollen crop may also cut off the windpipe, suffocating the chicken.

Proventriculus: The esophagus continues past the crop to connect the crop to the proventriculus. The proventriculus (also known as the '**true stomach**') is the **glandular stomach** where digestion begins. As with human stomachs, hydrochloric acid and digestive enzymes (e.g., pepsin) are added to the feed here and digestion begins. At this point, however, the food has not yet been ground up. The term 'proventriculus' is used since it comes before the 'ventriculus' or gizzard, with 'pro' being a Latin terming meaning before. **Gizzard/Ventriculus**: The gizzard, or ventriculus, is a part of the digestive tract unique to birds. It is often referred to as the '**mechanical stomach**'. It is made up of two sets of strong muscles which act as the bird's teeth. Consumed feed and the digestive juices from the salivary glands and the proventriculus pass into the gizzard for grinding, mixing, and mashing. When allowed to free-range, chickens will typically eat small stones. These stones remain in the gizzard until they become ground into pieces small enough to pass through to the rest of the digestive tract. The stones/pebbles are weakened by the acidic environment created in the proventriculus and then are ground into tiny pieces by the strong muscles of the gizzard.

Chickens fed only commercially prepared feed do not need stones. If, however, **whole grains** are fed, it is necessary to provide small pebbles, typically given as **grit**. Grit is a commercial product made up of small stones. It should not be confused with limestone or oyster shell which are given to laying hens as a source of calcium for their egg shells. Chickens kept on pasture will also require supplementation with grit, though many of them may consume enough pebbles when they forage.

Gizzards have a thick lining which protects their muscles. When chickens are slaughtered, the gizzards are often saved, the lining removed, and the gizzard consumed by the family or sold as a food item. While many people use chicken gizzards in home-made pet food (typically dogs and cats) they can also be a human food item, eaten alone or as part of a recipe. When a chicken eats a small, sharp object such as a tack or staple, the object is likely to get stuck in the gizzard. Because of the strong grinding motion of the gizzard's muscles, these sharp objects may eventually put a hole in the gizzard wall. Chickens with damaged gizzards will grow thin and eventually die – a very good reason to keep your poultry houses free of nails, glass shards, bits of wire and the like. **Small intestine**: The small intestine is made up of the duodenum (also referred to as the duodenal loop) and the lower small intestine. The **duodenum** receives digestive enzymes and bicarbonate (to counter the hydrochloric

acid from the proventriculus) from the **pancreas** and bile from the **liver** via the **gall bladder**.

The digestive enzymes produced by the pancreas are primarily involved in protein digestion. **Bile** is a detergent that is important in the digestion of lipids and absorption of fat soluble vitamins (vitamins A, D, E and K). The remainder of the digestion occurs in the duodenum and the released nutrients are absorbed mainly in the **lower small intestine**. The lower small intestine is composed of two parts, the jejunum and ileum. The Merkel's Diverticulum marks the end of the jejunum and the start of the ileum.

Ceca (plural form; singular = **cecum**): The ceca are two blind pouches located where the small and large intestines join. Some of the water remaining in the fecal material is reabsorbed here. Another important function of the ceca is the fermentation of any remaining coarse materials. In doing so they produce several fatty acids as well as the eight B vitamins (Thiamine, riboflavin, niacin, pantothenic acid, pyridoxine, biotin, folic acid and vitamin B_{12}). Because the ceca are located so close to the end of the digestive tract, however, very little of the produced nutrients are absorbed and available to the chicken. The ceca empty their contents two or three times a day, producing pasty droppings that often smell worse than regular droppings. Cecal droppings typically have a mustard to dark brown in color. The number of times **cecal droppings** are 'pooped', as well as their color and texture, tell you that the chicken's digestive tract is functionally normally. **Large intestine**, the large intestine is actually shorter than the small intestine. The large intestine is where the last of the water reabsorption occurs.

Cloaca: In the cloaca there is a mixing of the digestive wastes together with wastes from the urinary system (urates). Fecal material is usually voided as digestive waste with white uric acid crystals on the outer surface (i.e., chickens do not urinate/pee). The reproductive tract also exits through this area but when a hen lays an egg the vagina folds over to allow the egg to leave through the vent without coming into contact with the feces or urine. The color and texture of chicken fecal material can indicate the health status of the chicken's digestive tract. The white pasty material that commonly coats chicken fecal material is **uric acid**, the avian form of urine, and is normal

Intestinal Microflora

Both the small and large intestine are normally populated by beneficial bacteria, referred to as **microflora** ('micro' meaning small and 'flora' meaning plants). This population of microflora are important since they aid indigestion. Intestinal disease normally occurs when the balance of normal microflora is upset or the normal microflora is overrun by too many foreign organisms. The result is **enteritis** or inflammation of the intestines, producing symptoms that include diarrhea, increased thirst, dehydration, loss of appetite, weakness, and weight loss or slow growth. When the damage to the intestinal tract is severe it is typically referred to as **necrotic enteritis**