A Comparison of Digestive Systems
by Julia Hughes

This paper looks at the comparison of the various digestive systems of a cat, rat, goat, tortoise and a chicken, looking at their different diets to the structure of their buccal cavity through their internal digestive tract to elimination via the anus or cloaca.

### Definition

Digestion in animals is the break down of huge macromolecules (proteins, fats and starches) into smaller components by the body, using techniques of mechanical and chemical actions so that nutrition can be absorbed in the stomach and gastrointestinal tract or alimentary canal, into the circulatory system for dissemination around the body, ending with the excretion or defecation of the solid, semisolid or liquid waste material or faeces from the digestive tract via the anus.

### Diet

Food is essential to the diet in order to maintain a healthy body structure, vital organs and bowels.

Each animal is equipped with their own unique way of obtaining, masticating and absorbing their particular diet. Their individual diet dictates to them how they go about getting the most of their food by using the chemicals they produce in their saliva and the enzymes they have in their stomach and digestive system (see Table 1 below). The chicken’s digestive system is very simple and efficient compared to that of a goat.

<table>
<thead>
<tr>
<th>Animal</th>
<th>Diet</th>
</tr>
</thead>
</table>
| **Cats** | While the cat is essentially a carnivore. They get protein and fats from meats, vitamins and minerals from vegetables and carbohydrates from starchy foods. A cat on a rich protein diet will produce a lot of concentrated urea. They therefore need plenty of water to help flush this through their system.  
This particular food typically contains a full compliment of protein, fats, carbohydrates, vitamins and minerals a cat needs to keep strong, healthy and silky furred. The eating of dried foods helps keep the cats teeth clean and healthy by scraping any stale food away from the teeth as the cat breaks up the biscuit. The cat also tends to chew occasionally on grass or weeds but as they lack the enzymes to digest grass and weeds (unlike the ruminant) the main purpose of eating this is for the regurgitation of unwanted matter such as fur balls.  
Ref: DAVID TAYLOR, British Veterinary Association Guide to Cat Care |

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| **Rats** | Rodents generally live on a herbivore diet but are actually omnivores. Wild rats need a high calorific content in its diet to sustain the energy to go scavenging for food in order to survive. Most will live on plant based diet including seeds, grains, nuts and fruit. Some will also feed on insects, snails, clams, crayfish, ants and in some cases the dead bodies of other rodents.  

*Ref: Animal Corner, [www.animalcorner.co.uk](http://www.animalcorner.co.uk)* |

| **Chickens** | Chickens are omnivores and have a high metabolic rate so therefore need a constant supply of food. Starches and sugars are essential energy sources and can be found in grains of corn, wheat and rolled barley. These can be quickly converted to glucose which can be immediately used in the production of eggs and their own personal growth. Grains also contain vitamin D3 that help the regulation of calcium and phosphorus metabolism ensuring skeletal development and strong shells. Layers pellets are a complete meal containing fatty acids, proteins, minerals (especially calcium and phosphorus) and help form the shell of the eggs they lay. Fats are not only another excellent energy source but help maintain feather and skin quality and are an important component in eggs. Proteins, amino acids and mineral nutrition are essential in maintaining healthy bone and muscles and ensures the female bird produces eggs with strong shells. Chicken scratch at the ground and pick out insects and worms and they cannot go more than two days without water.  

*Ref: GAIL DAMEROW, [www.backyardpoultrymag.com](http://www.backyardpoultrymag.com)* |

| **Goats** | Goats have a natural curiosity and sensitive lips that makes them want to taste everything in sight, to see if they like it. They are herbivorous ruminants that feed mainly on high fibre food such as grass, hay, silage, oats, barley, soya, linseed, thistles, brambles, leaves, twigs and bark. Goats are very particular about what they eat and will not consume anything that is of poor quality, dirty or has been trampled on.  

*Ref: Animal Corner, [www.animalcorner.co.uk](http://www.animalcorner.co.uk)* |
**Table 1**

### The Different Digestive Systems

Below are diagrams that show the way that the digestive systems of each animal is set out.

**Digestive system of a cat**

**Digestive system of a rat**

*Source: Colorado State University*  
*Source: [http://io.uwinnipeg.ca/~simmons/lb8pg4.htm](http://io.uwinnipeg.ca/~simmons/lb8pg4.htm)*
Digestive system of a chicken

Source: REBECCA KODAT, The digestive system of birds

Digestive system of a goat

Source: http://www.aces.edu/pubs/docs/U/UNP-0060/
The Buccal Cavity

This table (Table 2) shows the difference between each animal’s teeth and their jaw movement and purpose.

<table>
<thead>
<tr>
<th></th>
<th>Cat</th>
<th>Rat</th>
<th>Chicken</th>
<th>Goat</th>
<th>Tortoise</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TEETH</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incisors</td>
<td>6</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>2</td>
<td>0</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>Canines</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pre-molars</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Molars</td>
<td>2</td>
<td>6</td>
<td>0</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>6</td>
<td>0</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td><strong>JAW</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Movement</td>
<td>Vertical</td>
<td>Back and forth</td>
<td>Vertical</td>
<td>Rotary</td>
<td>Vertical</td>
</tr>
<tr>
<td>Function</td>
<td>Tearing</td>
<td>Gnawing</td>
<td>Pecking</td>
<td>Grinding</td>
<td>Tearing</td>
</tr>
<tr>
<td>Mastication</td>
<td>Important</td>
<td>Important</td>
<td>Unimportant</td>
<td>Vital</td>
<td>Unimportant</td>
</tr>
<tr>
<td>Rumination</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Vital Function</td>
<td>No</td>
</tr>
</tbody>
</table>

The shape of an animal’s teeth are related to its diet. From this table it is easy to see that the cat is the carnivore with all the cutting and tearing type teeth at the front and the goat is the ruminant with all those molars to grind away at tough grassy material.
The cat’s jaw can only move in an up and down action; their incisors and premolars shear through meat and the canines are used to pierce and tear at the flesh (see diagram below).

The cat’s skull

![Diagram of cat's skull with labeled teeth: incisors, canine, premolars, molar, lower teeth, molar, premolars, canine, incisors.]

Source: HILL’S PET NUTRITION 2008 The Atlas of Veterinary Clinical Anatomy

Rodents gnaw at their food which is why they have large chewing muscles and chisel-like incisors and no canine teeth (see pictures below). Unlike the other teeth laden animals, the rodent’s teeth do not have roots. The front surface of the incisors has enamel and the back teeth are soft dentine. This allows them to continually sharpen their incisors and grow their teeth. However, because of this, if they do not have sufficient material to gnaw at, their teeth will continue to grow until they become so long they are unable to eat. The animal will then literally starve to death. Their jaw is able to work back and forth as well as up and down so they can grind the chips of food they’ve nibbled off with their back molars.

Ref: Rats a Complete Pet Owner’s Manual

The rat’s skull

![Diagram of rat's skull with labeled teeth: incisors, molars.]

Source: Colorado State University

As chickens and rats have their unique eating method, goats are different again in that they chew their cud, regurgitate their food to be chewed again. They also only have front teeth on the bottom part of their jaw, which meet the hard upper pallet to ‘mouth’ their food (see picture below). Their back molars grind up the food or ‘chew the cud’.

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The toothless tortoise has sharp cutting edge to their jaws which is covered by hooked or notched horny beak that shear through their vegetation (see picture below). Like the tortoise the chicken does not have any teeth, nor do they have lips. They have sharp beaks that peck at the ground, wheedle out worms and other insects or break down larger pieces of food (see picture above). The lower part of the beak is hinged at the jaw and is movable. The upper part of the beak is fused to the skull.

Ref: World of Animals: Chelonian’s Digestive System

The Tortoise

Source: Darren Smith - Hooper Virtual Natural History Museum
Tongue, Gums & Salivary Glands

Tongues are complex organs, made up of a system of muscles covered in taste buds and are used to manipulate food in one way or other.

A cat’s tongue is covered in mushroom shaped, barb-like structures called ‘papillae’ making it feel rough like sandpaper (see picture opposite). The cat laps up water by capturing it in between these barbs, swallowing every 4-5 laps. They also help remove the last bit of meat from bone and are a useful grooming aid.

The cat has four pairs of salivary glands, the parotid (through tubes that drain saliva near the upper teeth), mandibular, sublingual (through ducts in the floor of the mouth) and zygomatic and each gland secretes saliva into the mouth. The main purpose of saliva is to lubricate the mouth, initiate digestion, moisten food bolus and protect teeth from decay. The enzymes, ptyalin or salivary amylase, in the saliva play an important part in the first stages of digestion. Once this process has taken place the food bolus is swallowed and ingested into the oesophagus, a small hose-like tube which connects the mouth to the stomach. The walls of the oesophagus are composed of muscles that move in wave-like contractions called peristalsis that help push the food into the stomach.

Ref: DAVID TAYLOR, British Veterinary Association Guide to Cat Care

The salivary glands of a rat

The rat however has only three pairs of salivary glands – parotid, submaxillary and sublingual glands. Its fourth gland, the extraorbital lacrimal, is used to form tears (see figure above).

Ref: Rats a Complete Pet Owner’s Manual

The chicken’s tongue has a hyoid bone hinge at the lower jaw. It is pointed at the tip and has several barbed points projecting backwards on either side. There are numerous salivary glands that can be found on the hard pallet in the roof of the chicken’s mouth forming one large glandular tissue under the epithelium. Amylase starts to break down starch to glucose maltose.
Their tongues are long and pointed, with several barbed points projecting backwards on either side and follow the same shape as the beak which is used to push the food to the back of the mouth and is then ‘swallowed’ down the oesophagus which is composed of layers of tissue lined with mucous membrane, to the crop - a large dilation of the oesophagus, where food is temporarily stored. It is thought that the chicken, unlike the cat, has little or no taste buds.


The tortoise tongue

Source: http://flickr.com/photos/81862114@N00/2598304049

The tortoise also uses its thick vascular tongue (see picture above), fixed to their mouth cavity, to push ingested material down their gullet.

Ref: FLICKR, http://flickr.com/photos/81862114@N00/2598304049

Stomach

This table (Table 3) compares the stomachs of a cat, chicken and a goat.

<table>
<thead>
<tr>
<th></th>
<th>Cat</th>
<th>Chicken</th>
<th>Goat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity</td>
<td>Small</td>
<td>Small</td>
<td>6 - 8 gallons</td>
</tr>
<tr>
<td>Emptying time</td>
<td>2 hours</td>
<td>Never empties</td>
<td>Never empties</td>
</tr>
<tr>
<td>Inter-digestive rest</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Bacteria present</td>
<td>No</td>
<td>Yes</td>
<td>Yes – vital</td>
</tr>
<tr>
<td>Protozoa present</td>
<td>No</td>
<td>Yes</td>
<td>Yes – vital</td>
</tr>
<tr>
<td>Gastric acidity</td>
<td>Strong</td>
<td>Strong</td>
<td>Weak</td>
</tr>
<tr>
<td>Cellulose digestion</td>
<td>None</td>
<td>60%</td>
<td>70% - vital</td>
</tr>
<tr>
<td>Digestive activity</td>
<td>Weak</td>
<td>Vital function</td>
<td>Vital function</td>
</tr>
</tbody>
</table>

FEEDING HABITS

<table>
<thead>
<tr>
<th></th>
<th>Intermittent</th>
<th>Continuous</th>
<th>Continuous</th>
</tr>
</thead>
<tbody>
<tr>
<td>SURVIVAL WITHOUT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microorganisms</td>
<td>Possible</td>
<td>Impossible</td>
<td>Impossible</td>
</tr>
<tr>
<td>Plant foods</td>
<td>Possible</td>
<td>Impossible</td>
<td>Impossible</td>
</tr>
<tr>
<td>Animal protein</td>
<td>Impossible</td>
<td>Possible</td>
<td>Possible</td>
</tr>
</tbody>
</table>

Table 3
The cat’s stomach is a muscular bag designed to store a large volume of food and begin the digestive process (see diagram below). It has thick muscles at the top and bottom that act as one way valves – the top one is called the cardiac sphincter and this is so placed to prevent food from re-entering the oesophagus.

The muscle fibres in the walls of the stomach start to churn food over while glands secrete gastric acid, liquefying food. The bottom valve called the pyloric sphincter opens to empty the contents of the stomach into the duodenum. This whole process takes on average twelve hours. The cat, unlike the goat has no ability to utilize cellulose.

Ref: DAVID TAYLOR, British Veterinary Association Guide to Cat Care

The rat’s stomach has the typical sack-like structure like the cat, comprising of three areas – the cardiac portion which is the oesophagus entrance, the fundic portion which is middle part and the pyloric portion – constricted posterior.

Ref: Rats a Complete Pet Owner’s Manual

The goat’s stomach is made up of four chambers – the rumen, reticulum, omasum and abomasums (see diagram overleaf). The rumen or paunch is the largest of the four stomach compartments acts as a big fermentation vat and contains many microorganisms of bacteria and protozoa the supply enzymes that help break down partly chewed food and start to convert cellulose to volatile fatty acids, mainly acetic, propionic and butyric acids. The other components of the feed are broken down to useful products such as essential amino acids, complex B vitamins and vitamin K. Other enzymes convert sugar to fatty acids (carbon dioxide and methane is released into the oesophagus. The fatty acids are absorbed through the rumen wall and provide up to 80% of the total energy requirements of the goat.
The cud is then regurgitated and chewed again while the goat is laying down. Food is then swallowed for a second time which is bypassing the rumen into the reticulum compartment, known as the ‘hardware stomach’ or ‘honeycomb’ (this is connected to the rumen by an overflow connection and is located just below the entrance of the oesophagus stomach).

The omasum or ‘manyplies’ consists of many folds or layers of tissue that grind up and remove some of the water from the feed. The abomasums is considered the ‘true stomach’ and functions similarly to that of the cat and rat in that it contains digestive enzymes – proteases to digest protein which is absorbed as amino acids which are deaminated by the liver to urea, and hydrochloric acid to help break down food before entering into the small intestines.

A lot of urea is found in saliva. Urea is reconverted by to amino acids and then proteins by bacteria in the rumen. These are then digested again to amino acids in the abomasum and absorbed again.

Ref: Animal Corner, www.animalcorner.co.uk

Surprisingly, the tortoise does not have a fermentation chamber in its intestinal tract that would aid the breakdown of plant cellulose. Instead the ingested cellulose take up to four weeks to digest, 30% of which is digested in the intestines using bacteria and other micro-organisms, converting any excess energy into fat which is then stored within their abdomen.

Ref: FERRI, VINCENZO, World of Animals: Chelonian’s Digestive System

The chicken stores its food firstly in a crop. There is little digestion happening here, instead the food is moistened and softened. From the crop food particles move to the proventriculus or true stomach where significant amounts of digestive juices are added - hydrochloric acid and pepsin enzymes. The food particles then moves onto the gizzard (see picture overleaf) – a mechanical stomach that has two strong muscles and a collection of grit that help to physically grind and break up food into a mash. The glands in the gizzard produce a liquid keratinised material that helps replace worn tissues on the surface of the horny lining.

Ref: REBECCA KODAT, The digestive system of birds
Small Intestines - Gall Bladder / Bile Duct / Liver

For all the animals, liquefied food enters the small intestines (the duodenum, the jejunum and the ileum) via a further process of peristalsis and carries out the final stages in digestion.

The duodenum of the animals contains villi (see diagram below) – long finger-like projections providing an increased surface area for the absorption of nutrients and blood vessels that carry away nutrients to other parts of the body.

Villi

This is where most of the chemical digestion and absorption of nutrients take place. Food is neutralised by the excretion of enzymes – amylase, trypsinogen, carboxy-peptidase, elastase and lipase by the pancreas to aid digestion by breaking down protein, starch and fatty acids to produce glucose, maltose and dextrins. The small intestinal mucosa further break down nutrients into simple compounds that are absorbed into the bloodstream.
The cat’s pancreas

The pancreas (see diagram opposite) also secretes insulin hormones which help regulate blood sugar. Bile, containing acids as well as cholesterol, is stored in the gall bladder and added here by the liver, which is needed in the absorption of fats, however the rat does not have a gall bladder - instead bile is passed from the liver to the duodenum via bile ducts. The liver also stores and releases a compound called glycogen – a carbohydrate that can be changed into sugar should the sugar level fall.

Ref: Rats a Complete Pet Owner’s Manual & Washington State University

The small intestine (jejunum and ileum) in a mature chicken is over 4.5 feet in length and terminates at its juncture with the large intestine.

Ref: http://im.itcs.uiuc.edu/ak17supp.pdf

The Large Intestines - Colon and Caecum

Additional water, salts and minerals are removed from food in the large intestines or colon of the rat, cat and goat, the final journey of which ends with the rectum where waste matter is formed into stools and expelled via the anus.

**Chicken intestines**

![Diagram of chicken intestines](http://people.eku.edu/ritchisong/RITCHISO/birddigestion.html)

The large intestine or rectum of the chicken is about 4 inches in length, ending with the cloaca (see diagram above). The chicken has two blind pouches called ceca (one of which is the cecum)
which provides space for fermentation where undigested food particles are broken down by microbacteria - friendly bacteria such as microflora to aid digestion and enhance the immune system. The ceca secretes a foul smelling dark brown froth a couple of times a day. The major functions of the large intestine are storage of undigested waste material and absorption of water from their content. The cloaca is the common chamber into which the fecal, urogenital (elimination of urine) and vestibule (passage of eggs or seminal fluid) chambers meet. Its opening at the posterior end of the bird is known as the vent. The cloaca actually folds back at the vent allowing the rectal opening of the large intestine to push out, closing the reproductive opening. Thus, there is minimal chance of fecal wastes contaminating the reproductive system. Food passes through the chicken’s entire digestive system in three to four hours.

Ref: REBECCA KODAT, The digestive system of birds & POULTRY A GUIDE TO ANATOMY AND SELECTED SPECIES

The tortoise’s digestive system also ends with the cloaca, the structure of which follows the same pattern as most mammalian tracts. The caecum, like the other herbivores is quite large and contain microorganisms that continue to break down plant materials that hasn’t been broken down by the enzymes located in the small intestines. The main function of the large intestines is the re-absorption of large quantities of water resulting in a mass of waste material called faeces which is stored in the rectum until it is eliminated by the anus.

Ref: World of Animals: Chelonian’s Digestive System

Conclusion

In conclusion it is apparent that depending on the life style of each animal and the food that it feeds on determines the structure of its individual buccal cavity and the process of absorbing the necessary nutrients through their digestive system.

The cat is a carnivore and therefore requires sharp teeth to shear through meat and the digestive enzymes to break down protein, whereas the goat is a ruminant and only able to digest cellulose matter and regurgitates its food from its four chambered stomach. The tortoise should in theory also be a ruminant but because of its sedentary lifestyle it spends longer digesting its food.

The chicken is unique in that it first stores its food a crop and uses its gizzard to mechanical grind up food. Out of all the animals, it’s the only one that eliminates its waste from the same vent that it lays eggs.
References - Books


References - Internet

Animal Corner, [www.animalcorner.co.uk](http://www.animalcorner.co.uk), Accessed 19 October 2008


FLICKR, [http://flickr.com/photos/81862114@N00/2598304049](http://flickr.com/photos/81862114@N00/2598304049), Accessed 30 November 2008


Rat Digestive System, [http://kentsimmons.uwinipeg.ca/16cm05/16labman05/lb8pg3.htm](http://kentsimmons.uwinipeg.ca/16cm05/16labman05/lb8pg3.htm), Accessed 15 November 2008


