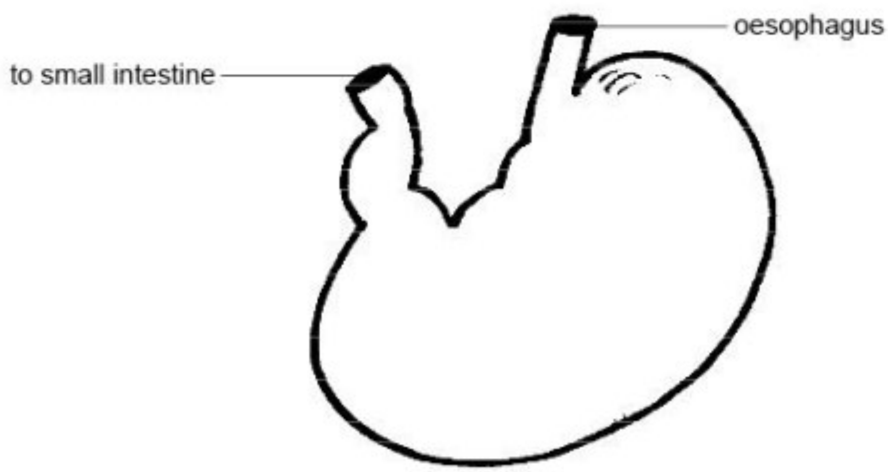
TOPIC: Anatomy and Physiology of Farm Animals/The Gut and Digestion (CONTD.)

Stomach

The stomach stores and mixes the food. Glands in the wall secrete gastric juice that contains enzymes to digest protein and fats as well as hydrochloric acid to make the contents very acidic. The walls of the stomach are very muscular and churn and mix the food with the gastric juice to form a watery mixture called chyme (pronounced kime). Rings of muscle called sphincters at the entrance and exit to the stomach control the movement of food into and out of it (see diagram 11.9).



The stomach

Small Intestine

Most of the breakdown of the large food molecules and absorption of the smaller molecules take place in the long and narrow small intestine. The total length varies but it is about 6.5 metres in humans, 21 metres in the horse, 40 metres in the ox and over 150 metres in the blue whale.

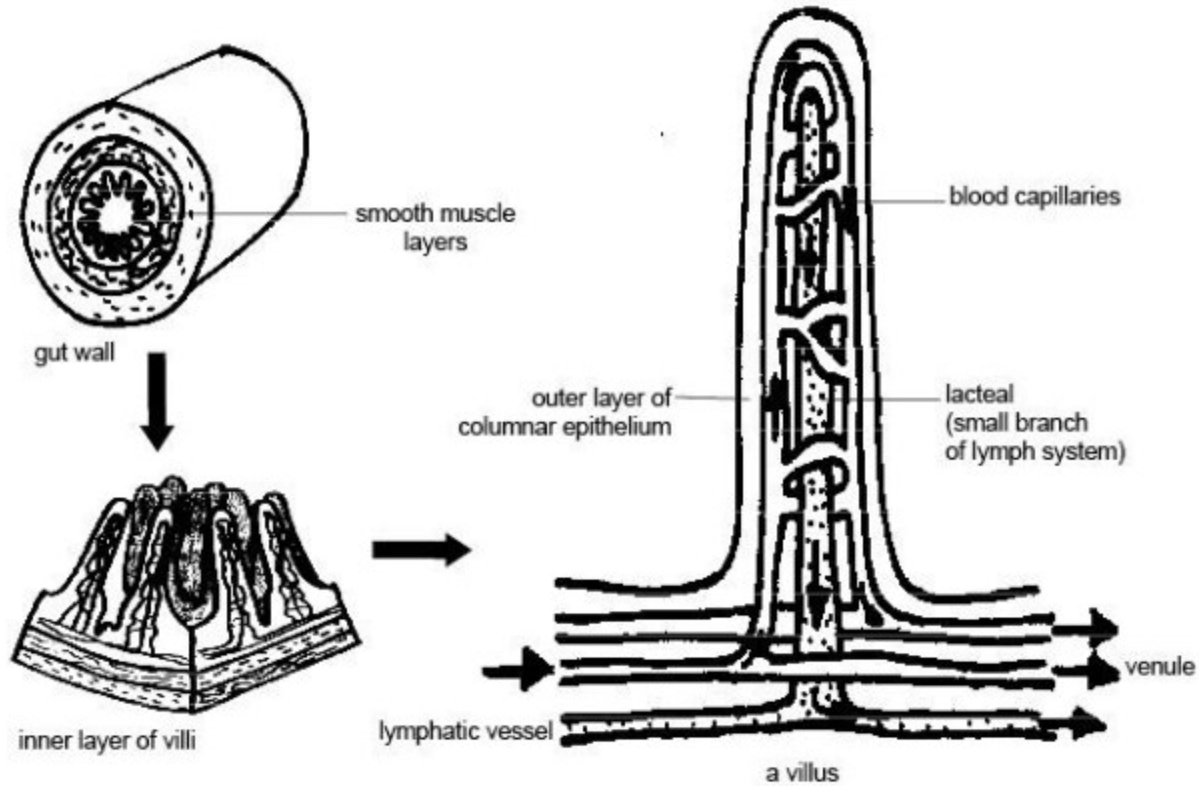
It is divided into 3 sections: the duodenum (after the stomach), jejunum and ileum. The duodenum receives 3 different secretions:

1) Bile from the liver;

2) Pancreatic juice from the pancreas and

3) Intestinal juice from glands in the intestinal wall.

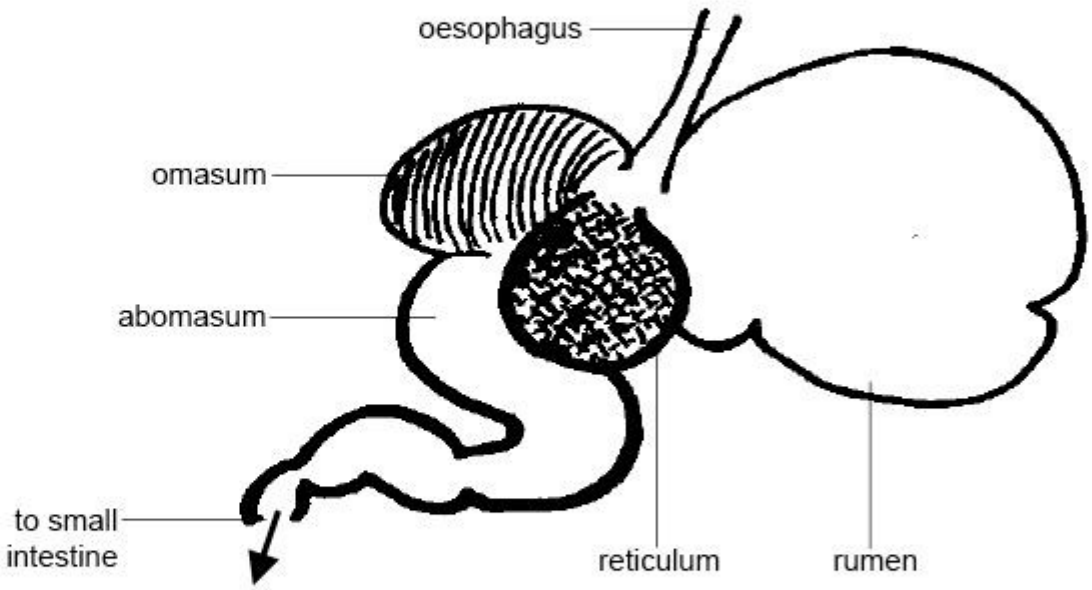
These complete the digestion of starch, fats and protein. The products of digestion are absorbed into the blood and lymphatic system through the wall of the intestine, which is lined with tiny finger-like projections called villi that increase the surface area for more efficient absorption (see diagram 11.10).



The wall of the small intestine showing villi

The Rumen

In ruminant herbivores like cows, sheep and antelopes the stomach is highly modified to act as a "fermentation vat". It is divided into four parts. The largest part is called the rumen. In the cow it occupies the entire left half of the abdominal cavity and can hold up to 270 litres. The reticulum is much smaller and has a honeycomb of raised folds on its inner surface. In the camel the reticulum is further modified to store water. The next part is called the omasum with a folded inner surface. Camels have no omasum. The final compartment is called the abomasum. This is the 'true' stomach where muscular walls churn the food and gastric juice is secreted (see diagram 11.11).



The rumen

Ruminants swallow the grass they graze almost without chewing and it passes down the oesophagus to the rumen and reticulum. Here liquid is added and the muscular walls churn the food. These chambers provide the main fermentation vat of the ruminant stomach. Here bacteria and single-celled animals start to act on the cellulose plant cell walls. These organisms break down the cellulose to smaller molecules that are absorbed to provide the cow or sheep with energy. In the process, the gases methane and carbon dioxide are produced. These cause the “burps” you may hear cows and sheep making.

Not only do the micro-organisms break down the cellulose but they also produce the vitamins E, B and K for use by the animal. Their digested bodies provide the ruminant with the majority of its protein requirements.

In the wild grazing is a dangerous activity as it exposes the herbivore to predators. They crop the grass as quickly as possible and then when the animal is in a safer place the food in the rumen can be regurgitated to be chewed at the animal’s leisure. This is ‘chewing the cud’ or rumination. The finely ground food may be returned to the rumen for further work by the microorganisms or, if the particles are small enough, it will pass down a special groove in the wall of the oesophagus straight into the omasum. Here the contents are kneaded and water is absorbed before they pass to the abomasum. The abomasum acts as a “proper” stomach and gastric juice is secreted to digest the protein.

Large Intestine

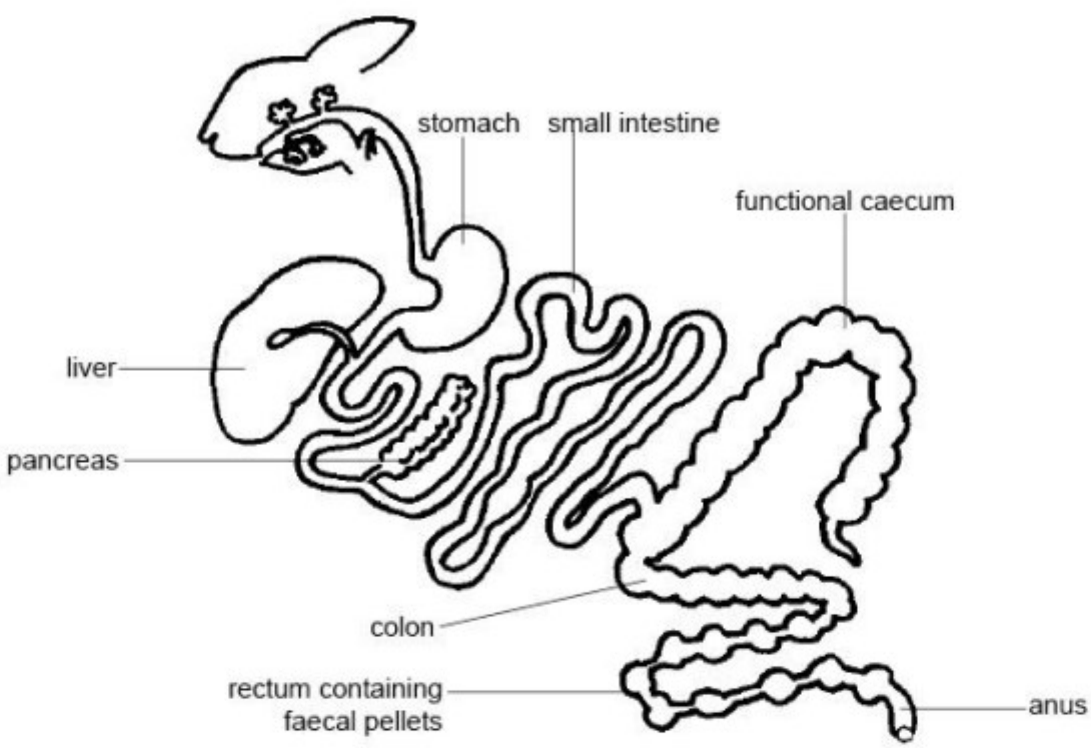
The large intestine consists of the caecum, colon and rectum. The chyme from the small intestine that enters the colon consists mainly of water and undigested material such as cellulose (fibre or roughage).

In omnivores like the pig and humans the main function of the colon is absorption of water to give solid faeces. Bacteria in this part of the gut produce vitamins B and K.

The caecum, which forms a dead-end pouch where the small intestine joins the large intestine, is small in pigs and humans and helps water absorption. However, in rabbits, rodents and horses, the caecum is very large and called the functional caecum. It is here that cellulose is digested by micro-organisms. The appendix, a narrow dead end tube at the end of the caecum, is particularly large in primates but seems to have no digestive function.

Functional Caecum

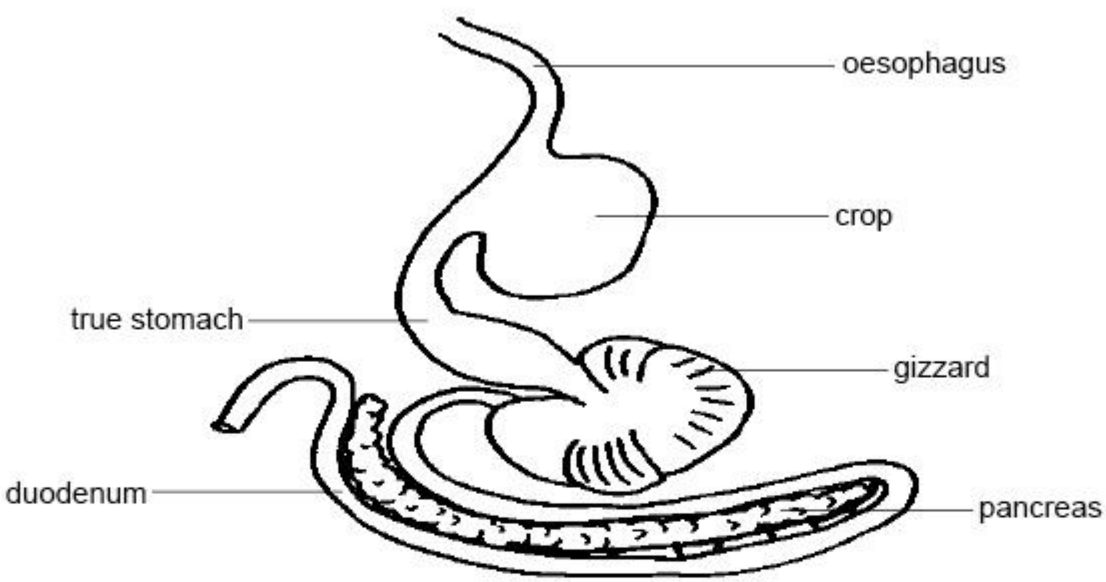
The caecum in the rabbit, rat and guinea pig is greatly enlarged to provide a "fermentation vat" for micro-organisms to break down the cellulose plant cell walls. This is called a functional caecum (see diagram 11.12). In the horse both the caecum and the colon are enlarged. As in the rumen, the large cellulose molecules are broken down to smaller molecules that can be absorbed. However, the position of the functional caecum after the main areas of digestion and absorption, means it is potentially less effective than the rumen. This means that the small molecules that are produced there can not be absorbed by the gut but pass out in the faeces. The rabbit and rodents (and foals) solve this problem by eating their own faeces so that they pass through the gut a second time and the products of cellulose digestion can be absorbed in the small intestine. Rabbits produce two kinds of faeces. Softer night-time faeces are eaten directly from the anus and the harder pellets you are probably familiar with, that have passed through the gut twice.



The gut of a rabbit

The Gut Of Birds

Birds' guts have important differences from mammals' guts. Most obviously, birds have a beak instead of teeth. Beaks are much lighter than teeth and are an adaptation for flight. Imagine a bird trying to take off and fly with a whole set of teeth in its head! At the base of the oesophagus birds have a bag-like structure called a crop. In many birds the crop stores food before it enters the stomach, while in pigeons and doves glands in the crop secretes a special fluid called crop-milk which parent birds regurgitate to feed their young. The stomach is also modified and consists of two compartments. The first is the true stomach with muscular walls and enzyme secreting glands. The second compartment is the gizzard. In seed eating birds this has very muscular walls and contains pebbles swallowed by the bird to help grind the food. This is the reason why you must always supply a caged bird with grit. In birds of prey like the falcon the walls of the gizzard are much thinner and expand to accommodate large meals (see diagram 11.13).



The stomach and small intestine of a hen

Digestion

During digestion the large food molecules are broken down into smaller molecules by enzymes. The three most important groups of enzymes secreted into the gut are:

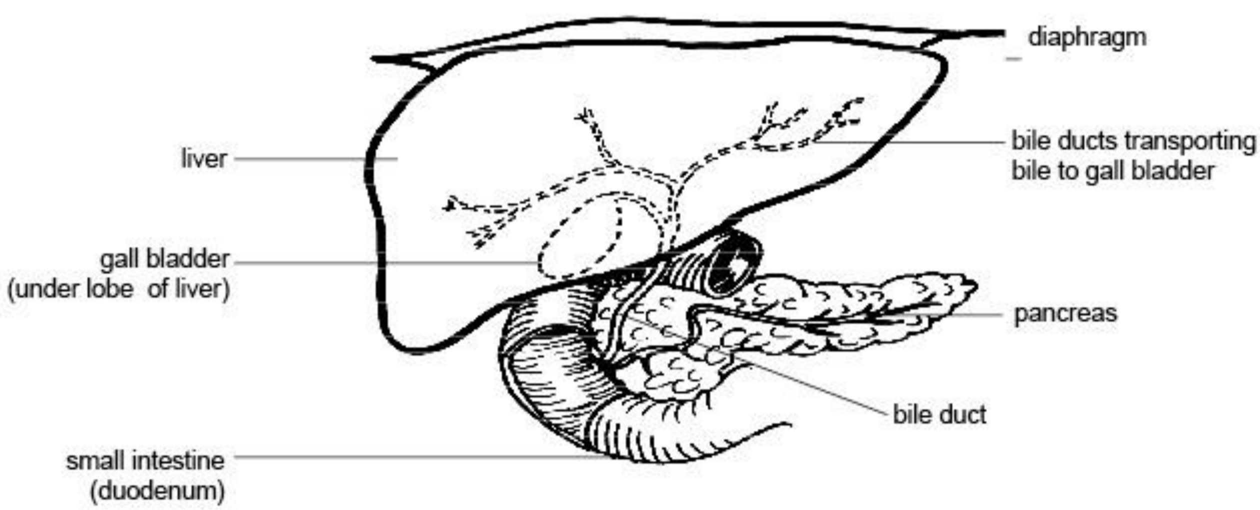
1. Amylases that split carbohydrates like starch and glycogen into monosaccharides like glucose.

2. Proteases that split proteins into amino acids.
3. Lipases that split lipids or fats into fatty acids and glycerol.

Glands produce various secretions which mix with the food as it passes along the gut.

These secretions include:

1. Saliva secreted into the mouth from several pairs of salivary glands (see diagram 11.3). Saliva consists mainly of water but contains salts, mucous and salivary amylase. The function of saliva is to lubricate food as it is chewed and swallowed and salivary amylase begins the digestion of starch.
2. Gastric juice secreted into the stomach from glands in its walls. Gastric juice contains pepsin that breaks down protein and hydrochloric acid to produce the acidic conditions under which this enzyme works best. In baby animals rennin to digest milk is also produced in the stomach.
3. Bile produced by the liver. It is stored in the gall bladder and secreted into the duodenum via the bile duct (see diagram 11.14). (Note that the horse, deer, parrot and rat have no gall bladder). Bile is not a digestive enzyme. Its function is to break up large globules of fat into smaller ones so the fat splitting enzymes can gain access the fat molecules.



The liver, gall bladder and pancreas

Pancreatic juice

The pancreas is a gland located near the beginning of the duodenum (see diagram 11.14). In most animals it is large and easily seen but in rodents and rabbits it lies within the membrane linking the loops of the intestine (the mesentery) and is quite difficult to find. Pancreatic juice is produced in the pancreas. It flows into the duodenum and contains amylase for digesting starch, lipase for digesting fats and protease for digesting proteins.

Intestinal juice

Intestinal juice is produced by glands in the lining of the small intestine. It contains enzymes for digesting disaccharides and proteins as well as mucus and salts to make the contents of the small intestine more alkaline so the enzymes can work.

Absorption

The small molecules produced by digestion are absorbed into the villi of the wall of the small intestine. The tiny finger-like projections of the villi increase the surface area for absorption. Glucose and amino acids pass directly through the wall into the blood stream by diffusion or active transport. Fatty acids and glycerol enter vessels of the lymphatic system (lacteals) that run up the centre of each villus.

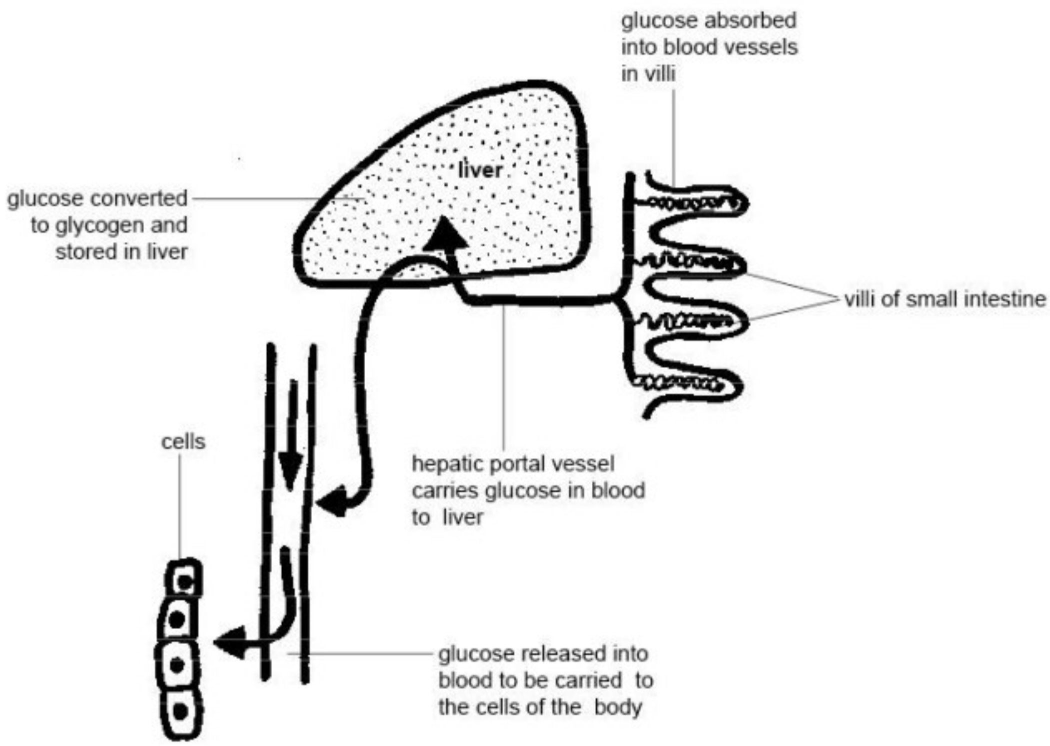
The Liver

The liver is situated in the abdominal cavity adjacent to the diaphragm (see diagrams 2 and 14). It is the largest single organ of the body and has over 100 known functions. Its most important digestive functions are:

1. the production of bile to help the digestion of fats (described above) and

2. the control of blood sugar levels

Glucose is absorbed into the capillaries of the villi of the intestine. The blood stream takes it directly to the liver via a blood vessel known as the hepatic portal vessel or vein (see diagram 11.15).



The liver converts this glucose into glycogen which it stores. When glucose levels are low the liver can convert the glycogen back into glucose. It releases this back into the blood to keep the level of glucose constant. The hormone insulin, produced by special cells in the pancreas, controls this process.

The control of blood glucose by the liver

Other functions of the liver include:

1. making vitamin A,
2. making the proteins that are found in the blood plasma (albumin, globulin and fibrinogen),
3. storing iron,
4. removing toxic substances like alcohol and poisons from the blood and converting them to safer substances,
5. producing heat to help maintain the temperature of the body.