**Lecture4 & 5 Digestive system**

**Classification of various digestive systems:**

One variation between the gastrointestinal (GI) tracts of the common domestic animals is classified into groups based on their type of diet with many sub-groups:

1. **Herbivores** – Animals that consume primarily **plant materials**.
2. **Carnivores** - Animals that **eat other animals**.
3. **Omnivores** - Animals that eat a **combination of plant and animal matter**.

**\* Animals classification based on their digestive physiology:**

1. **Non- ruminant animals:**
2. **Poultry**: Non-ruminants that are omnivorous and they have a complex foregut (three section that replaces the normal stomach) and a relatively simple intestinal tract.
3. **Dogs and cats**: Non-ruminant animals those are carnivorous.
4. **Horses and mules**: Non-ruminant animals, but they are herbivorous and have rather large and complex large intestine.
5. **Rabbits**: Non-ruminant animals that is an herbivorous with a complex large intestine.
6. **Ruminant animals:**

Capable to consume and digest plant materials and classified as herbivorous. Include **cattle**, **sheep**, **goat**, **deer** and many **other wild species**.

**Treatment of food**

 Whether an animal eats plants or feed, the carbohydrates, fats and proteins in the food it eats are generally giant molecules. These need to be digested (split up) into smaller ones before they can pass into the blood and enter the cells to be used for energy or to make new cell constituents. For example:

1. **Carbohydrates** like **cellulose**, **starch**, and **glycogen** need to be digested into **glucose** and other **monosaccharides;**
2. **Proteins** need to be digested into **amino acids**.
3. **Fats** or lipids need to be digested into **fatty acids** and **glycerol**.

**The Gut**

The digestive tract, alimentary canal or gut is a hollow tube stretching from the mouth to the anus. It is the organ system concerned with the treatment of foods.

At the mouth the large food molecules are taken into the gut - this is called **ingestion**. They must then be **broken down into smaller ones** by **digestive enzymes** (**digestion)** before they can be taken from the **gut into the blood stream** (**absorption)**. The cells of the body can then use these small molecules (**assimilation**). The indigestible waste products are eliminated from the body by the act of.

**The major functions of the gut are:**

1. Transporting the food;

2. Processing the food physically by breaking it up (chewing), mixing, adding fluid etc.

3. Processing the food chemically by adding digestive enzymes to split large food molecules into smaller ones.

4. Absorbing these small molecules into the blood stream so the body can use them.

The regions of a typical mammals gut (for example a monogastric animals: rabbit, cat or dog) are shown in diagram 1.



**Diagram 1 - A typical mammalian gut**

 The food that enters the mouth passes to the esophagus, then to the stomach, small intestine, cecum, large intestine, rectum and finally undigested material exits at the anus. The liver and pancreas produce secretions that aid digestion and the gall bladder stores bile.

**Stomach**

The **stomach** stores and mixes the food. Glands in the wall secrete **gastric juice** that contains **pepsinogen**;it converts to **pepsin** by **hydrochloric acid** (HCL) secretions to make the contents very **acidic** to **digest protein**.

**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 meters in humans, 21 meters in the horse, and over 150 meters 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.

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.

**The Rumen stomach:**

In ruminant herbivores like cows and sheep the stomach is highly modified to act as a “fermentation vat”. It is divided into **four parts**.

1-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.

2-The **reticulum** is much smaller and has a honeycomb of raised folds on its inner surface.

3-The **omasum** with a folded inner surface.

4-The **abomasum**. This is the‘true’ stomach where muscular walls churn the food and gastric juice is secreted.

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**Diagram 2- The ruminant gut** (**digestive system)**

 **The function of the ruminant digestive system:**

1- Ruminants swallow the grass they graze almost without chewing and it passes down the esophagus to the rumen and reticulum. Here liquid is added and the muscular walls churn the food.

2-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.

3- 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.

**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 (fiber or roughage). In omnivores like the pig and humans the main function of the colon is absorption of water to give solid feces. Bacteria in this part of the gut produce vitamins B and K.

 The cecum, 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**.

**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 digest **carbohydrates** like **starch** and **glycogen** into **monosaccharides** like **glucose**.

2. **Proteases** that digest **proteins** into **amino acids**.

3. **Lipases** that digest **lipids** or **fats** into **fatty acids** and **glycerol**.

**Glands and secretions :**

**1-Saliva** secreted into the mouth from several pairs of **salivary glands**. 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** and HCL to produce the acidic conditions under which this enzyme works best that breaks down protein. 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**. Bile is not a digestiveenzyme. **Its function** is to **break up large globules of fat** into **smaller ones** by presence of lipase enzyme.

(Note that the horse, deer, parrot and rat have no gall bladder).

**Pancreatic juice**

 The **pancreas** is a gland located near the beginning of the duodenum. In most animals it is large and easily. **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 **di-saccharides** 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.

**The Liver**

 The liver is the largest single organ, situated in the abdominal cavity of the body. The most important **functions of liver are**:

1. The production of **bile** to help the **digestion of fats**.

2. The control of **blood sugar** (glucose) levels is absorbed into the capillaries of the villi of the intestine. The blood stream takes it directly to the liver via a blood vessel.

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 by **insulin** hormone.

3. Making the **proteins** that are found in the **blood plasma** (**albumin, globulin** and **fibrinogen**).

4. Making **vitamin A**.

5. Storing **iron**s.

6. Removing **toxic substances** like **alcohol** and **poisons** from the blood and **converting** them to **safer substances**.

7. Producing **heat** to help **maintain the temperature of the body**.