Digestion

Introduction.

The body's cells need nutrients: carbohydrates, lipids, proteins, vitamins, minerals and water. These nutrients are present in our food, but in complex form, unable to cross cell membranes.

The role of digestion is therefore to simplify the food bolus, gradually bringing it to physical and chemical forms that are compatible with digestive absorption and transfer to the cellular distribution system: the blood and lymph. This role is performed by the digestive tract, which functions as follows:

- Mechanical activity: aspiration, chewing, swallowing, mixing, filling and emptying.

- Chemical and biochemical activity, especially enzymatic, involving juices produced by cells or glands.

The temperature, osmolarity, pH of the food bolus, the size of the particles, their liposolubility and their hydrosolubility will gradually be brought to characteristics favourable to trans-membrane passage by the work of the different segments of the digestive system.

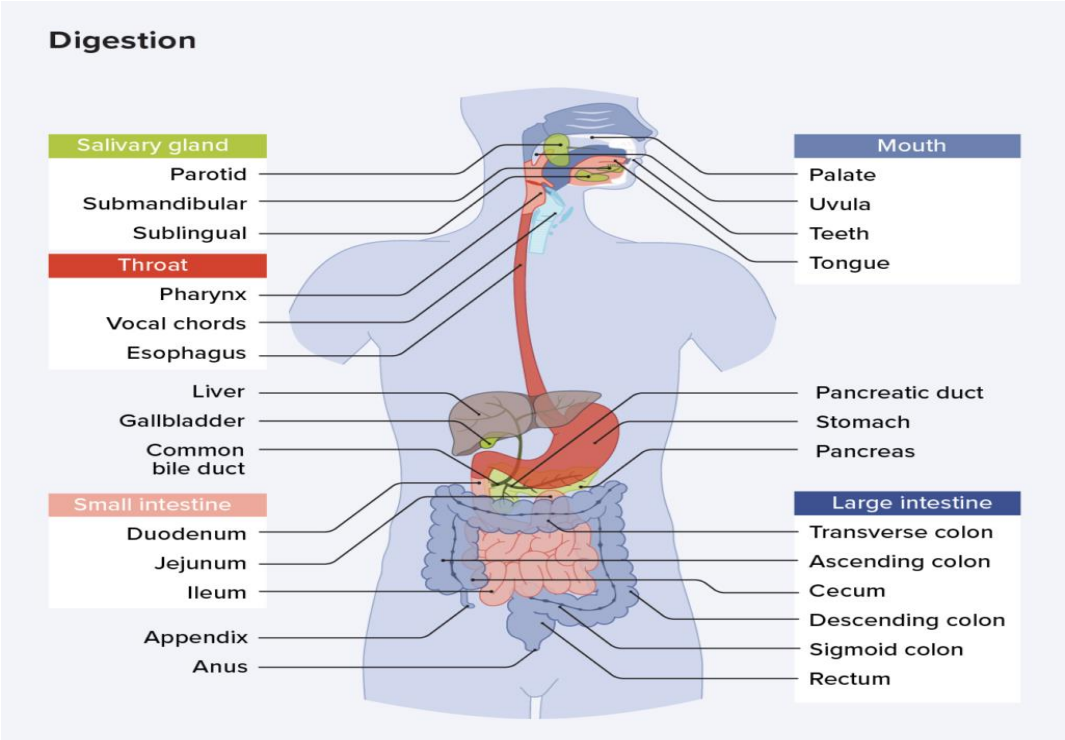
1. Anatomy.

1.1 General structure

The digestive system comprises the digestive tract, which includes the mouth, pharynx, oesophagus, stomach, small intestine, colon, rectum and associated glands, such as the salivary glands, gallbladder and parts of the liver and pancreas.

The digestive tract can be likened to a duct of variable calibre, crossing the body from the mouth to the anus. It is about 5m long, and its lumen is continuous with the outside environment, so that its contents are not an integral part of the organism: for example, bacteria are very present in the terminal part of the intestine, where they are harmless and even useful, but if they penetrate the organism, they rapidly become pathogenic, as happens during attacks of appendicitis.

The anatomy of each segment of the digestive tract will be described in detail as we study the different stages of digestion.



1.2 Histology.

The histology of the digestive tract is identical along its entire length. Moving from the outside towards the lumen of the digestive tract, we find :

- a serosa enveloping the tube

- a 1st layer of longitudinally oriented smooth muscle,

- a 2nd layer of circular smooth muscle,

- a 3rd layer called ‘muscularis mucosae’ or, more explicitly, ‘the muscularis of the mucosa’; it is made up of circular and longitudinal fibres and lies exactly between the submucosa (which is in contact with the layer of circular smooth muscle) and the mucosa.

- The mucosa is the cellular layer in contact with the lumen; this is where the exocrine glands are located, which discharge the products of their secretion into the lumen, and the epithelial villi responsible for absorbing nutrients. It is a pleated layer which increases the surface area in contact with the alimentary bolus.

The submucosa is a connective tissue which contains a few exocrine glandular cells, but above all the blood and lymphatic vessels which drain the absorbed nutrients.

1.3 Neurohumoral control of secretory and motor activity.

The motor and secretory activities of the digestive tract are under dual nervous and endocrine control. Secretory activity is both exocrine and endocrine.

Exocrine glands are located in the wall of the digestive tract itself, but also at a distance from the digestive tract: salivary glands, liver, pancreas; their production is discharged into the lumen of the digestive tract via ducts of varying length.

The endocrine glands are located in the mucous membrane of the digestive tract; they secrete three main hormones:

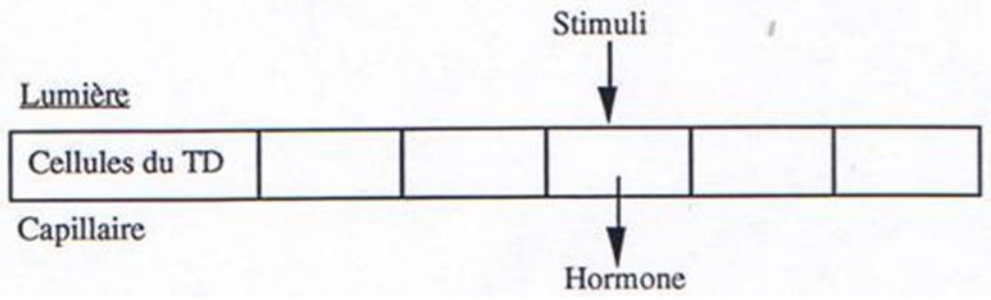
- gastrin (stomach)

- secretin and

- cholecystokinin (first portion of the small intestine), which are drained directly by the blood (venous route) and redistributed (arterial route) to the digestive tract, where they can affect motility and secretion, even in portions that are sometimes far from their point of origin (secretion site).

1.3. Hormonal regulation.

Unlike the endocrine elements (gonads, adrenals, pituitary, thyroid), the cells which secrete TD hormones are isolated cells throughout the epithelium of the stomach and small intestine; in other words, they are not grouped into small organs or glands.



Stimulation takes place in the lumen of the TD, with secretion taking place in the capillaries, i.e. on the other side of the target cell.

Some hormones are also found in small quantities in the lumen of the gastrointestinal tract (paracrine role of hormones). A dozen hormones are considered to be gastrointestinal hormones, but only three actually are: Secretin - CCK - Gastrin.

2. Physiology.

2 .1. Digestion.

Thanks to its mucus glands, the digestive tract secretes a lubricating and protective film against the mechanical and chemical aggression of food. This film contains :

- glycoproteins, or mucopolysaccharides, secreted by superficial glands, or by the upper glands of the crypts; they help to adjust the pH, thanks to their buffering capacity; their secretion is permanent but accelerated by contact with food.

- juices secreted by a wide variety of glands; these juices generally contain :

- bicarbonates of plasma origin (to a small extent) but mainly synthesised.
- electrolytes, which also come from plasma in variable concentrations, due to the mechanisms of secretion and reabsorption.
- enzymatic proteins synthesised in the classical way by the cells.

Examples:

- Stimulation of the vagus nerve sensitises the stomach gland to the action of gastrin.

- Gastrin secretion activates the stomach cells which secrete HCl; the H+ ions released lower the pH which inhibits gastrin secretion.

2.1. Mouth - Pharynx - Oesophagus.

The oral end is a grasping organ thanks to its muscles (cheeks, lips, tongue); solid foods will be the object, in the mouth, of mechanical (mastication) and chemical (insalivation) actions.

a. Mastication

The essential functions of the teeth are to bite and to chew in order to take and reduce this mouthful into fragments small enough to be swallowed. The pressure exerted by the teeth is very great; incisor pressure: 10 to 25 kg; molar pressure: around 100 kg.

Prolonged chewing is characteristic of humans. Many animals (cats, dogs) swallow without chewing; the essential action of chewing is to reduce the size of the pieces to avoid accidents.

b. Salivation.

Three pairs of exocrine glands secrete saliva (in humans, around 1 to 2 litres /24 H); these are the parotid, sub-maxillary and sublingual glands.

Parotid saliva is fluid (rich in water); the other 2 salivas are more viscous (mucus). Saliva contains 99% water, mineral salts and proteins (1%).

The most characteristic proteins are :

- mucins which, when mixed with water, form the mucus that soaks and lubricates the bolus: glycoproteins, mucopolysaccharides.

- Ptyalin is an amylase which breaks down polysaccharides into disaccharides; this work begins in the mouth and continues in the stomach, as long as the acid pH does not inhibit this enzyme.

The composition of saliva varies according to the rate of secretion and the stimulus that triggers salivation; there will be a primary secretion provided by the acinuses and reworked in the course of its flow by reabsorption (Na+), (C03H-) or secretion (K+) phenomena, leading to a definitive saliva.

Salivary secretion is permanent but its flow varies according to circumstances.

c. Swallowing.

This is a complex reflex action which is triggered when the bolus of food pushed by the tongue is propelled into the stomach. There are mechanical receptors in the pharynx which send sensory impulses to the bulbar swallowing centre. This centre coordinates swallowing movements by sending motor impulses to the effectors, made up of the 25 muscles of the pharynx, larynx and oesophagus. Once swallowing has started, it can no longer be stopped; it's an all-or-nothing reflex, coordinated, automatic, programmed by synaptic connections.

2.2. Digestion in the stomach

The stomach is a reservoir that secretes a strong acid, HCl, and several enzymes. Stomach digestion consists of breaking down the bolus of food into molecules, or groups of molecules, that are still too large to be absorbed: this is known as stomach chyme.

a. Mechanical digestion.

The stomach is a highly pleated pouch, with an average volume of 50 mL when empty and which unfolds when full (1.5 L); its structure is described in the previous section on anatomy. The stomach has the most plexuses (punch) and orthosympathetic and parasympathetic fibres provide the link with the cerebrospinal axis.

There is basic electrical activity, in the form of waves, which provoke slow muscular contractions from the cardia to the pylorus.

The first mouthful swallowed stops this activity and the stomach remains immobile for 30 to 60 minutes after the start of the meal; the food ingested is arranged in successive layers.

After this time, the waves start up again, mixing the food and the juices; they push the bowl towards the pylorus, whose sphincter is closed; the bowl flows back towards the cardia and this mixing continues until the chyme meets the pH and granulometry criteria. The stomach is emptied by successive small ejaculations and the evacuation time can vary from 20 minutes for liquids, 5-6 hours for normal meals to 12, 18 and even 24 hours for large ‘binges’. These movements are regulated by short reflexes (plexus) and long reflexes (SNV): the stimuli are thermal, mechanical and chemical. Stimulation of the vagus nerve increases gastric activity, while the orthosympathetic system decreases it. These actions are supplemented by various hormones: gastrin increases gastric activity, while glucagon, secretin and VIP decrease it.

b. Gastric juice.

Gastric juice is secreted continuously (approximately 2 litres/24 h); it increases with meals; it is a colourless, viscous and acidic liquid; it contains mucus, electrolytes (H+, Cl, Na+, K+, CO3H-, enzymes, especially pepsins and a glycoprotein, intrinsic Castle factor, which is necessary for the absorption of vitamin B12).