Dr. Bbosa Science

Heterotrophic nutrition

Heterotrophic organisms are organisms that feed on complex ready-made organic food. They use it as source of: -

(i) energy for their vital activities,
(ii) building materials, that is specific atoms and molecules for cell maintenance and repair and growth,
(iii) vitamins (co-enzymes) that cannot be synthesised in organism but which are vital specific cellular processes.

The main forms of heterotrophic nutrition include
(i) holozoic,
(ii) saprotrophic (or saprophytic) e.g. mould, mushroom
(iii) mutualistic
(iv) parasitic, although some overlap between groups may occur.

Holozoic nutrition

It is a type of heterotrophic nutrition involves the following processes

(i) **Ingestion:** is taking in of complex organic food(solid or liquid).
(ii) **Digestion:** is the breakdown of large complex insoluble organic molecules into small, simple soluble diffusible molecules. This is achieved by mechanical break down and enzymatic hydrolysis. Digestion may be either extra or intra cellular.
(iii)**Absorption:** is the uptake of the soluble molecules from the digestion region, across a membrane and into the body tissue proper. The food may pass into the blood stream to be transported to appropriate regions within the body of the organism.
(iv) **Assimilation** is the utilisation of the absorbed molecules by the body to provide either energy or materials to be incorporated into the body.
(v) **Egestion** is the elimination from the body of undigested waste food materials.

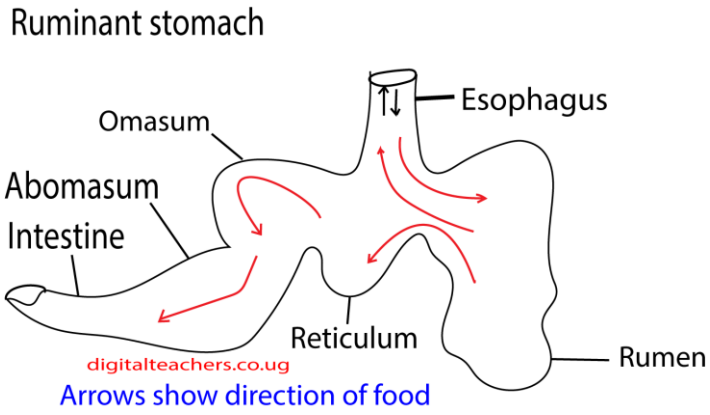
Animals which feed one plants are called **herbivores,** those that feed on other animals **carnivores,** and those that eat a mixed diet of animal and vegetable matter are termed **omnivores.**

If they take in food in form of small particles the animals are **microphagous** feeders, for example earthworms, whereas if the food is ingested in liquid form they are, classed as **fluid feeders,** such as aphids and mosquitoes. Animals which take in food in the form of large pieces are termed as **macrophagous.**

Herbivores

Challenges of herbivores while feeding on plant

(i) Indigestible cellulose
This is overcome in two ways
(a) Ruminant e.g. cow and goat; developed a porch at anterior end of the stomach called rumen that provides space for bacterial fermentation of ingested leaves.



(b) Other herbivores such as horse, zebra, rabbit, have well developed cecum inside which bacteria digest cellulose. Unfortunately, the cecum is ta the end of the intestine that absorption of digested materials may not be efficient. Actually, rabbit feed on their faeces to obtain enough nutrients from their food.

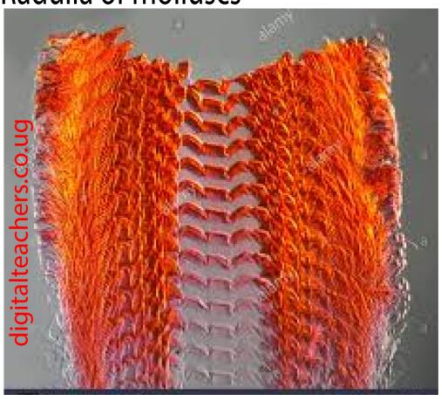
(ii) Low nutrient value in plant materials: this is overcome by eating large volume of food.

(iii) Cellulose in plant cell walls makes materials tough and difficult to digest, herbivores like cow and elephants have strong premolar and/or molar with ridges and large surface area to grind food. These molar and premolar grow throughout life.

Molar of cow

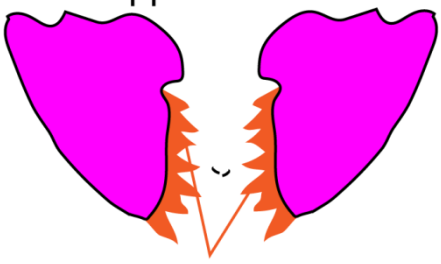
Herbivorous molluscs such as the snail possess a rasping organ, the **radula.** The radula is like a serrated conveyor belt, which by rubbing backwards and forwards against the hardened roof of the mouth can tear plant food

Radulla of molluscs



Herbivorous insects like the locust have a pair of mandibles with a gagged edge for cutting through leaves of grass and other plants

Grasshopper mandibles



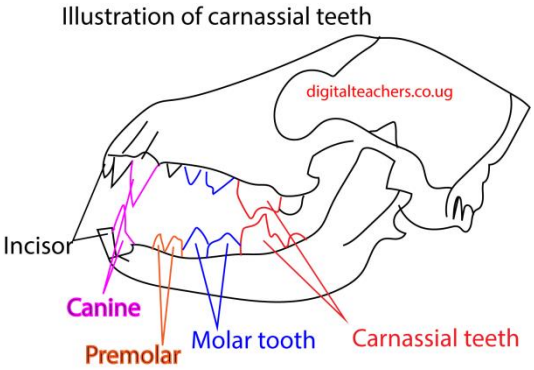
Sharp cutting edges

Carnivores

The challenge is not so much digesting the food as obtaining it.

Adaptation of carnivores to obtaining food

1. high speed locomotion,
2. sharp claws and dagger like **canine** teeth in the great cats,
3. sucker **- bearing tentacles** in octopus and squids
4. tentacles armed **with stinging cells** in sea anemones and jelly fishes.
5. teeth for tearing flesh for instance dog has strong canine and carnassial teeth for tearing meat.



Insectivorous plants.

These insectivorous plants live in nitrogen - deficient soils. All have green leaves and obtain their carbonhydrates by photosynthesis; they obtain nitrogen from trapping and digestion of small animals, particularly insects

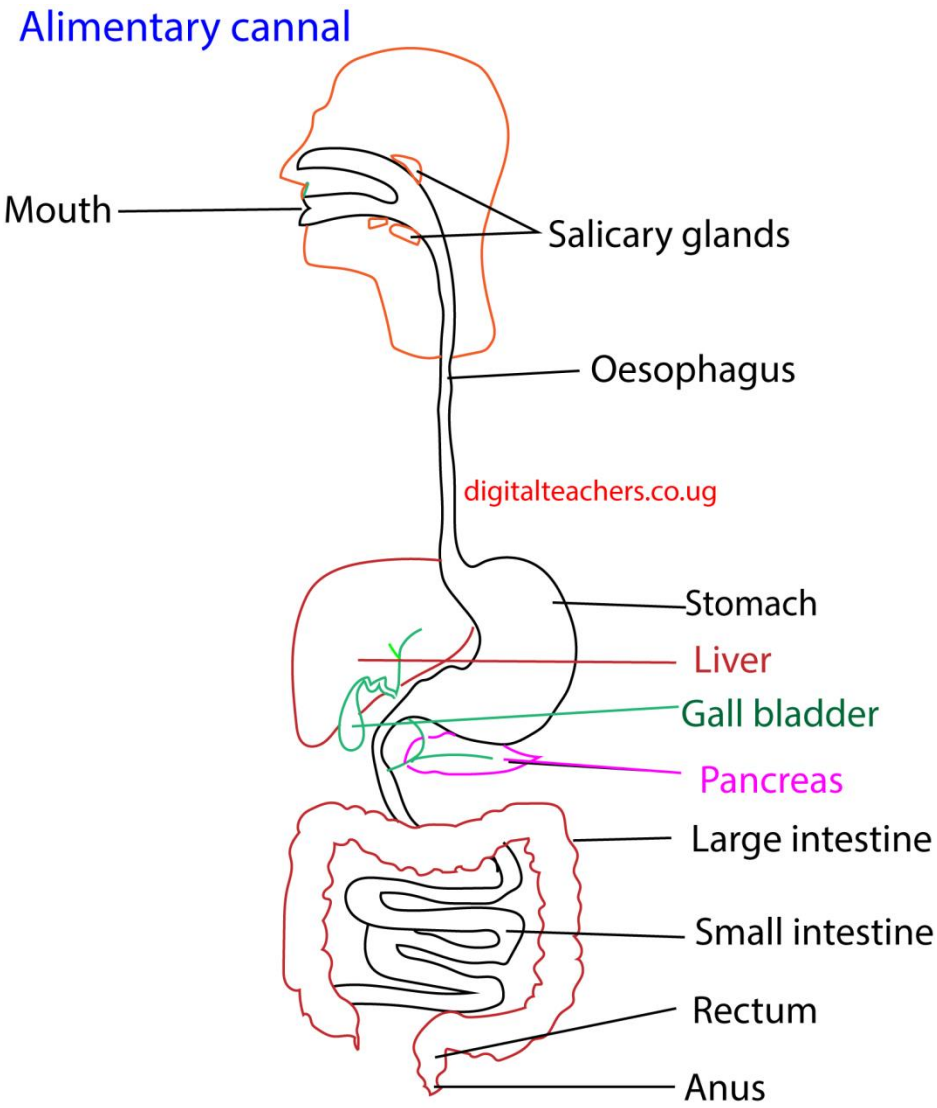
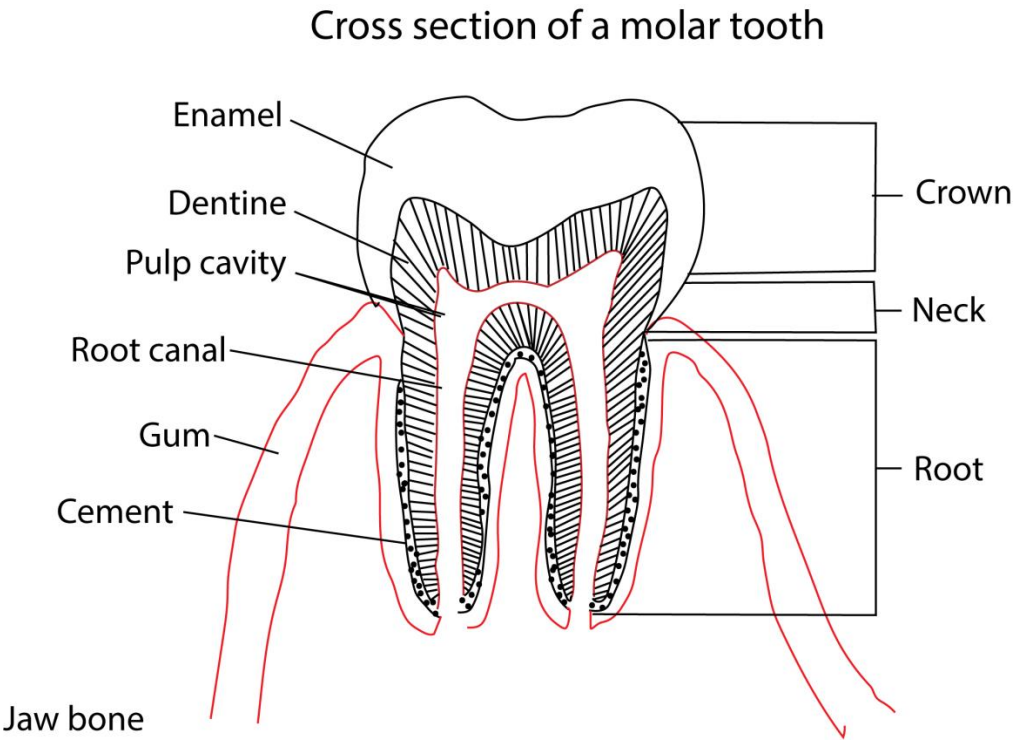


Table 1.: Summary of the functions of the different parts of the human digestive system.

SPECIALISED PART	FUNCTION
Buccal cavity	Ingestion, mastication.
Pharynx	Swallowing.
Oesophagus	Links pharynx to stomach
Stomach	Food storage and digestion of proteins.
Duodenum	Digestion and absorption.
Liver (bile)	Emulsification of fats.
Pancreas (pancreatic juice)	Digestion of starch, proteins and fats.
Iteum	Completion of digestion & absorption of food
Colon	Absorption of water.
Rectum	Formation and storage of faeces.
Anus	Egestion

In the buccal cavity.
The food is broken up into smaller pieces by the chewing action of the teeth (**mastication)** and moistened by **saliva** from the salivary glands.



<u>In the stomach</u>.

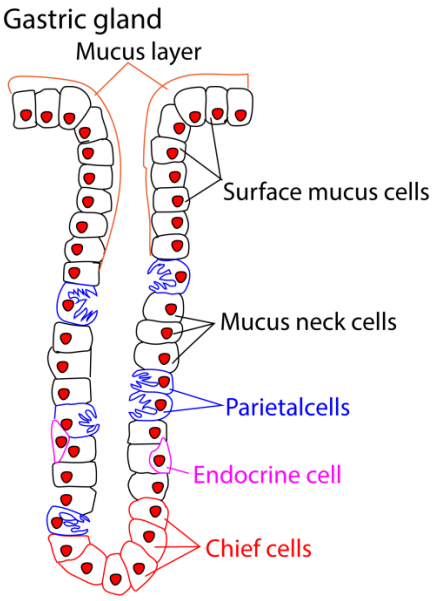
The stomach is a dilated part of the gut where the food remains for two or more hours

Once in the stomach the food gastric gland in gastric wall secrete **gastric juice**

Gastric juice contains

(i) **Hydrochloric acid** that kills germs and provide pH for the action of pepsin
(ii) Enzyme **pepsin** which breaks down proteins into short polypeptide chains. Pepsin is secreted as an inactive precursor **pepsinogen** to prevent the gastric gland being destroyed by its own enzyme (auto-digestion).
(iii) Enzyme **renin** coagulates casein, the soluble protein of milk, forming insoluble card which is then attacked by pepsin.

These enzymes are secreted by the **chief (or peptic) cells** in the walls of the gastric glands.



Parts of gastric gland

(i) Mucus cell secrete mucus that protects stomach wall for pepsin,

(ii) Parietal cells (**oxyntic** cells) are the epithelial cells that secrete hydrochloric acid (HCl) and **intrinsic** factor.

(iii) The **gastric chief** cell (also known as a zymogenic cell or peptic cell) is a cell in the stomach that releases pepsinogen and chymosin. Pepsinogen is activated into the digestive enzyme pepsin when it comes in contact with acid produced by gastric parietal cells.

Duodenum

Receives secretion from pancreas and gall bladder

(a) Gall bladder produces bile that emulsifies fats.

(b) Pancreas produces pancreatic juice that contains.

(i) Pancreatic amylase: breaks down starch to disaccharide maltose.

(ii) Pancreatic lipase**:** breaks down tri-glycerides in the emulsified fat into mono-glyceride and fatty acids.

(iii) Protease**:** (Protein - splitting enzymes) which include **trypsin, chymotripsin, carboxy-**peptidare and **elastase**).

The four proteases are secreted as inactive precursors; **trypsinogen, chymotrypsinogen, pro-carboxypeptidase** and **pro-elaslase to** prevents auto-digestion. Trypsinogen is converted into trypsin by the action of the enzymes **enterokinase,** secreted by the wall of the small intestine. The trypsin then activates the other three proteases. These pancreatic protease breaks down proteins and polypeptides into **tripeptides** and **dipeptides.**

Pancreatic juice also contains **nucleases** which break down nucleic acids into nucleotides and a variety of **peptidases** which release some free amino acids from polypeptide chains.

(iv) **Bicarbonate** neutralise acidic chime from the stomach

Intestinal enzymes

Various enzymes, associated with the epithelial lining of small intestine complete the digestion of carbohydrate by breaking down disaccharides into mono-saccharides.

These enzymes include: -

- **Maltase:** hydrolyses maltose to glucose, thus completing digestion of starch.
- **Sucrase** hydrolyses sucrose (Sugar cane) to glucose & fructose.
- **Lactase** hydrolyses lactose (Milk sugar) to glucose & galactose.

The end products of carbohydrate digestion are all mono-saccharides. The final stage of carbohydrate digestion is **intra-cellular**, as disaccharides are absorbed by the plasma membrane of the epithelial cell before broken down into monosaccharides.

The epithelial cells also absorb tripeptides and dipeptides which are then broken down into **amino acids** by various peptidases. Thus, the final stages of protein digestion are also intra-cellular.

Nucleotidases: are also present in the epithelial cells of the small intestine. They split nucleosides into constituent submits.

Brunner's gland

Found in the walls of duodenum, secrete alkaline mucus which:

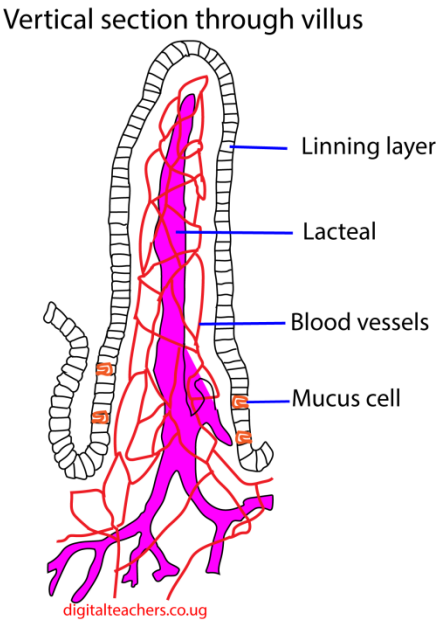
- protect the duodenum from the acidic content of **chyme** (which is introduced into the duodenum from the stomach);
- provide an alkaline condition for the intestinal enzymes to be active, thus enabling absorption to take place;
- lubricates the intestinal walls.

At the bottom of Brunner's gland are cells called Crypts of **lieberkutin** that secrete enzyme for final digestion.

Adaptation of small intestine for absorption of food

1. Long to allow food enough time for absorption
2. Villi and microvilli increase surface area for absorption
3. Well supplied by blood to carry away absorbed food so as to maintain diffusion gradient
4. The villi have thin membrane to reduce diffusion gradient
5. Villi have high concentration of mitochondria to provide energy for active transport.
6. **circular fold** increase surface area for absorption

7. Villi contain lacteal for absorption of fats



Control of digestion

The regulation of food intake is complex. It involves gut hormones and the enteric nervous system as well as the brain.

The cells in the lining of the stomach and small intestine produce and release hormones that **control** the functions of the **digestive** system. These hormones stimulate production of **digestive** juices and regulate appetite.

These hormones include

(i) **Ghrelin** is produced in the stomach, and its function is to tell the brain that the body has to be fed. It increases appetite.

(ii) **Gastrin** is produced in the stomach when it is stretched. It
   (a) Stimulates the release of gastric juice rich in pepsin and hydrochloric acid.
   (b) Stimulates of smooth muscle contraction in the stomach, small intestine, and large intestine, which increases gastric and intestinal motility.
   (c) Relaxation of the pyloric sphincter, which promotes gastric emptying into the small intestine.
   (d) Acidic pH levels reduce the levels of gastrin.

(iii) **Secretin** is produced in the duodenum and
   (a) stimulates the pancreas to produce alkaline secretions (rich in bicarbonate ions)
   (b) slows the emptying of the stomach
   (c) stimulates the liver to produce bile.

(iv) **Cholecystokinin (CCK)** is produced in the duodenum.
   (a) It reduces appetite,
   (b) slows down the emptying of the stomach
   (c) stimulates the release of bile from the gall bladder.

(v) **Peptide YY (PYY)** is produced in the last part of the small intestine known as the ileum as well as parts of the large intestine. It plays a role in slowing down the passage of food along the gut, which increases the efficiency of digestion and nutrient absorption after meal and inhibits appetite.

(vi) **Glucagon-like peptide 1 (GLP-1)** is produced in the small intestine and colon and has multiple actions including inhibition of gastric emptying and appetite as well as the stimulation of insulin release.

(vii) **Motilin** — stimulates the production of pepsin and speeds up peristalsis.

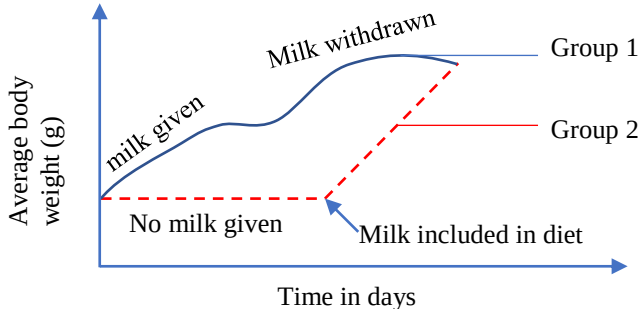
Nerve Regulators

Two types of nerves help control the action of the digestive system: extrinsic and intrinsic nerves.

Extrinsic, or outside, nerves connect the digestive organs to the brain and spinal cord. These nerves release chemicals that cause the muscle layer of the GI tract to either contract or relax, depending on whether food needs digesting.

The intrinsic, or inside, nerves within the GI tract are triggered when food stretches the walls of the hollow organs. The nerves release many different substances that speed up or delay the movement of food and the production of digestive juices.

1.	Which one of the following features characterises the omnivore gut? A. Large divided stomach B. Poorly developed appendix and caecum C. Long pouched colon D. Short ileum and colon
2.	Which one of the following enzymes is not secreted by lining of the ileum? A. Lipase B. Sucrase C. Enterokinase D. Lactase
3.	In a human with non-functional pancreas, digestion of starch in the intestine would A. Be possible because of the suitable pH due to bile B. Not occur for absence of enzymes C. Would be possible because succus entericus contains the necessary enzyme D. Would not occur because of the acid pH of chyme
4.	Which one of the following explains why digestion of fats does not occur in human stomach? A. Absence of digesting enzymes B. Low pH for fat digesting enzyme C. High pH for the fat-digesting enzyme D. Absence of bile salts the emulsify the fats
5.	The absorption of amino acids after eating a heavy protein meal is aided by A. Diffusion and active transport B. Osmosis and diffusion C. Diffusion and pinocytosis D. Active transport only
6.	Which one of the following hormones induces the liver to secrete non-enzymatic substances used in digestion? A. Thyroxine B. Adrenaline C. Secretin D. Insulin
7.	Which one of the following enzymes would be adversely affect by high pH? A. Trypsin B. Pepsin C. Amylase D. lipase

8	The figure below shows growth curves of rats provided with milk diet at different times  The most appropriate conclusion of the results is that A. In rats, normal growth occurs if the milk contains essential vitamins B. Milk stimulate growth while lack of milk retards growth in rate C. If milk is added to a milk deficient diet, the body weight of rats decreases further D. Lack of milk in the diet has no effect on the growth of rats.
9.	Pancreatic juice contains the enzyme: A. Amylase, peptidase, trypsinogen, renin B. Amylase, pepsin, trypsinogen, peptidase C. Lipase, amylase, trypsinogen, peptidase D. Lipase, amylase, pepsin, maltase
10.	In the duodenum, the product ready for absorption are those of the A. Lipase and amylase B. Amylase only C. Trypsin and lipase D. Lipase only
11.	Which one of the following organisms exhibit intracellular digestion? A. Snail B. Insects C. Mammals D. Fungi
12.	Termites are able to eat wood because they A. Produce cellulase enzyme B. Possess strong mandibles C. Contain cellulose digesting bacteria in the gut D. Contain fungi in the gut.
13	Which one of the following will result in the formation of gall stones in the liver? A. Blockage of bile duct B. Breakdown of haemoglobin in the liver C. High level of cholesterol in the diet D. Accumulation of bile salts

14	The adaptations of the small intestine to the digestive process is to increase A. Surface area and absorption of end products B. Secretory and absorptive surfaces C. Secretory and digestive surfaces D. The duration of the digestive process
15.	Which one of the following secretion contains an enzyme that digests maltose? A. Gastric juice B. Succus entericus C. Pancreatic juice D. saliva
16.	Which of the following indirectly stimulates secretion of alkaline fluids by the pancreas? A. Stimulation by sympathetic nerves B. The presence of gastrin in blood C. The presence of food in the duodenum D. The presence of hydrochloric acid in the stomach

Proposed answers

1	B	6	C	11	C	16	B		
2	A	7	B	12	C				
3	B	8	B	13	C				
4	A	9	C	14	C				
5	A	10	D	15	B				