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((Entomolog I))

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LEC- ((EIGHT))

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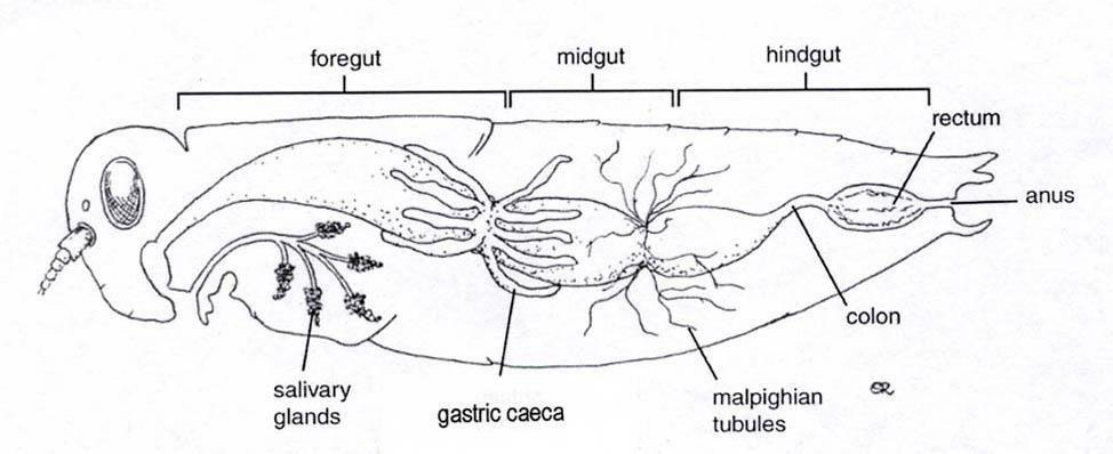
Anatomy: Digestive system

Digestive system



The **digestive system** (sometimes referred to as the **alimentary canal**) should be easily seen in the dissected specimens. It is a long tube-like structure that runs from the mouth to the anus and is centrally located within the body cavity, or **hemocoel**. The anterior-most region is called the **foregut** (or **stomodeum**) which includes the Buccal cavity, the esophagus, and the crop. The primary function of the foregut is to begin the breakdown of food particles and transport them to the next region, the **midgut** (or **mesenteron**). The midgut is the major area of digestion and absorption. Undigested food particles then pass into the third region, the **hindgut** (or **proctodeum**), which consists of the ileum, colon, **rectum**, and (often) rectal pads. The hindgut functions in water and solute reabsorption and waste excretion.

The three sections of the digestive tract can be easily identified by structures found at the junction of each region. **Gastric caecae**, for example, mark the end of the foregut and beginning of the midgut. It is believed that the purpose of these structures is to increase surface area for greater nutrient absorption. The constriction at the gastric caecae also marks the spot of the cardiac valve (or sphincter).

The alimentary canal of insects is a long, muscular and tubular structure extending from mouth to anus. It is differentiated into three regions viz., Foregut, midgut and hindgut.

1. **Foregut**: It is ectodermal in origin. Anterior invagination of ectoderm forms foregut (Stomodeum). Internal cuticular lining is present. Terminal mouthparts leads into a preoralcavity. Preoralcavity between epipharynx and hypopharynx is called as Cibarium. Preoralcavity between hypopharynx and salivary duct is Salivarium. Behind the mouth a

well musculated organ called Pharynx is present which pushes the food into oesophagous. Pharynx acts as a sucking pump in sap feeders. Oesophagous is a narrow tube which conduct food into crop. Crop is the dilated distal part of oesophagus acting as food reservoir. In bees crop is called as honey stomach where nectar conversion occurs. Proventriculus or Gizzard is the posterior part of foregut and is musculated. It is found in solid feeders and absent in fluid feeders or sap feeders. Food flow from foregut to midgut is regulated through cardial or oesophageal valve. The internal cuticle of gizzard is variously modified as follows.

i. Teeth like in cockroach to grind and strain food.
ii. Plate like in honey bee to separate pollen grains from nectar
iii. Spine like in flea to break the blood corpuscles

2. **Midgut**: It is endodermal in origin and also called as mesentron. This part contains no cuticular lining. Midgut is made up of three types of epithelial cells. (i) Secretory cells (Columnar cells) (ii) Goblet cells (aged secretory cells), (iii) Regenerative cells which replaces secretory cells. Important structures present in midgut are as follows:

a. **Peritrophic membrane**: It is the internal lining of midgut, secreted by anterior or entire layer of midgut epithelial cells. Present in solid feeders and absent in sap feeders. This layer is semipermeable in nature to digestive juices and digestion products. It lubricate and facilitate food movement. Envelops the food and protects the midgut epithelial cells against harder food particles.

(ii) **Gastric caecae**: (Enteric caecae or Hepatic caecae) Finger like outgrowths found in anterior or posterior ends of midgut. This structure increases the functional area of midgut and shelter symbiotic bacteria in some insects.

(iii) **Pyloric valve**: (Proctodeal valve) Midgut opens into hindgut through pyloric valve, which regulate food flow. In certain immature stages of insects midgut is not connected to hindgut till pupation. e.g. Honey bee grub.

(iv) **Filter chamber**: It is a complex organ in which two ends of ventriculus and the begining of hind gut are enclosed in a sac. This is useful to short circuit excess water found in liquid food in homopteran insects. This process avoids dilution of digestive enzymes and concentrates food for efficient digestion. Also helps in osmoregulation by preventing dilution of haemolymph.

3. **Hindgut**: It is ectodermal in origin and produced by the posterior invagination of ectoderm. Internal cuticular lining is present, which is permeable to salts, ions, aminoacids and water. The main functions of hindgut are the absorption of water, salt and other useful substances from the faeces and urine. Hindgut is differentiated into three regions viz., **ileum, colon and rectum**. In the larva of scarabids and termites, illeum is pouch like for housing symbionts and acts as fermentation chamber. Rectum contains rectal pads helping in dehydration of faeces and it opens out through anus.

Gut physiology: Primary functions of the gut is to digest the ingested food and to absorb the metabolites. Digestion process is enhanced with the help of enzymes produced by digestive glands and microbes housed in special cells.

Digestive glands:

a. **Salivary glands**: In Cockroach a pair of labial glands acts as salivary gland where the salivary ducts open into salivarium. In caterpillars mandibular glands are modified to secrete saliva, where the salivary glands are modified for silk production. Functions of saliva:
   1. To moisten and to dissolve food
   2. To lubricate mouthparts
   3. To add flavour to gustatory receptors
   4. In cockroach the saliva contains amylase for the digestion of starch.
   5. In honey bee saliva contains invertase for sucrose digestion
6. In Jassid saliva contains lipase and protease for lipids and protein digestion. Jassid saliva also contains toxins which produces tissue necrosis and phytotoxemia on the plant parts.
7. In plant bug saliva contains pectinase which helps in stylet penetration and extra intestinal digestion.
   8. In mosquito, saliva contains anticoagulin which prevents blood clotting.
   9. In gall producing midges saliva contains Indole Acetic Acid (IAA).
   10. In disease transmitting ectors the saliva paves way for the entry of pathogens.

b. **Hepatic caecae and midgut epithelial cells**: It secretes most of the digestive juices. Two types of cells were involved in the enzyme secretion.
   Holocrine : Epithelial cells disintegrate in the process of enzyme secretion.
   Merocrine : Enzyme secretion occurs without cell break down.

Digestive enzymes

Insect Group	**Enzyme**	**Substrate**
Phytophagous larvae	Amylase	Starch
Maltase		Maltose
Invertase		Sucrose
Omnivorous insects	Protease	Protein
Lipase		Lipid
Nectar feeders	Invertase	Sucrose
Wood boring insects and Termites	Cellulase	Cellulose
Meat eating maggots	Collagenase	Collagen and elastin
Bird lice	Keratinase	Keratin

C. Microbes in digestion: In the insect body few cells were housing symbiotic microorganisms called as mycetocyte. These mycetocytes aggregate to form an organ called mycetome.

(i) Flagellate protozoa - It produces cellulase for cellulose digestion in termites and wood cockroach.
(ii) Bacteria - It helps in wax digestion in wax moth.

(iii) Bed bug and cockroach obtain vitamin and aminoacids from microbes.

These microbes were transmitted between individuals through food exchange (mouth to mouth feeding) called **trophallaxis** and through egg called as **transovarial** transmission. In plant bug and ant lion grub partial digestion occurs in the host body prior to food ingestion called as extra intestinal digestion. In most of the insects digestion occurs in mid gut.

Absorption: In many insects absorption of nutrients occurs through microvilli of midgut epithelial cells by diffusion. Absorption of water and ions occur through rectum. In cockroach lipid absorption occurs through crop. In termites and scarabaeids (White grubs) absorption occurs through ileum. In solid feeders, resorption of water from the faeces occurs in the rectum and the faeces is expelled as pellets. In sap feeders (liquid feeders) the faeces is liquid like. The liquid faeces of homopteran bugs (aphids, mealy bugs, Scales and psyllids) with soluble sugars and amino acids is known as honey dew, which attracts ants for feeding.