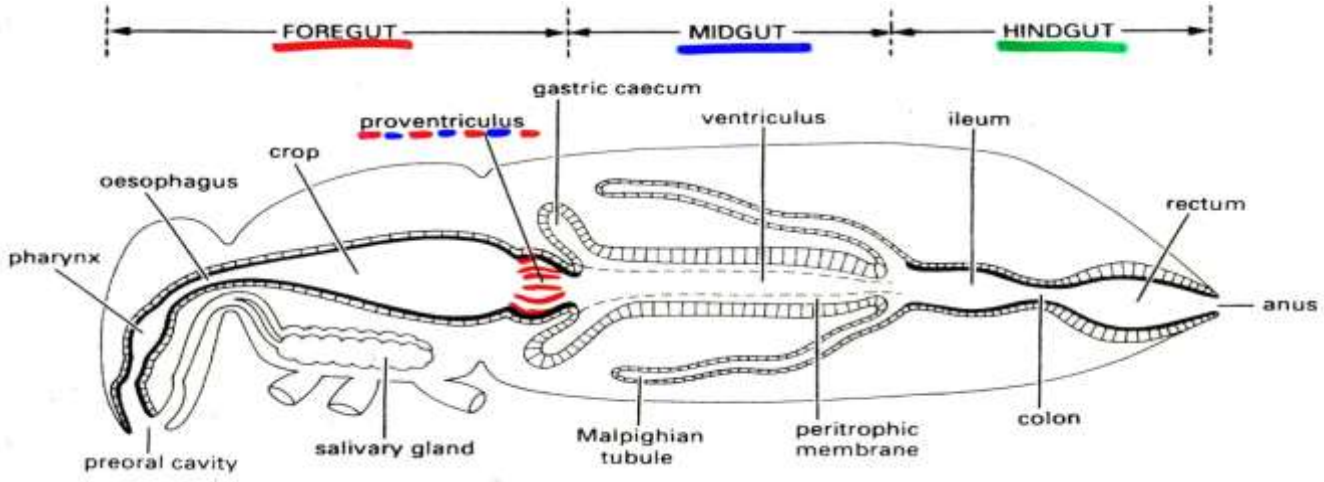
General Entomology **College of Education**
Lecture: 10 Insect digestive system

Insect digestive system (Alimentary canal):
The digestive tract consists of a tube of epithelial cells running from the mouth to the anus. It is divided into three major regions based on embryonic originsand physiological functions: the foregut, midgut, and hindgut (Figure-1) the stomodeum and proctodeum both arise as invaginations of the embryonic ectoderm and produce the foregut and hindgut, respectively. The midgut (mesenteron) forms from endodermal tissues. The midgut epithelium is the only insect tissue that differentiates from endoderm.

Alimentary canal is divided into 3 parts:

1) Foregut. is the anterior part of the alimentary canal which starts with the **mouth cavity** and ends with the gizzard (or) proventriculus. In mandibulate insects, the preoral cavity is divided by the hypopharynx into an anterior cibarium and a posterior salivarium. In many mosquitoes, the cibarium is armed with cuticular spines that lysered blood cells before they pass into the midgut. A pair of salivary glands, modified from the epidermal cells of the labium segment, empties their secretions into the salivarium through the cuticle-lined salivary duct.
Foregutis divided in to pharynx, oesophagus, crop and gizzard (Figure 1).
The mouth cavity is formed by the labrum as upper lip, labium as lower lip with mandibles and maxillae laterally and hypopharynx at the centre. At the base of the hypopharynx, salivary glands open into the mouth cavity.
Pharynx: It is the region between the mouth and oesophagus. **Oesophagus**: it is a narrow part of the foregut through which the foods get transported from pharynx into the crop. **Crop**: It is a sac like structure which is a dilated form and mainly serves the purposeof storage of food material. **Gizzard**: It is a small constricted part of the alimentary canal which consists of thecuticular intima layer modified in to a tooth like denticles that help for grinding the food material. In some insects such as honey bees, the gizzard functions as honey stopper (or) stainer separating the pollen from the nectar.



After gizzard the fore gut forms into a stomodeal valve which is surrounded by gastric (or) hepatic caecae, which may vary from 5-6 in numbers (Fig. 1).

Internally foregut consists of the following layers:
(i) Inner most intima layer,(ii) Epithelial cells,(iii) Basement membrane,(iv) Longitudinal muscles and (v) Circular muscles
2) Midgut: It is also known as mesenteronor stomach. Foregut opens in to midgut through stomodael / cardiac valve. Midgut is a short, straight tube in case of primitiveinsects or a sac or may be pyriform or fusiform in shape in caterpillars. In some insects midgut appears as a completely separated sac like structure that gets connected with the hindgut. **Structurally midgut consists of:**
(i) Inner peritrophic membrane, (ii) A layer of epithelial cells,(iii) Basement membrane,(iv) Circular muscles and (v) Longitudinal muscles
Midgut consists of an inner delicate layer called **peritrophic membrane (PM)** secreted by the epithelial cells. The peritrophic membrane protects the tenderepithelial cells of the midgut from abrasion by hard food particles as no mucous issecreted in insects that feed on the solid food material. The peritrophic membrane forms a coat over the food particles and no damage will occur to epithelial cells of midgut. This layer is said to be permeable to the digestive enzymes and the products of digestion. It is absent in case of sap sucking insects.The epithelial layer of midgut consists of 3 types of cells
1) Columnar cells: These are columnar in shape; vary in size and release enzymes through a series of microvilli arranged in a brush border (or) honey combborder**.**
2) Regenerative cells: These epithelial cells are involved in the production (or) Formation of new cells to replace the whole columnar cells involved in holocrine secretion of enzymes. These regenerative cells may be arranged either in groups (or) may remain scattered (or) sometimes singly. If they are arranged in groups (or) clusters they are called Nidhi.
3) **Goblet cells**: Mainly serve for storage and excretion.

3. Hindgut. It is also known as proctodaeum which is lined inside by intima. It is morepermeable than that of the foregut. Anterior end of the hindgut can be marked by thepresence of a set of malpighian tubules and a pyloric valve. Internally hindgut has same structure as that of the foregut.
Hindgut is divided into 3 regions namely **ileum, colon** and **rectum** (Fig. 1). The epithelial cells of the rectum may sometimes get differentiated into **rectal papillae** (or) **pads** which vary in number from 3-6. These are involved in reabsorption of water, salts from the fecal matter.

Salivary glands: These are a pair of glands involved in the secretion of salivary juices. These glands open at the base of the hypopharynx through small salivary ducts (Figure 2). The secretion of the glands contain the enzymes such as amylases, lipases, proteases, but never cellulase. In case of silkworm (or) lepidopteran larvae, the salivary glands produce silk whichcontains two proteins fibroin and sericin and anti coagulantsin blood suckers likemosquitoes.

Glands related to digestive system

1-Mandibular glands (small glands open near to the base of mandible) its functions: secrete salvia, in larval lepidoptera become specialized for silk production, in apis queen they produce the pheromones concernedwith colony control.

2- Maxillary glands (present in some primitive group of insects,information about its function is not available)

3-Labial glands or Salivary glands: Present in the majority of insects its main functions are: A-produce saliva (could be specialized for secret silk in lepidopteronlarvae)

B-in some blood sucking insects salvia contains substances inhibit thecoagulation of its blood.

4-Pharyngeal glands (occur in hymenoptera) It has many functions for example :plays role in cast determination,produce diet of laying queen and drone

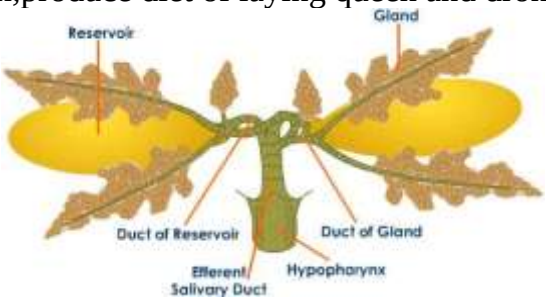


Figure 2. Salivary Glands

Modification of digestive system: Filter chamber: This is a characteristic arrangement of the midgut in Homopteran insects (fluid feeders). Anterior part of midgut forms a thin-walled bladder i.e filter chamber (Figure 3) which is closely bound to either posterior part of midgut or the anterior hindgut and Filter chamber enables the excess fluids includingsugar in the food to pass directly from the anterior part of the midgut to the hindgut by diffusion, without passing through the middle portion of midgut thus preventing excessive dilution of haemolymph, enzymes and facilitate better enzyme activity. In aphids, the honey dew (rich in sugars) is the substance that is being excreted after passingthrough the filter chamber.

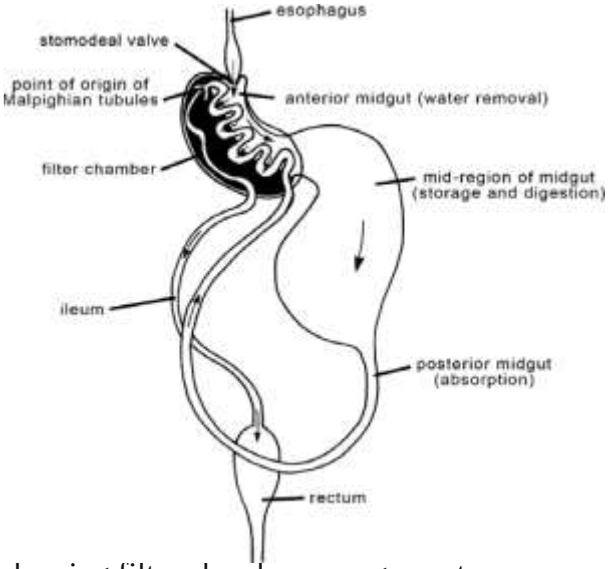


Fig.3. Alimentary canal ofcercopid(Cercopoidea) showing filter chamber arrangement.

Process of digestion

The food ingested by the insects through the mouth cavity enters into thealimentary canal, get digested and the undigested waste material is excreted throughanus. During this process, food material is broken down into small particles (or) in toa form that can be readily absorbed by the cells of the midgut and hindgut.Digestion mainly takes place in 5 steps.

1. Ingestion : Food is partially digested in the oral cavity with the help of salivary enzymes. In insects like fluid feeders, carnivorous hemiptera, blowfly larvae etc, digestion occurs outside the intestine by a process called **extra intestinal (or) extraoral digestion** .

2. Transportation : The food material entered in to the oesophagus is transported into the crop by muscular activity i.e. by peristatic movements. Food movescontinuously from oesophagus in to the crop where it is stored. From the crop, foodenters in to the gizzard where it is still broken in to very minute particles with the helpof denticles or the cuticular teeth.

3. Digestion: From the gizzard through the stomodeal valve, food passes in to the midgut where actually digestion starts. The epithelial cells produce enzymes i.e.

proteases which break proteins in to aminoacids, carbohydrases breaking carbohydrates in to mono &disaccharides, lipases breaking lipids in to fatty acidsand glycerol.In termites, digestion takes place in colon of hindgut where mycetomes (groupof cells which harbour the microorganisms like protozoans) secrete the enzyme cellulase which can digest the wood material rich in cellulose.

In scarabid beetle larvae, bacteria are involved in digestion. In wood feeders,keratin digestion is facilitated by alkaline pH of midgut. In *Tineola*(cloths moth), keratinasesecreted by protozoans.

4. Absorption: Midgut epithelial cells absorb the nutrients from the digested food and pass on the faecal matter and undigested food material in to the hindgut. TheMalpighian tubules maintain ionic balance by absorbing Na and K saltsfrom the blood. The cells of the hindgut are also involved in the re absorption ofwater, salts and other metabolites from the faecal matter.

5. Egestion: The waste food material is discharged through the anus due to the action of the anal muscles.