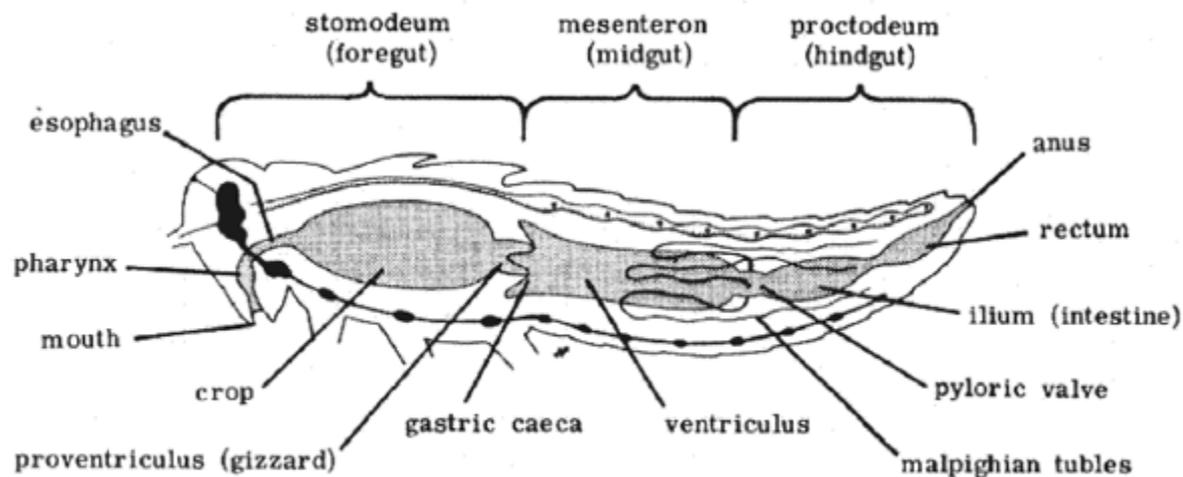


# Digestive system



- **solid** food material, possess the **biting and chewing type** of mouth parts where as **sap** feeding ones have **sucking type**
- Sap suckers possess a **filter chamber** and solid feeders have well developed **gizzard**
- The alimentary canal in insects extends from mouth to anus which is divided in to
- **Anterior stomodaeum (foregut)**
- **Middle midgut (mesenteron or stomach or ventriculus)**
- **Posterior hindgut (proctodaeum)**
- The **foregut and hindgut are ectodermal** in origin where as the **midgut is endodermal** in origin
- Compared to the carnivores (or) sap suckers, the **phytophagous solid feeders** possess longer alimentary canal



The "generalized" digestive system of insects.

## 1) Foregut/Stomodeum

- starts with the mouth cavity and ends with the gizzard (or) Proventriculus

**Mouth cavity** is formed by the labrum, labium **with mandibles and maxillae**

- At the base of the hypopharynx, **salivary glands** open into the mouth cavity

**Pharynx:** It is the region between the mouth and oesophagus

**Oesophagus:** narrow part of the foregut, food get transported from pharynx into the crop

**Crop :** It is a sac like structure which is a dilated form and mainly stores the food material

**Gizzard :** constricted part of the alimentary canal and the cuticular intima layer with teeth like denticles, help for grinding the food material

- In some insects such as **honey bees**, the gizzard functions as honey stopper separating the pollen from nectar
- After gizzard the foregut forms into a **stomodaeal valve** which is surrounded by **gastric (or) hepatic caecae**, which may vary from 5-6 in number



Internally foregut consists of the following layers

- (i) Inner most intima layer
- (ii) Epithelial cells
- (iii) Basement membrane
- (iv) Longitudinal muscles
- (v) Circular muscles

2) **Midgut/mesenteron:** Foregut opens in to midgut through stomodaeum / cardiac valve

Structurally midgut consists of

- (i) Inner peritrophic membrane
- (ii) A layer of epithelial cells
- (iii) Basement membrane
- (iv) Circular muscles
- (v) Longitudinal muscles

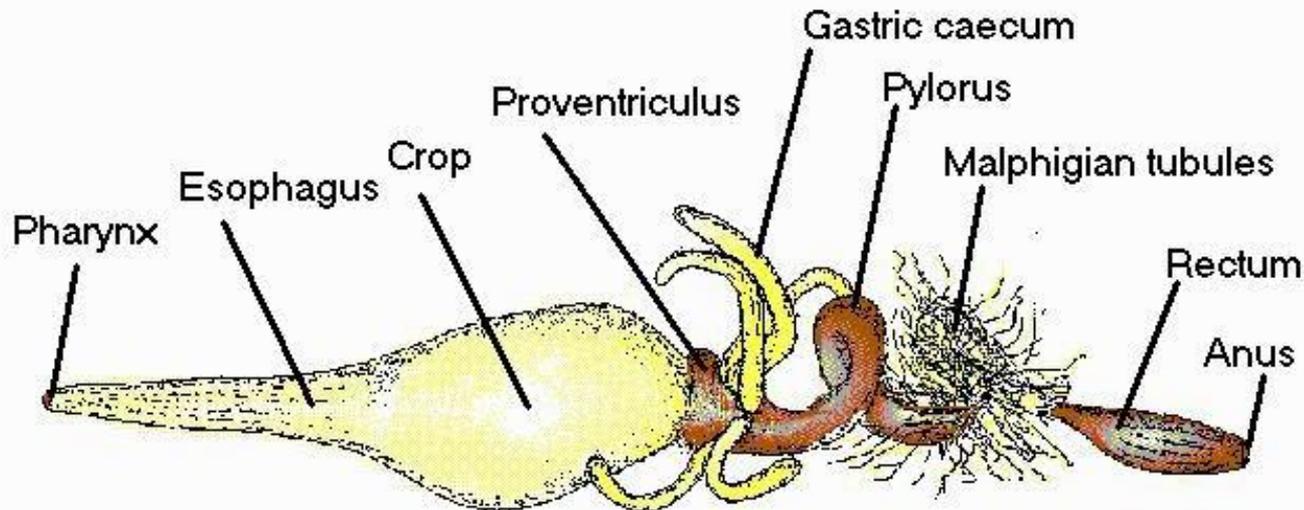
- Midgut consists of **peritrophic membrane** secreted by the epithelial cells
- Protects epithelial cells by forming coat over the food particles
- permeable to the **digestive enzymes** and the products of digestion
- **absent** in case of **sap sucking insects**

The epithelial layer of midgut consists of 3 types of cells

- 1) **Columnar cells:** columnar in shape, release enzymes through a series of **microvilli** arranged in a **brush border (or) honey comb border**
- 2) **Regenerative cells:** production (or) formation of new cells to replace the whole columnar cells involved in holocrine secretion of enzymes, If arranged in groups, called **Nidhi**
- 3) **Goblet cells:** Mainly serve for **storage and excretion**

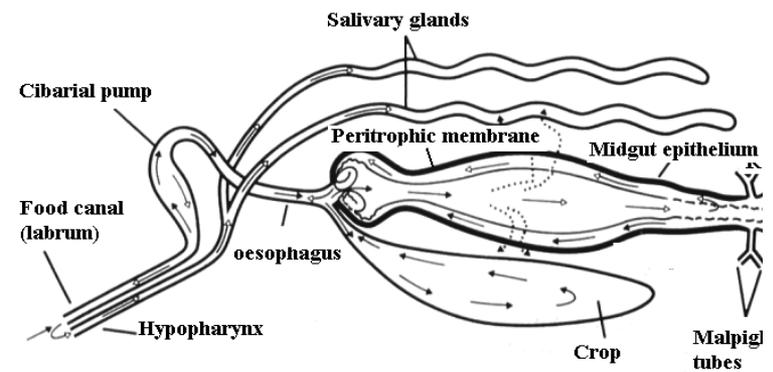
### 3. Hindgut/Proctodeum

- Lined inside by intima and more permeable than that of the foregut
- Anterior end be marked by 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
- **Ileum** is small intestine (or) tube like and appears as a **pouch in scarabids**
- **Colon** may (or) may not be present and if present, it leads to rectum
- Epithelial cells of **rectum** may get differentiated into rectal papillae (or) pads 3-6 in no.
- These are involved in **reabsorption of water, salts** from the faecal matter



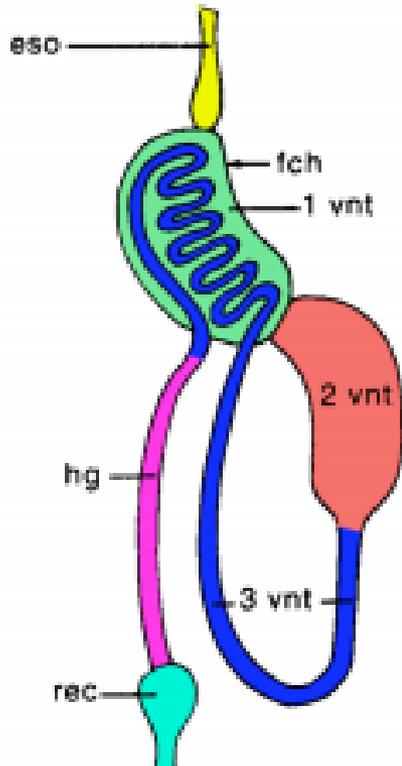
## Salivary glands:

- pair of glands secretes **salivary juices**
- open at the **base of hypopharynx**
- contain the enzymes such as amylases, lipases, proteases, **but never cellulase**
- In case of **silkworm (or) lepidopteran larvae**, produce silk with two proteins **fibroin and sericin**
- Secretes anti coagulants in blood suckers eg. mosquitoes



## Filter chamber:

- In the **midgut in hemipteran insects** (fluid feeders)
- Anterior part of midgut forms a thin-walled bladder i.e filter chamber, closely bound to either **posterior part of midgut** or the **anterior hindgut and Malpighian tubules**
- enables the excess fluids including sugar in the food to pass directly from the anterior part of the midgut to the hindgut
- prevents **excessive dilution of haemolymph, enzymes** and facilitate better enzyme activity
- In **aphids**, **honey dew** secreted after passing through filter chamber



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) extra oral digestion**
  
2. **Transportation** : from the Pharynx is transported in to the crop by muscular activity i.e. by **peristaltic movements** and in crop, it is stored  
Food enters in to the gizzard where it is still broken in to very minute particles with the help of **denticles or the cuticular teeth**
  
3. **Digestion**: food passes in to the midgut where actually digestion starts  
The epithelial cells produce enzymes i.e.
  - **proteases** break proteins in to aminoacids
  - **carbohydrases** breaking carbohydrates in to mono & disaccharides
  - **lipases** breaking lipids in to fatty acids and glycerol
  - ❖ In **termites**, digestion takes place in colon of hindgut where **mycetomes** (group of cells which harbour the micro organisms 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), keratinase** secreted by **protozoans**
  
4. **Absorption**: Midgut epithelial cells absorb the nutrients from the digested food