**Lec:3**

# The digestive and excretory system

# of insects

Insects feed upon almost every type of organic substance found in nature; some on plants, others on animals, and some on sap of plant tissue, fluids of animals, some on fungi or the live and dead bacteria.

Digestion :: Is the break-down process of macromolecules and other complex substances (such as proteins, polysaccharides, fats, and nucleic acids) into smaller molecules (i.e. amino acids, simple sugars, uric acid and…etc.) before being used by cells of the body for energy, growth, or reproduction. All insects have a **complete digestive system**. Ingested food usually travels in only one direction, it begins with mouth opening and ends with the anus.

The digestive processes are (6 steps).

1. **ingestion, 2- propulsion, 3-mechanical digestion, 4-chemical digestion, 5-absorption, and 6-defecation**

The insect's digestive system is **a closed system, with one long enclosed coiled tube called the alimentary canal which runs lengthwise through the body, it is often divided into three main regions:**

1-Foregut (Stomodeum). Is ectodermal in origin

2- Midgut (Mesentron). Is endodermal in origin

3- Hindgut (Proctodeum). Is ectodermal in origin

Each of three sections of the alimentary canal performs a different process of digestion.

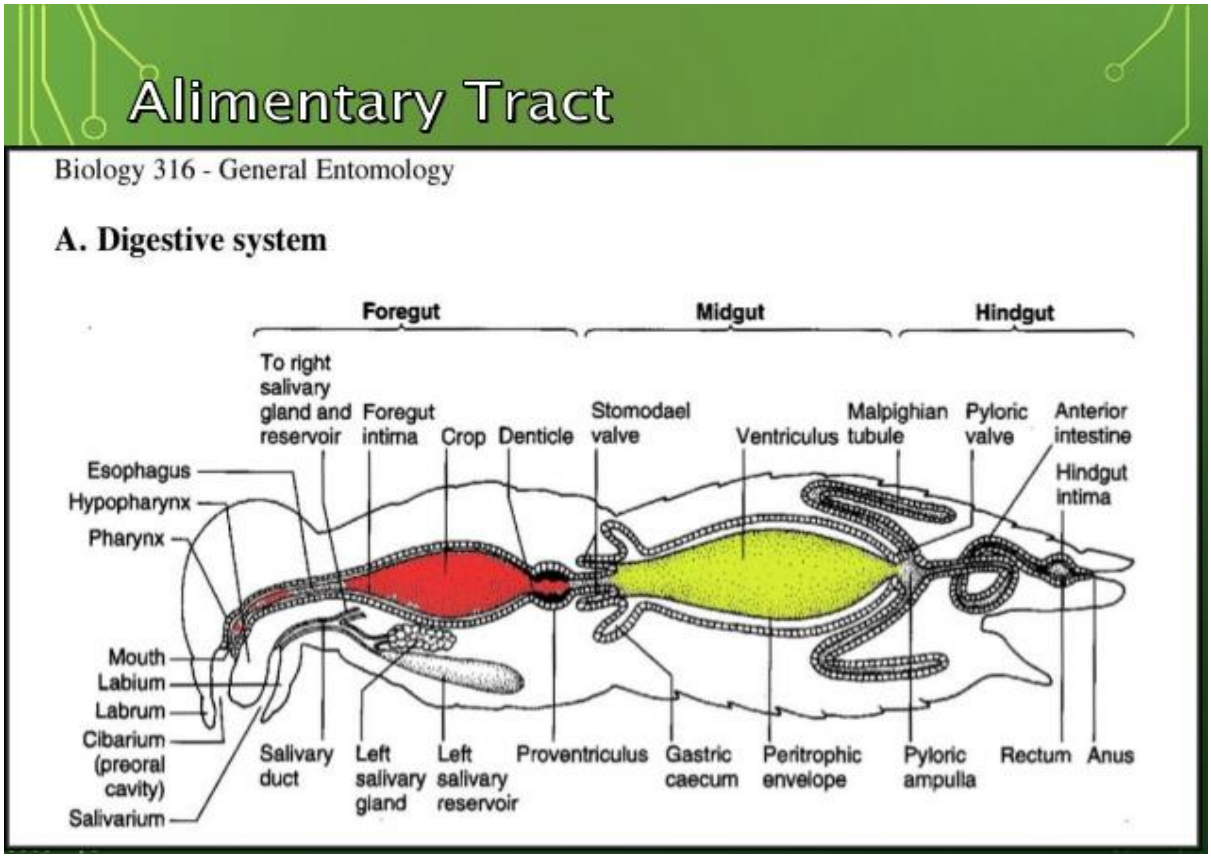



**Fig (1)** The digestive system of grasshopper

**Stomodeum** (Foregut), **The foregut consists of: -**

- **Mouth (oral cavity):** The salivary glands provide fluids and enzymes to the mouth for lubrication and to begin food breakdown.
- **Pharynx:** It is the region between the mouth and the esophagus. It provides the muscles and run to the head capsule.
- **Esophagus:** Is just a simple tube that connects **pharynx** to the **crop.**

- **Crop:** A food-storage organ.
- **Proventriculus (or gizzard):** this organ contains tooth-like denticles that **grind food particles**.

Proventriculus(gizzard)has several important functions.

- **Aiding digestion by particle size reduction.**
- **Chemical degradation of nutrients**
- **Regulation of feed flow,**
- **Responds rapidly to changes in the coarseness of the diet**.

The foregut and the midgut are separated by the Cardiac Valve.

In addition to the alimentary canal, insects also have paired **salivary glands** and **salivary reservoirs**. These structures usually reside in the thorax (adjacent to the foregut and have many functions).

## Salivary glands

Immediately behind the mouth are the salivary glands, in most species these secrete saliva which travels through salivary tubes into the mouth.

Saliva generally the watery fluid that lubricates the food and contains a few enzymes to begin the processes which mixes with food and begins the process of breaking it down.

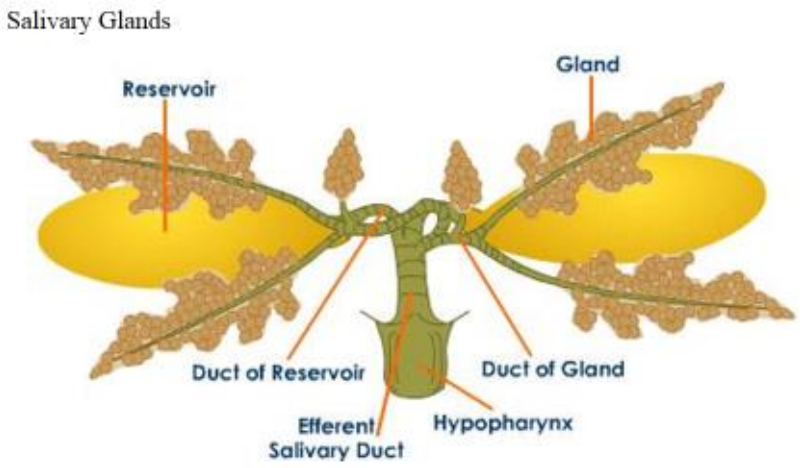



**Fig.(2)** The general structure of salivary gland

## Functions of salivary glands

### (A) Digestive functions

**1-** Moisten food.

**2-** Lubricate mouthparts.

**3-** Amylase--- coplex sugars to simple sugars.

**4-** Salivary enzymes for preoral digestion.

**5-** To add flavour to gustatory receptors.

### (B ) Non digestive functions

**1-** 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.

**2-** In plant bug saliva contains pectinase which helps in stylet penetration and extra intestinal digestion.

**3-** In mosquito, saliva contains anticoagulin which prevents blood clotting.

**4-** In gall midge saliva contains Indole Acetic Acid (IAA) which produces galls on plant parts.

**5-** In disease transmitting insects (vectors) the salivapaves way for the entry of pathogens.

**6-** Silk production.

**Mesenteron (midgut):**

The mesenteron or midgut has diverse functions for all insects.

1- It produces and secrete most of the digestive enzymes and the first site of digestion.

2- Digestive enzymes in this region are produced and secreted into the lumen and here nutrients are absorbed into the insect's body.

3- Food is enveloped by the **peritrophic membrane.**

4- It also acts as a filter allowing small molecules through but preventing large molecules and particles of food from reaching the midgut cells.

Near the anterior end, of midgut there are finger-like projections (usually from 2 to 10), called the **gastric caeca** serve as to increase surface area for secretion of enzymes or absorption of water and other substances from the alimentary canal.

The Midgut and the Hindgut are separated by the Pyloric Valve.

**Hindgut (Proctodeum)** divided into three sections.

1-The anterior portion is the ileum.

2- The middle portion the colon.

3-The posterior portion is the rectum, An important function of the rectum in terrestrial insects is the **removal of water from the feces**.

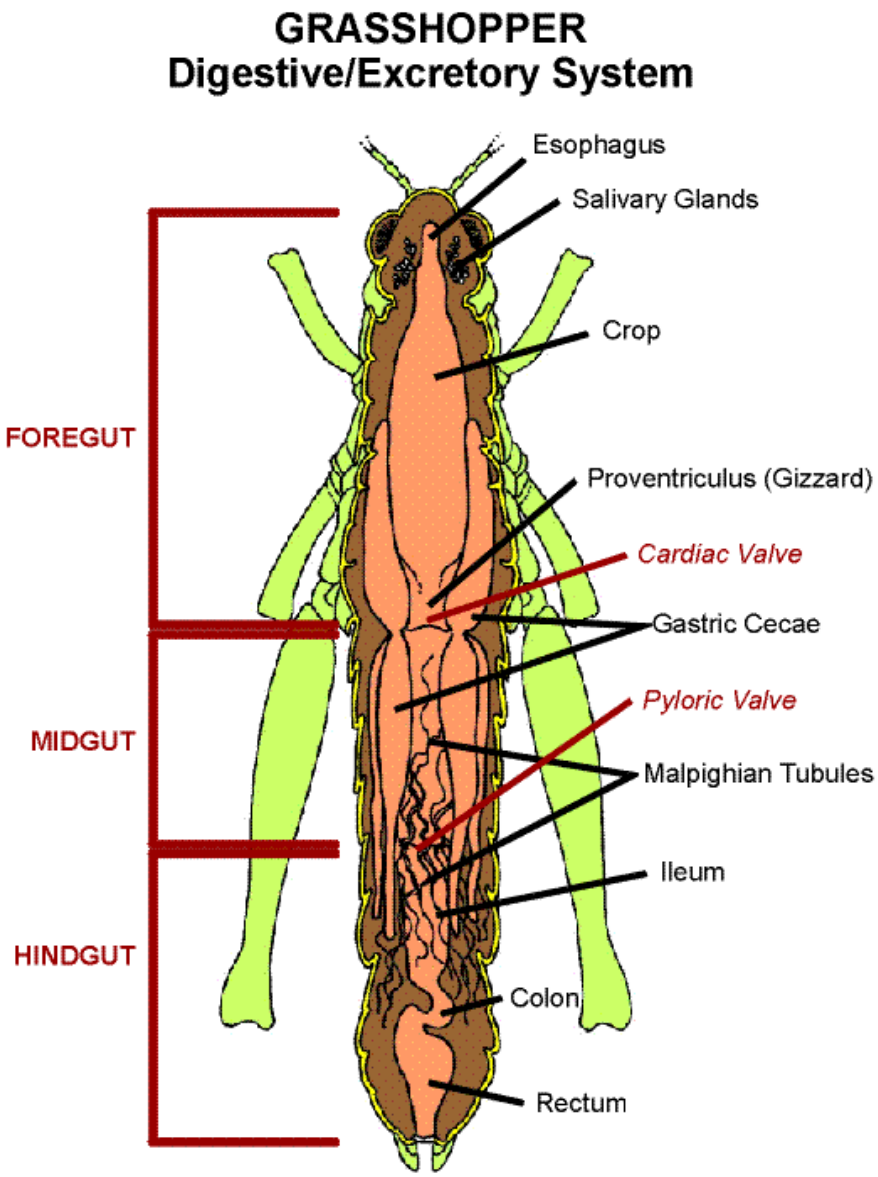
The main functions of hindgut are the **absorption of water, salt and other useful substances from the faeces and urine.**

However, for very small animals like insects, water conservation is a priority, because of this, blind-ended ducts called **Malpighian tubules** come into play. These ducts emerge as evaginations at the anterior end of the hindgut and are the main organs of **osmoregulation and excretion**. These extract the waste products from the hemolymph. These tubules continually produce the insect's uric acid, which is transported to the hindgut, where important salts and water are re-absorbed by both the hindgut and rectum.

Excretion and osmoregulation in insects are not orchestrated by the Malpighian tubules alone but require a joint function of the ileum and/or rectum.

What does Malpighian tubule mean?

**any of a group of long blind vessels opening into the posterior part of the digestive tract in most insects and some other arthropods and functioning primarily as excretory organs**.




## Fat bodies

The fat body is a relatively large organ distributed throughout the insect body, underneath the integument and surrounding the gut and reproductive organ. Unlike the solid structure of the liver, the insect fat body is a loose tissue. It is important in the storage of fat, protein, and glycogen and as such, grows in larvae, and is reduced during pupation and metamorphosis. It is quite small in the adult when reserves are

used for egg production. The fat body is also involved in intermediate metabolism and in this way, resembles the vertebrate liver. The fat body is rich in enzymes. Fats may be synthesized, released by the fat body into the haemocoel or be broken down. It is also important in detoxification and symbiotics are present in some insect fat bodies and aid in the synthesis of various vitamins and amino acids for protein synthesis. from the partially digested food. Moreover, it is a powerful secretory organ responsible to produce virtually all hemolymph proteins, including most immune defense factors. The fat body is capable of extremely high levels of protein synthesis and secretion, as exemplified by the massive production of yolk protein precursors during vitellogenesis in female insects.

Winifred Doane, the first person to study fat accumulation in insects.

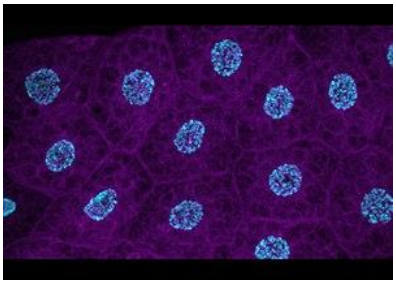


**Fig (5)** Stained cells of an insect fat body

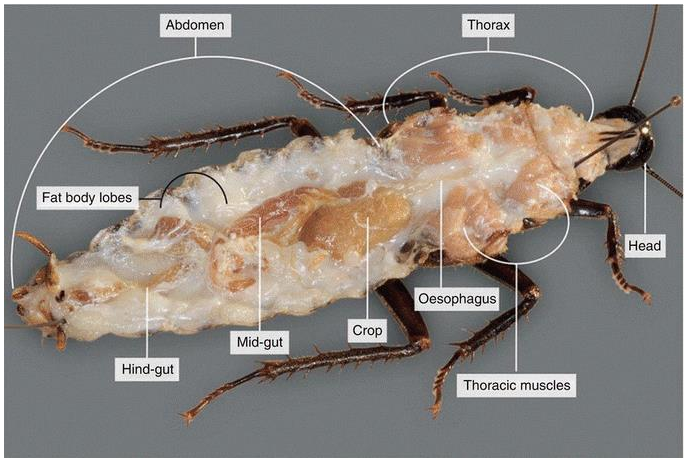



**Fig. (6)** The digestive system of Cockroach as shown with Dissecting microscope, see the fat bodies