STRUCTURE AND FUNCTIONS OF EXCRETORY SYSTEM

Different types and their functional mechanisms

The removal of waste products of metabolism, especially nitrogenous compounds from the body of insects is known as excretion. The excretion process helps the insect to maintain **salt water** balance and thereby **physiological homeostasis**. Following are the excretory organs.

1. Malpighian tubules

Thin, blind-ending tubules, originating near the junction of mid and hindgut, predominantly involved in regulation of salt, water and nitrogenous waste excretion. This structure was discovered by Marcello Malpighi.

2. Nephrocytes

Cells that sieve the haemolmph for products that they metabolize (pericardial cells).

3. Fat bodies

A loose or compact aggregation of cells, mostly **trophocytes**, suspended in the haemocoel, responsible for storage and excretion.

4. Oenocytes

The cells of haemocoel, epidermis or fat body with many functions.

5. Integument

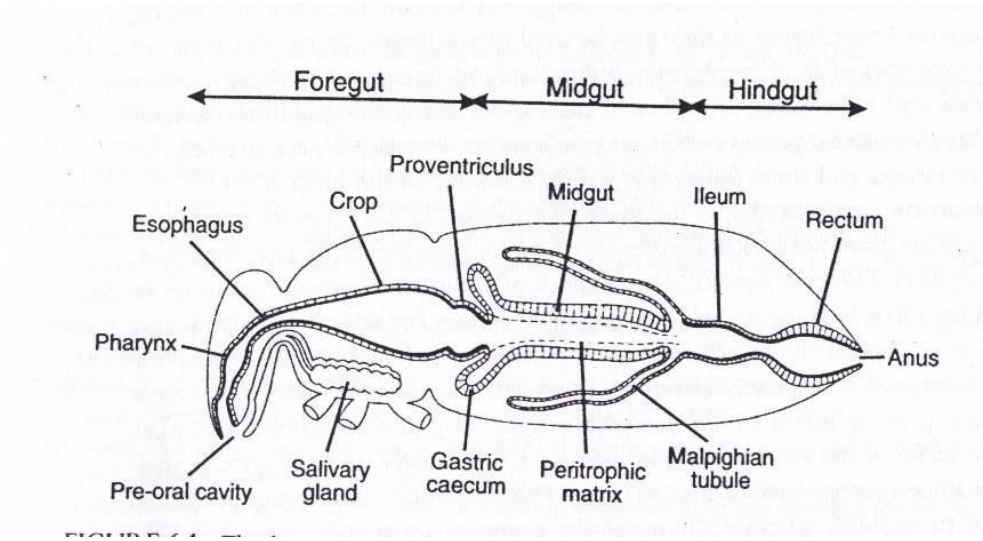
The outer covering of the living tissues of an insect.

6.Tracheal system

The insect gas exchange system, comprising tracheae and tracheoles.

7. Rectum

The posterior part of hind gut. Among the above organs, malpighian tubules are the major organ of excretion.

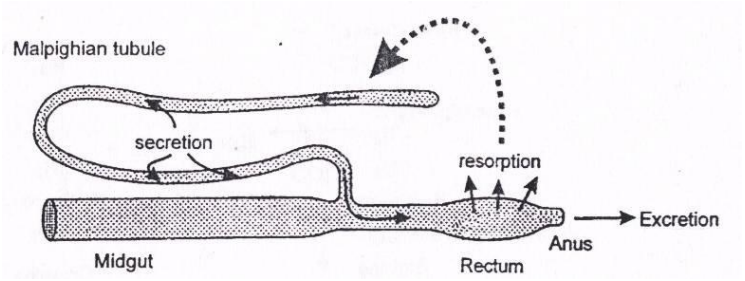


Excretion and Osmoregulation

Insect faeces, either in liquid form or solid pellets, contains both undigested food and metabolic excretions. Aquatic insects excrete dilute wastes from their anus directly into water by flushing with water. But, Terrestrial insects must conserve water. This requires efficient waste disposal in a concentrated or even dry form, simultaneously avoiding the toxic effects of nitrogen. Both terrestrial and aquatic insects must conserve ions, such as sodium (Na^+), potassium (K^+) and chloride (Cl^-), that may be limiting in their food or lost into the water by diffusion. Therefore the production of insect excreta (urine or pellets) is a result of two related processes: **excretion and osmoregulation** (maintenance of favourable osmotic pressure and ionic concentration of body fluid). **The system responsible for excretion and osmoregulation is referred to as excretory system** and its activities are performed largely by the Malpighian tubules and hindgut. However in fresh water insects, haemolymph composition is regulated in response to loss of ions to the surrounding water, with the help of excretory system and special cells. Special cells are called **Chloride cells** which are present in the hindgut, capable of absorbing inorganic ions from the dilute solutions. (e.g. Naids of dragonflies and damselflies).

Malpighian Tubules

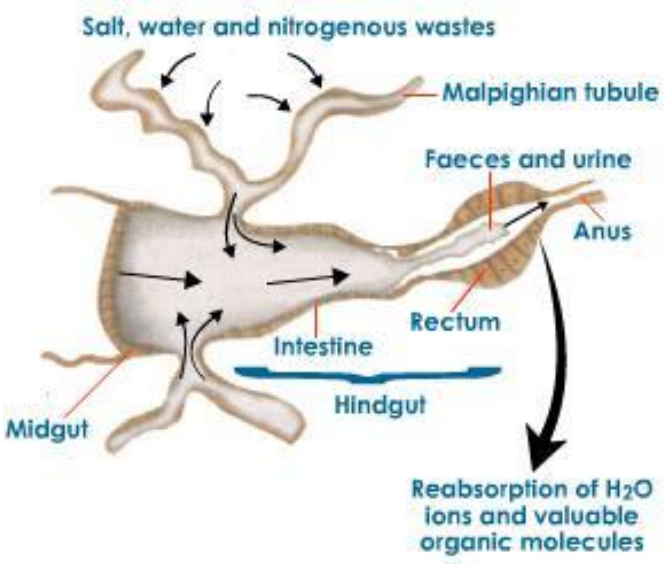
The main organ of excretion and osmoregulation in insects are the malpighian tubules, acting in association with rectum or ileum. Malpighian tubules are outgrowths of the alimentary canal and consist of long thin tubles formed of a **single layer of cells** surrounding a blind-ending **lumen,** they are absent in spring tail and aphids, 2 numbers in scale insects, 4 in bugs, 5 in mosquitoes, 6 in moths and butterflies, 60 in cockroach and more than 200 in locusts. Generally they are free, waving around in the haemolymph where they filter out solutes. Each tubule is externally covered by **peritonial coat** and supplied with muscle fibres (aiding in peristalsis) and tracheloes. Functional differentiation of the tubules was seen, with the **distal secretory** region and **proximal absorptive** region.

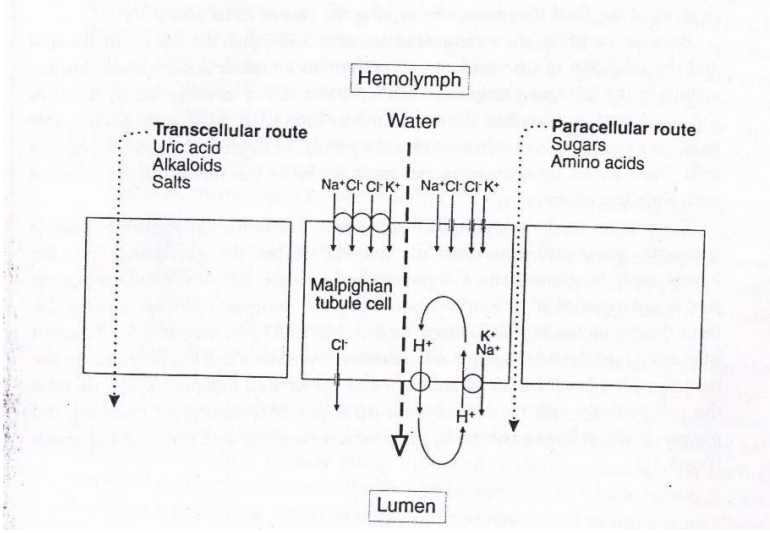


Physiology

The malpighian tubules produce a filtrate (the primary urine) which is isosmotic but ionically dissimilar to the haemolymph and selectively reabsorbs water and certain solutes, but eliminates others. The malpighian tubules produces an isosmotic filtrate which is high in K^+ and low in Na^+ with Cl^- as major anion. The active transport of ions especially K^+ into the tubule lumen generates an osmotic pressure gradiant for the passive flow of **water**.

Sugars and most amino acids are also passively filtered from the haemolymph via junctions between the tubule cells, where as amino acids and non-metabolizables and toxic organic compounds are actively transported into the tubule lumen. Sugars are reabsorbed from the lumen and returned to the haemolymph. The continuous secretory activity of each Malpighian tubule leads to a flow of primary urine from its lumen towards and into the gut. In the rectum, the urine is modified by removal of solutes and water to maintain fluid and ionic homeostasis of the body



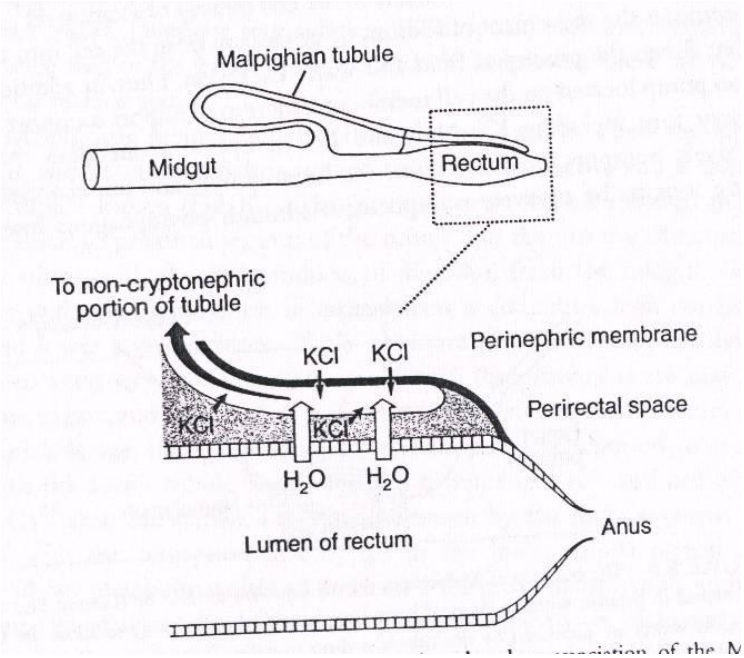


Nitrogen excretion

Terrestrial insects excrete waste products as uric acid or certain of its salts called urates, which were water insoluble and requires less amount of water for waste product removal. This type of excretion is known as **uricotelism**. In aquatic insects ammonia is the excretory product, which is freely soluble in water and requires more amount of water for waste product removal. This type of excretion is known as **ammonotelism**.

Cryptonephry

The distal ends of the Malpighian tubules are held in contact with the rectal wall by the perinephric membrane, which is concerned either with efficient **dehydration of faeces** before their elimination or **ionic regulation**. (e.g. Adult Coleptera, larval Lepidoptera and larval symphyta)



Functions of malphighian tubule

Excretory in function, mainly concerned with removal of nitrogenous wastes. The other accessory functions are as follows:

1. Spittle secretion in spittle bug
2. Light production in **Bolitophila**
3. Silk production in larval neuroptera

Storage Excretion

The excretory waste materials are retained within the body in different sites.

Uric acid is stored as urates in the **cells of fat body** e.g., American cockroach.

Uric acid is stored in the **body wall**, giving white colour, e.g., Red cotton bug.

Uric acid is stored in the **male accessory glands** to produce the outer coat of spermatophore, which is excreted during copulation.

Uric acid is stored in the **wing scales** giving white colour. e.g., Pierid butterflies.

Waste products of pupal metabolism (**meconium**) is stored and released during adult emergence.