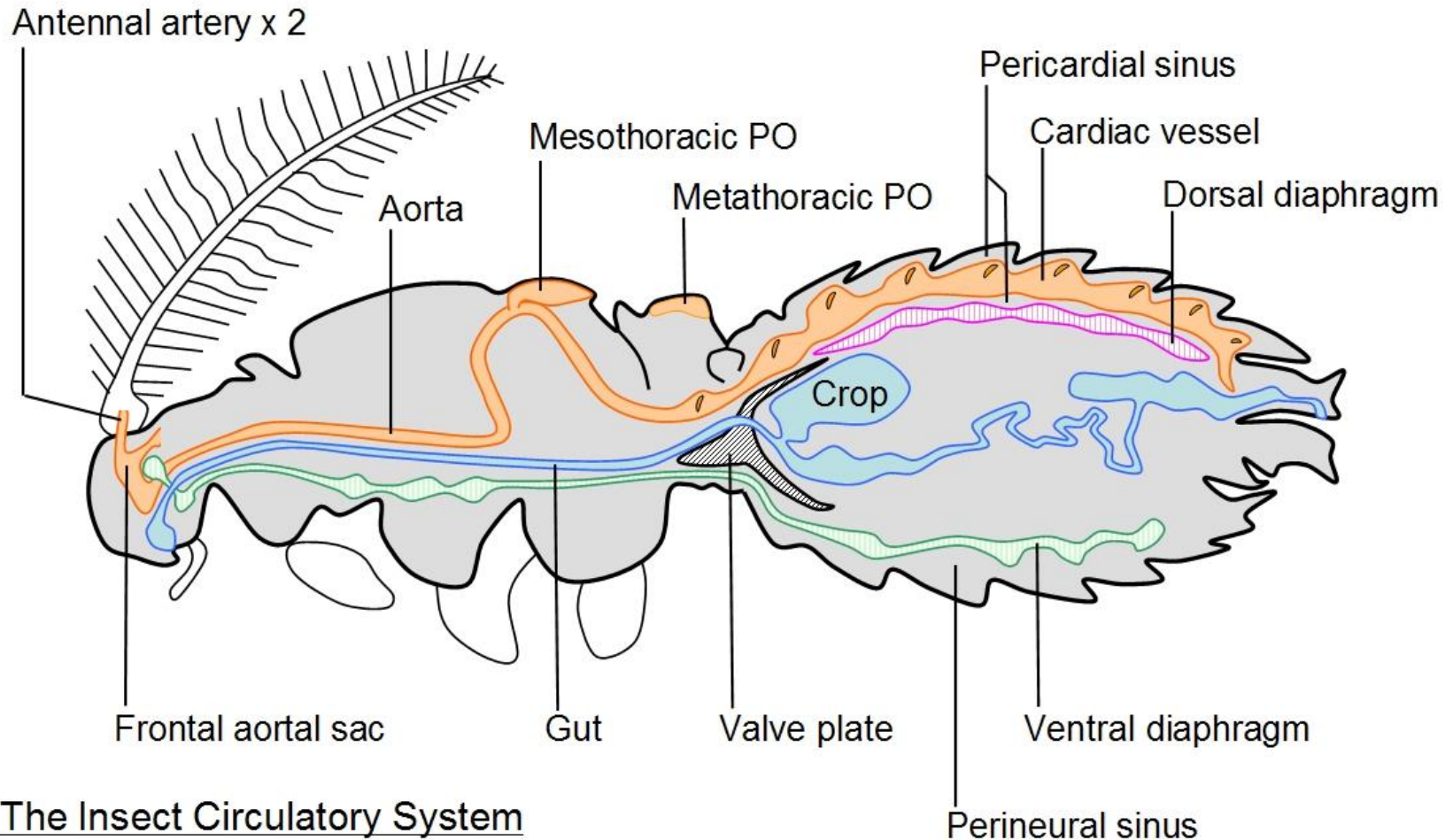


Insect Circulatory system



- If blood travels through vessels like **arteries, capillaries and veins**- closed type
- In insects the blood flows through **body cavity i.e. haemocoel** - open type
- Haemocoel of the insects is divided into 3 sinuses (or) regions separated by two fibro muscular septa (or) diaphragms composed of connective tissues

Dorsal or Pericardial Sinus:

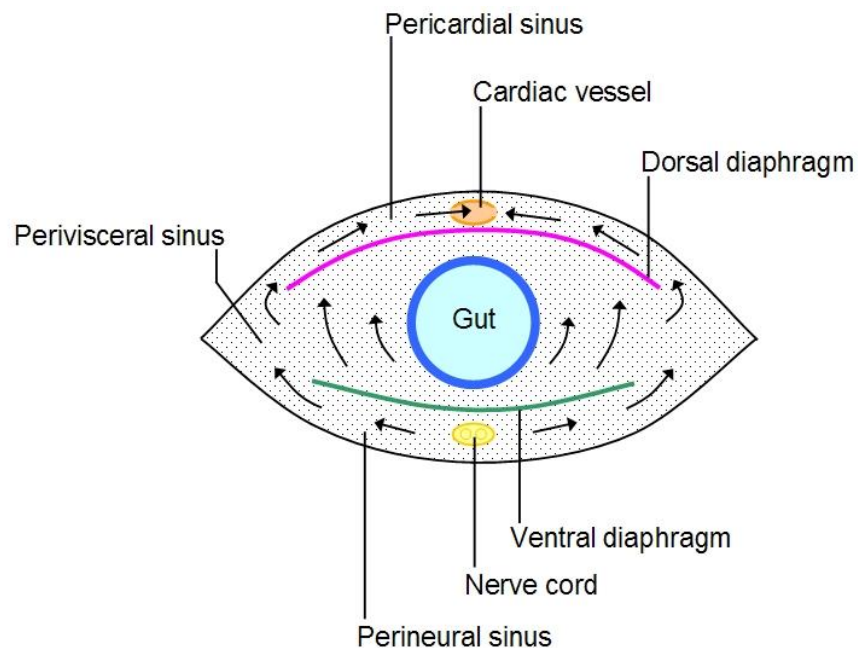
- area between tergum and dorsal diaphragm
- contains heart

Ventral or Perineural Sinus:

- area between sternum and ventral diaphragm
- contains nerve cord

Visceral Sinus:

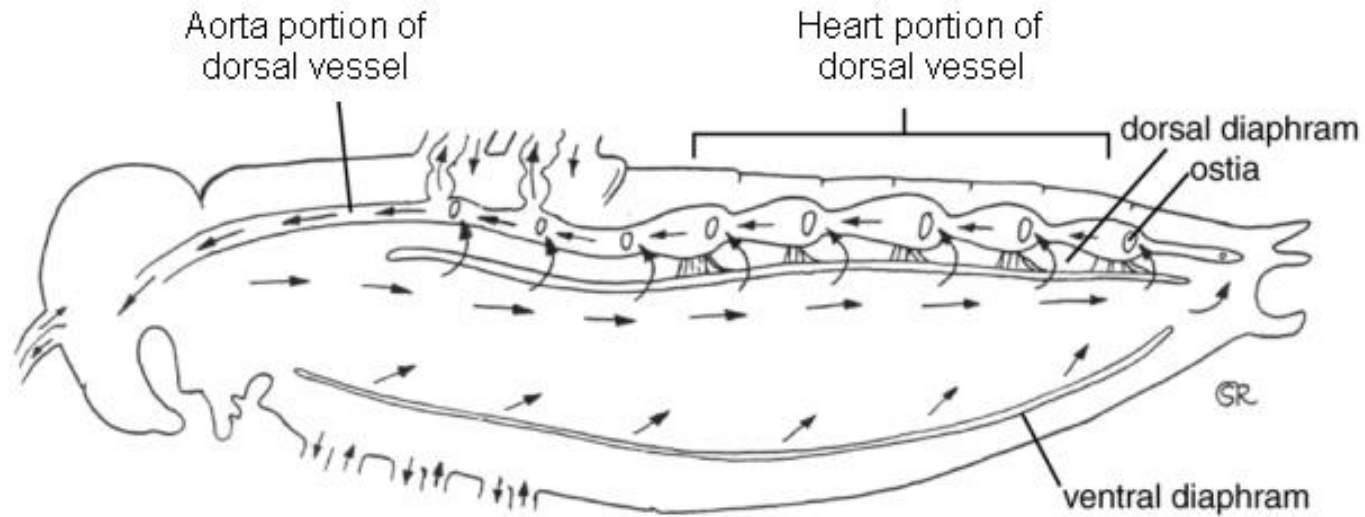
- Between dorsal and ventral diaphragms
- harbor the gut and gonads



Dorsal blood vessel

- principal blood conducting organ, closed at the posterior and opens anteriorly in to head
- It is divided into an **anterior aorta** and **posterior heart** extending throughout body length

1. **Aorta:** anterior part of the dorsal blood vessel
principal artery present in the **thoracic region** opens in to the head near the brain
Attachment with heart is marked by a **aortic valve**
sometimes it gets divided into 2 (or) more **cephalic arteries** in the head

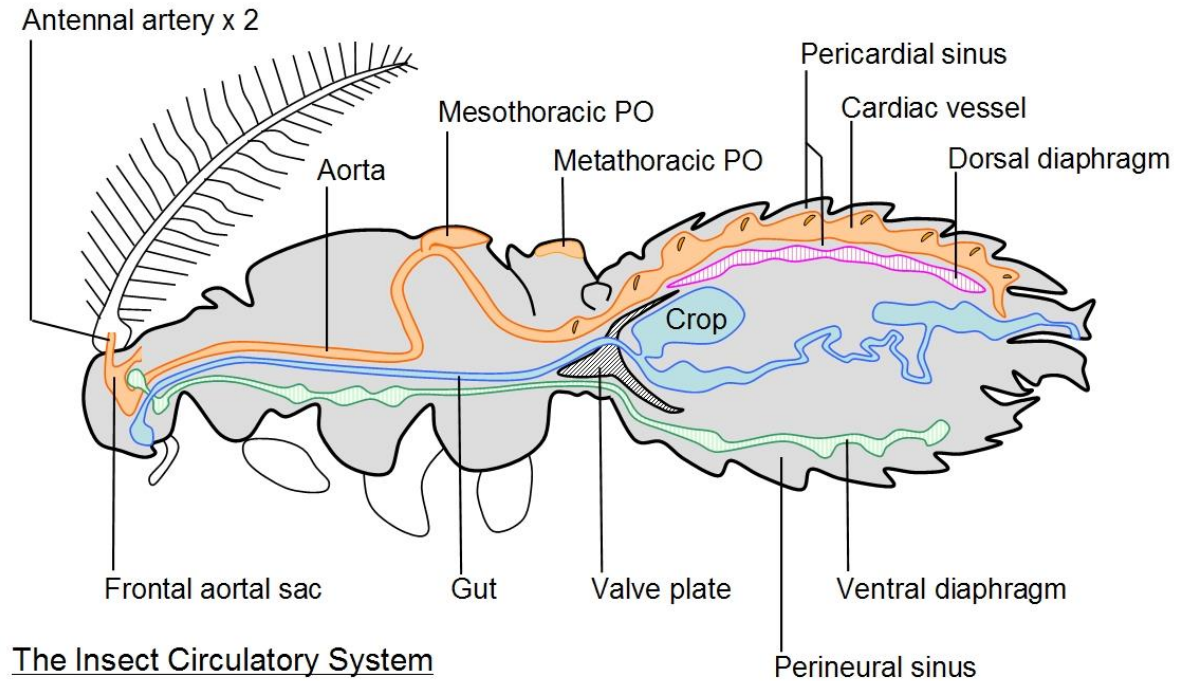


2. Heart:

- **posterior part of dorsal blood vessel** up to end of the abdomen
- remains in position with the help of **alary muscles**,
Attached to the **tergum of the abdomen** on one side
To the **dorsal diaphragm** on other side
- These alary muscles distributed **fan like** over the heart
- Number of chambers marked by constrictions and the openings are incurrent '**ostia**'
- Allow the entry of blood from **pericardial sinus in to the heart**
- The **number of ostia = number of heart chambers** which will be usually **9**
- functions as the **pumping organ** in to the aorta

Accessory pulsatile organs:

Insects consists of **sac like structures** called accessory pulsatile organs present at the **base of the appendages** such as **wings, legs and antenna pulsate independently** and supply **adequate blood to the appendages**



Process of blood circulation:

Heart mainly function as a pulsatile organ

expansion and contraction leads to blood circulation

In an **anti clock manner** starting from **posterior to anterior end** in **forward direction**

Circulation of blood takes place in **two phases** due to

the **action of the alary muscles** as well as the **muscles of the walls of the heart**

The two phases are

1. Diastole: Expansion of heart

alary muscles spread fan like over the heart and connected to the tergum **get contracted**

increase of volume of heart and **decrease the area of pericardial sinus**

creates pressure on blood in pericardial sinus **forcing it into the heart through ostia**

ostia **allow only the entry of blood from the sinus in to the heart** and **prevents its backflow**

2. Systole : Contraction of heart

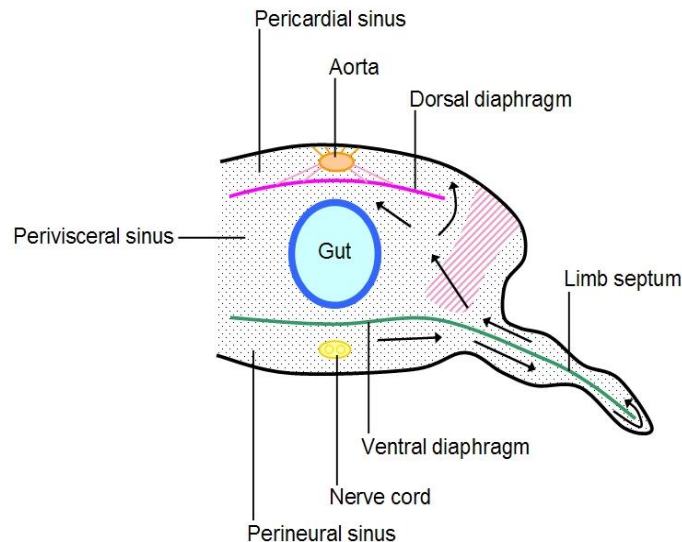
by the **expansion of the alary muscles** as well as contraction of the muscles of the heart wall creates pressure on the blood within the heart leading to its **forward movement into aorta**

From the aorta blood enters in to the head

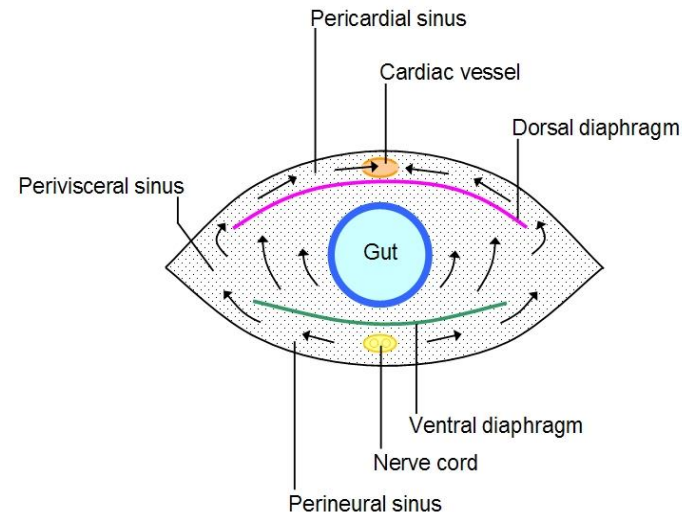
flows back **bathing visceral organs in the visceral sinus** and **neural cord in perineural sinus**

In between diastole and systole there will be a short period of rest **diastasis**

Circulation across the insect thorax



Circulation across the insect abdomen



Properties of blood:

1. Blood is colourless (or) green /yellowish with different types of **haemocytes and plasma**

Green colour is due to **chlorophyll** dissolved in the plasma

red colour is due to **haemoglobin** in Chironomus midge

2. Blood covers up **5 – 40% of the total body weight** that vary with the sex and stage (or) age

3. blood contain proteins, lipids, sugars, organic acids, phosphates, pigments, uric acid etc

4. The insect blood of **phytophagous** insect is rich in '**K**' and **carnivores** is rich in '**Na**'

5. Specific gravity of the blood varies from **1.01 to 1.06**

6. pH of the blood generally varies from **6-7**

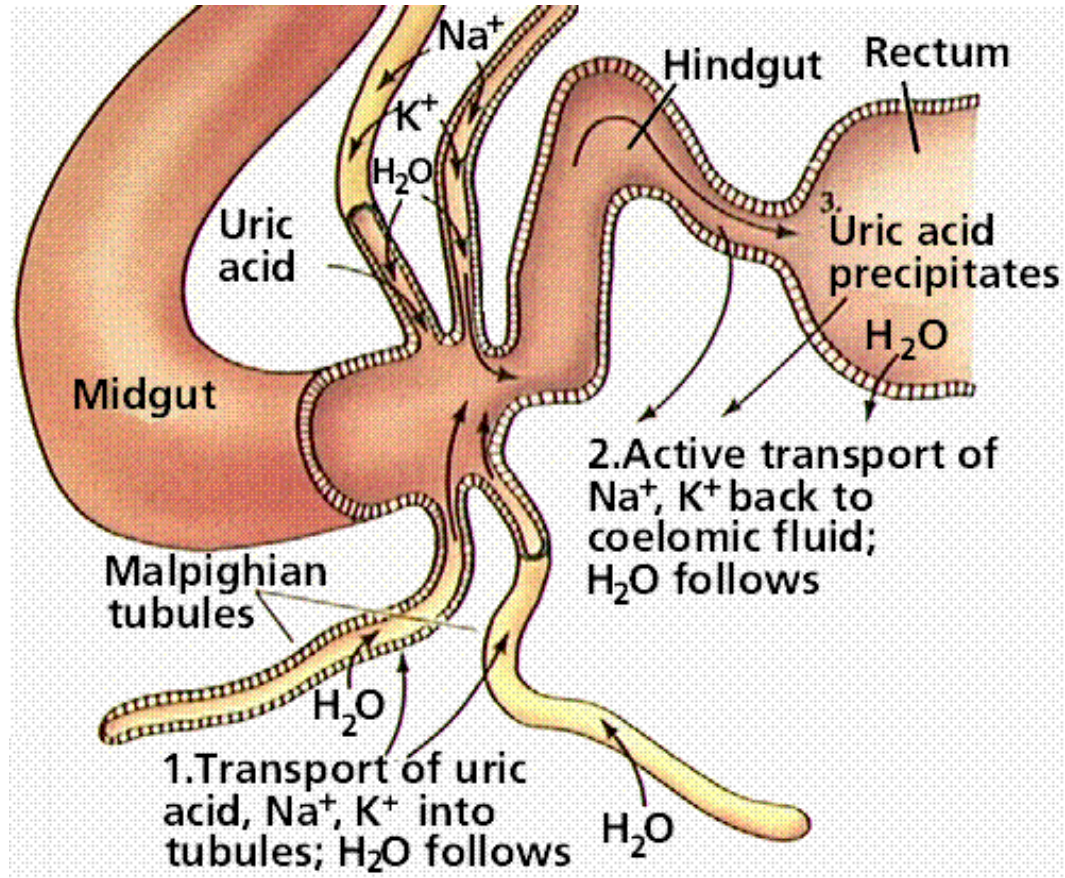
7. The blood sugar of insects is **trehalose**

8. Blood lacks vitamin '**K**'

Functions of blood :

1. **Transport** of minerals or food materials
2. **Stores water** for the tissues
3. Helps during the process of **moulting** for **splitting up of the old cuticle**
4. **Encapsulation** : to protect **from the large metazoan parasites**, the haemocytes of blood, become aggregated around the foreign body forming a capsule of 2-3 layers
5. **Phagocytosis** : haemocytes completely **engulf the foreign body** and **gets autolysed**
6. Immunity: blood gives immunity by producing **antibodies** to restrict further infections
7. Tissue formation : blood provides lipoproteins for formation of **connective tissue**
8. Wound healing (or) coagulation : haemocytes extend **pseudopodia** which forms a cellular network over the wounded site (or) **plasmatocytes** that coagulate forming a plug
9. **Detoxification** : haemocytes are capable of detoxifying the toxic chemicals
10. **Reflex bleeding: emission of blood** occurs through the pores (or) slits of the cuticle helps the insects for getting protection from their natural enemies

Excretory system



- involved in the elimination of **excess** or **unwanted** materials either **toxic** or **not useful**
- These toxic materials are **nitrogenous products of metabolism** (mainly ammonia), **pigments, salts** etc.
- For the efficient maintenance of **water and the ionic balance** in the haemolymph
- These waste material may be in solid, semisolid, liquid or gaseous form

gaseous form is **CO₂**

liquid form is **honey dew**

solid form is **urea/uric acid**

semi solid form is **allantoin**

- The organs that are involved in the process of excretion are

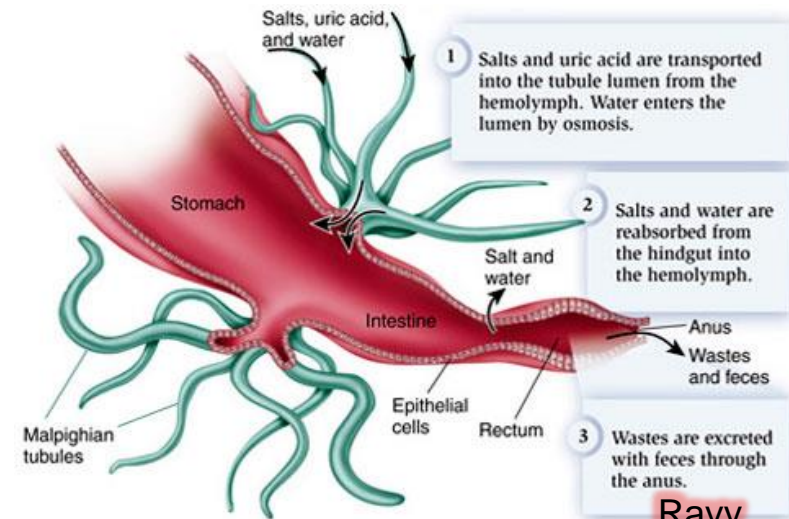
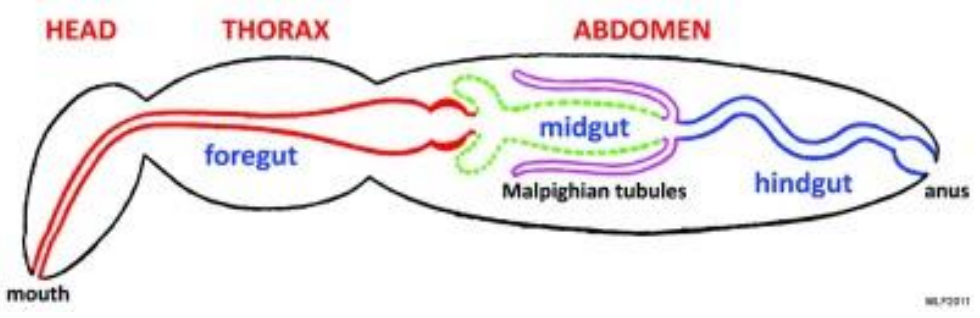
1. **Malpighian tubules** 2. **Integument or body wall** 3. **Tracheal system**

4. **Alimentary canal** 5. **Nephrocytes** 6. **Urate cells**

7. **Oenocytes** 8. **Labial glands** and 9. **Chloride cells**

Malpighian tubules

- Discovered by an Italian scientist, **Marcello Malpighi** in 1669, named by **Heckel** in 1820.
- Long, tubular, open proximally in **between midgut and hindgut** and closed distally
- Number varies from **2-250** (in coccids – 2; in locust – 250)
- The shape of tubules may be sac like, papillae like or branched
- Malpighian tubules are **absent in aphids and Collembola**
- **‘cryptonephridial condition’**- distal ends of the Malpighian tubules get reattached to the alimentary canal by opening in to the rectum of hindgut Eg: **caterpillars and coleopterans**
- concerned with **re absorption of water from rectum**
- also produce **enzymes, acid and alkaline phosphatases, dehydrogenase (succinic), lipases, vitamins like thiamine, ascorbic acid etc**



Functions of Malpighian tubules

1. excretion or removal of waste products
2. regulate the internal body environment by maintaining **ionic and water balance**
3. In **glow worms**, the distal ends of tubules produces **light energy**
4. Also helps in the **storage of Ca** necessary for **hardening of puparium**
4. In **aphid lion (chrysoperla)**, the secretions of the tubules produce **stalked eggs**
5. In **spittle bugs**, secretes **spittle around the immature stages**



2. Integument: Through **moulting**, remove the waste nitrogenous products

In some insects, respiration occurs through body wall, CO₂ is removed through integument

3. Tracheal system: trachea functions in elimination of CO₂ through spiracles

4. Alimentary canal : removes the unwanted material, dead cells formed during enzyme secretion (holocrine) and **intima layer during moulting**

Rectum plays an important role in excretion by **reabsorbing the water** from faeces

5. Nephrocytes: special cells scattered in the body cavity

Take up foreign chemicals of relatively high molecular weight which Malpighian tubules may be incapable of dealing with

1. Dorsal or pericardial nephrocytes- on **either side of the heart** in pericardial sinus, present in **immature and adult stages of most of the insects**

2. Ventral nephrocytes- arranged as a chain **below the foregut** and attached by its two ends to the salivary glands. **e.g.: dipterous larvae**

Nephrocytes helps in the **removal of ammonia, chlorides, dyes, colloidal particles** etc.

- 6. Oenocytes:** Present near the **abdominal spiracles** arise from the ectoderm or hypodermis
- **secrete cuticulin layer of the epicuticle and in cockroach**, surface grease which covers the integument
- 7. Urate cells:** fat body cells which store **urea or uric acid in the form of granules**
- present when Malpighian tubules are absent or may become nonfunctional
 - In insects such as cockroach, urea or uric acid is stored throughout its life in the fat body cells without any harmful effect- **'storage excretion'**
 - useful for supply of nitrogen, when insect feeds on nitrogen deficient food
- 8. Labial glands:** These are seen in **Collembola, Diplura, Thysanura** helps to **remove ammonia**
- They consists of a **sac like ampulla** that leads to a **long coiled labyrinth** that open at the **base of labium** in the head
- 9. Chloride cells:** Distributed on the body of **aquatic insects like larva of mayfly or stone fly**
- They absorb ions from salt water (body) and then excrete in to surrounding medium to compensate the changes in the ionic concentration of haemolymph