STRUCTURE AND FUNCTIONS OF CIRCULATORY SYSTEM

Circulation in insects is maintained by a system of muscular pumps moving haemolymph through compartments separated by fibromuscular septa or membranes. The main pump is the pulsatile **dorsal vessel (`heart')**. The anterior part may be called **aorta** and the posterior part the heart. The dorsal vessel is a simple tube, generally composed of one layer of myocardial cells and with segmentally arranged openings called **ostia**. The ostia permit the one-way flow of haemolymph into the dorsal vessel due to valves that prevent backflow. There may be upto three pairs of thoracic ostia and nine pairs of abdominal ostia. The dorsal vessel lies in the **pericardial sinus**, a compartment above a **dorsal diaphragm** (a fibromuscular septum - a separating membrane) formed of connective tissue and segmental pairs of **alary muscles**. The alary muscles support the dorsal vessel but their contractions do not affect heartbeat.

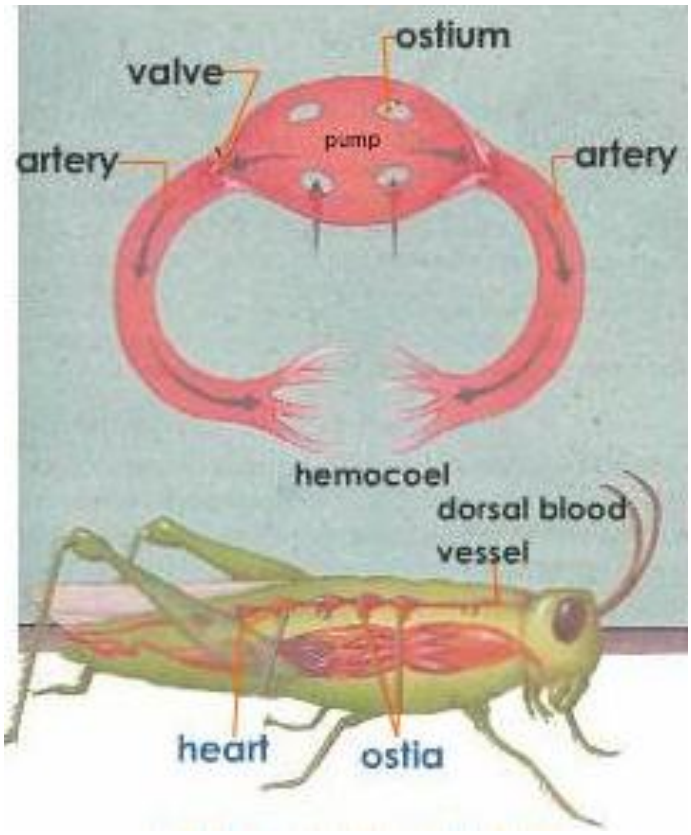
Haemolymph enters the periocardial sinus via segmental openings in the diaphragm and then moves into the dorsal vessel via the ostia during a muscular relaxation phase. Waves of contraction start at the posterior end of the body, pump the haemolymph forward in the dorsal vessel and out via the aorta into the head. Next the appendages of the head and thorax are supplied with haemolymph as it circulates posteroventrally and finally returns to the pericardial sinus and dorsal vessel. The direction of haemolymph circulation in the body is shown in the figure.

Another important component of the insect circulatory system is the ventral diaphragm, a fibromuscular septum that lies in the floor of the body cavity associated with the ventral nerve cord. Circulation of the haemolymph is aided by active peristaltic contractions of the ventral diaphragm which direct the haemolymph backwards and laterally in the perineural sinus below the diaphragm. These movements are important in insects that use the circulation in thermoregulation. Ventral diaphragm also facilitate rapid exchange of chemicals between the ventral nerve cord and the haemolymph.

Haemolymph is generally circulated to appendages unidirectionally by various tubes, septa, valves and pumps. The muscular pumps are termed accessory pulsatile organs and occur

at the base of the antennae and legs. Antennal pulsatile organs releases neurohormones that are carried to the antennal lumen to influence the sensory neurones. Circulation occurs in the wings of young adult. In wing circulation is sustained by influxes of air into the wing veins, rather than any pulsatile organs. Pulses of air in the fine tracheal tubes of the veins push the haemolymph through the enclosed space of the veins.

The insect circulatory system shows high degree of co-ordination between dorsal vessel, fibro-muscular diaphragms and accessory pumps.



HAEMOLYMPH AND ITS FUNCTIONS

Haemolymph is a watery fluid containing ions, molecules and cells. It is often clear and colourless but may be variously pigmented or rarely red due to haemoglobin in the immature stages of few aquatic and endoparasitic flies (e.g., Chironomid larva). Haemolymph performs the function of both blood and lymph. It is not involved in gas transporting function

(respiration).Haemolymph contains a fluid portion called **plasma** and cellular fractions called **haemocytes**.

I. PLASMA

Plasma is an aqueous solution of inorganic ions, lipids, sugars (mainly trehalose), amino acids, proteins, organic acids and other compounds. **pH** is usually acidic (6.7). **Density** is 1.01 to 1.06. **Water** content is 84-92 per cent. **Inorganic ions** present are `Na' in predators and parasites, `Mg' and `K'in phytophagous insects. **Carbohydrate** is in the form of trehalose sugar. Major **proteins** are lipoproteins, glycoproteins and enzymes. **Lipids** in form of fat particles or lipoproteins. Higher concentration of amino acids leads to a condition called **aminoacidemia** which effects the osmosis process. In high altitude insects **glycerol** is present which acts as a anti freezing compound. **Nitrogenous waste**is present in the form of uric acid.

II. HAEMOCYTES

The blood cells or haemocytes are of several types and all are nucleate. Different types of haemocytes are as follows:

1. Prohaemocyte - Smallest of all cells with largest nucleus.
2. Plasmatocyte - (Phagocyte) aids in phagocytocis
3. Granular heamocyte - Contains large number of cytoplasmic inclusions
4. Spherule cell - Cytoplasmic inclusions obscure the nucleus
5. Cystocyte - (Coagulocyte) Role in blood coagulation and plasma precipitation.
6. Oenocytoids - Large cells with ecentric nucleus
7. Adipo haemocytes - Round or avoid with distinct fat droplets
8. Podocyte - Large flattened cells with number of protoplasmic projections.
9. Vermiform cells - Rare type, long thread like.

Functions of haemolymph

1. Lubricant

Haemolymph keeps the internal cells moist and the movement of internal organs is also made easy.

2. Hydraulic medium

Hydrostatis pressure developed due to blood pumping is useful in the following processes.

i. Ecdysis (moulting)

ii. Wing expansion in adults

iii. Ecolosion in diptera (adult emergence from the puparium using ptilinum)

iv. Eversion of penis in male insects

v. Eversion of osmeteria in papilionid larvae

vi. Eversion of mask in naiad of dragonfly

vii. Maintenance of body shape in soft bodied catepillars.

3. Transport and storage

Digested nutrients, hormones and gases (chironomid larva) were transported with the help of haemolymph. It also removes the waste materials to the excretory organs. Water and raw materials required for histogenesis is stored in haemolymph.

4. Protection

Protection helps in phagocytocis, encapsulation, detoxification, coagulation, and wound healing. Non celluar component like **lysozymes** also kill the invading bacteria.

5. Heat transfer

Haemolymph through its movement in the circulatory system regulate the body heat (Thermoregulation)

6. Maintenance of osmotic pressure

Ions, amino acids and organic acids present in the haemolymph helps in maintaining osmotic pressure required for normal physiological functions.

7. Reflex bleeding

Exudation of heamolymph through slit, pore etc repels natural enemies. e.g. Aphids.

8. Haemolymph

Haemolymph serves as a medium for on going metabolic reactions (trahalose is converted into glucose).