

Circulatory system:

There are two types of circulatory systems in the animal kingdom. In many animals, the blood travels through vessels like arteries, capillaries and veins. This is known as closed type of circulatory system. In insects the blood flows through the body cavity (ie, haemocoel) irrigating various tissues and organs. It is known as open type of circulatory system, it consist of:

1-**The diaphragms and sinus.** Haemocoel of the insects is divided into **3 sinuses** (or) regions due to the presence of two fibro muscular septa (or) **diaphragms** composed of connective tissues (Fig.1)

A- Dorsal or Pericardial Sinus: The area lying in between the tergum and dorsaldiaphragm. It contains heart.

B- Ventral or Perineural Sinus: The area lying in between the sternum and ventraldiaphragm .It contains nerve cord.

C- Visceral Sinus: The area in between dorsal and ventral diaphragms. It contains the visceral organs like alimentary canal and gonads.

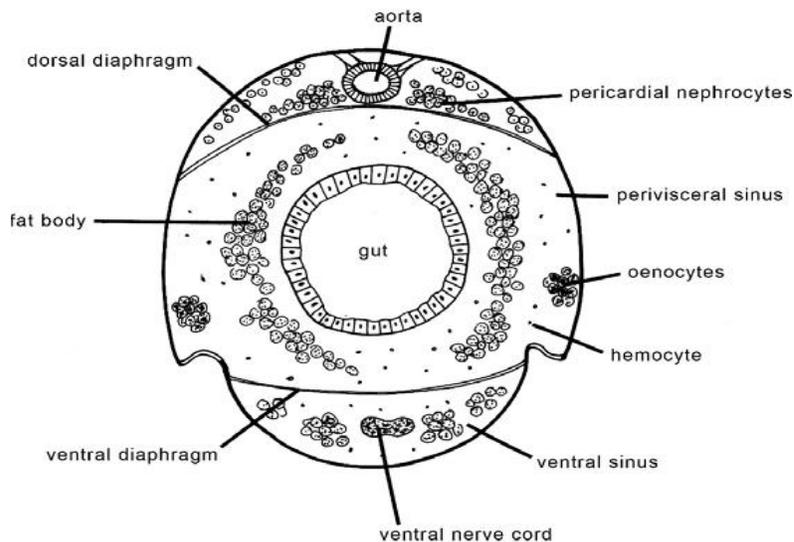


Fig. 1 Main sinuses of haemocoel.

2- Dorsal blood vessel. It is the principal blood conducting organ in insects which remain closed at the posterior end and opens anteriorly in to the head. It is divided into an anterior **aorta** and posterior **heart** extending throughout the length of the body (Fig. 2). Heart remains in position with the help of alary muscles that are attached to the tergum of the abdomen on one side and to the dorsal diaphragm on other side. These alary muscles appear to be distributed fan like over the heart.

Heart consists of number of chambers marked by constrictions and the presence of the opening called the incurrent 'ostia' which allow the entry of blood from pericardial sinus in to the heart. The number of ostia depends upon the number of heart chambers which will be usually 9. The walls of heart also consists of muscles. Heart mainly functions as the pumping organ in to the aorta.

3-Accessory pulsatile organs: Insects consists of sac like structures called accessory pulsatile organs, which are present at the base of the appendages such as wings, legs and antenna. They pulsate independently and supply adequate blood to the appendages.

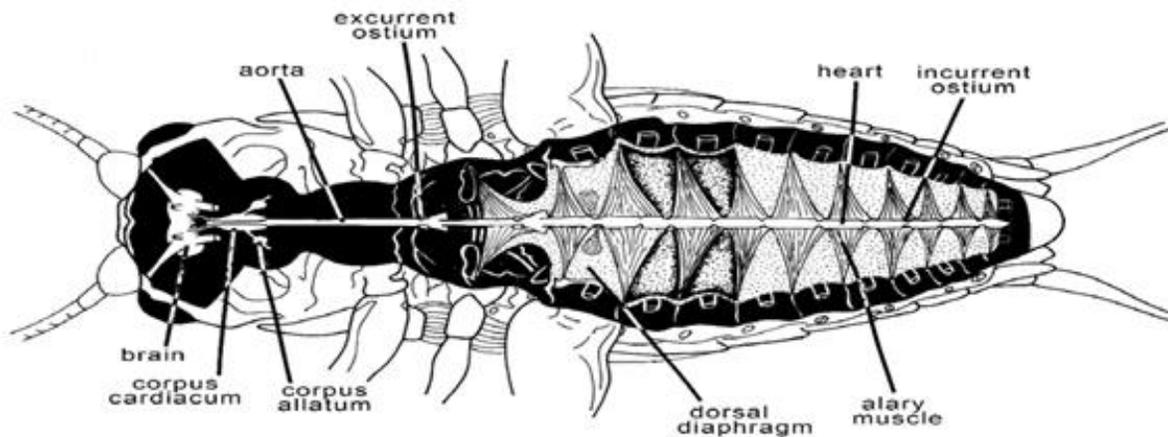


Fig.2 (A) Ventral dissection of the field cricket, to show dorsal vessel and associated structures.

Process of blood circulation: Heart mainly function as a pulsatile organ whose expansion and contraction leads to blood circulation . It takes place generally in **an anti-clock** manner starting from posterior end to the anterior end in a 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:** During which expansion of heart takes place (Fig.3).
2. **Systole:** During which Contraction of heart takes place (Fig. 3)

Diastole: Expansion of heart (diastole) occurs, when the alary muscles those are spread fan like over the heart and connected to the tergum get contracted. It results in increase of volume of heart and decrease in the area of pericardial sinus. This creates a pressure on the blood in pericardial sinus forcing the blood to enter into the heart through the incurrent ostia. These incurrent ostia allow only the entry of blood from the sinus in to the heart and prevents its backflow from the heart to the sinus.

Systole: Contraction of heart (systole), is brought about by the expansion of the alary muscles as well as contraction of the muscles of the heart wall. This creates pressure

on the blood within the heart leading to its forward movement in to the aorta. From the aorta blood enters in to the head and flows back bathing the visceral (Fig.4).

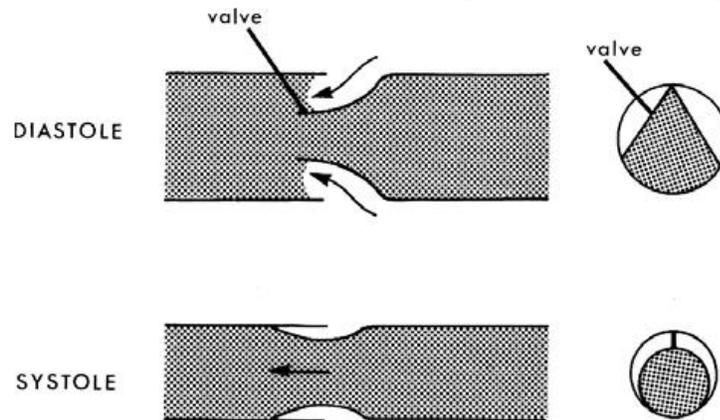


Fig.3. Incurrent ostia of *Bombyx* shown during diastole and systole. Arrows indicate direction of hemolymph flow.

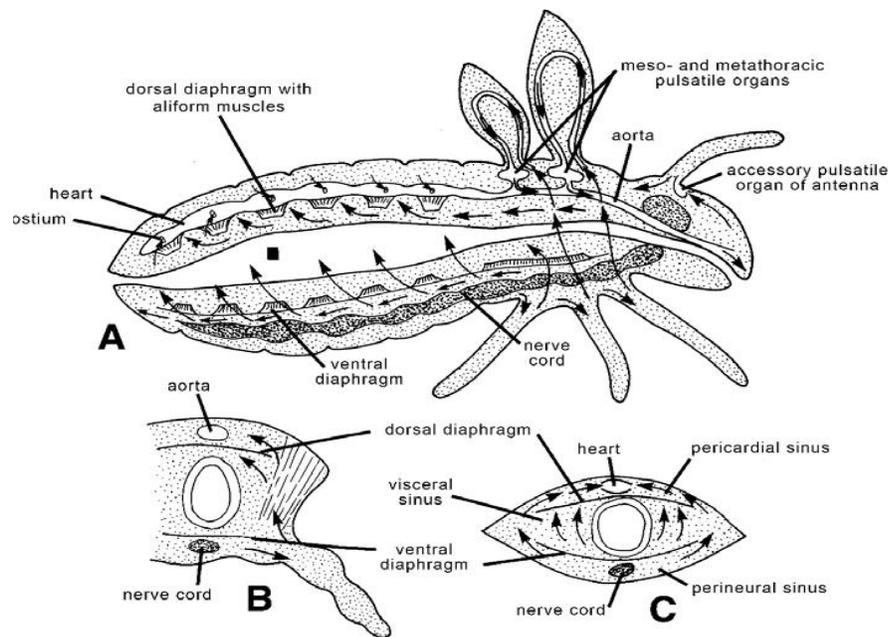


Fig.4 Diagrams of well-developed circulatory system. (A) Longitudinal section through body; (B) transverse section through thorax; and (C) transverse section through abdomen. Arrows indicate direction of flow.

Blood cells:

Though several types of hemocytes have been recognized, which differ in size, stain ability, function, and cytology (including fine structure) (Figure 5), their classification and relationships have proven difficult.

The three types common to most insects are prohemocytes, plasmatocytes, and granularhemocytes (granulocytes). **Prohemocytes (stem cells)** are small (10 μm or less in diameter), spherical, whose nucleus fills almost the entire cytoplasm. They are frequently seen undergoing mitosis and are assumed to be the primary source of new hemocytes and the type from which other forms differentiate. **Plasmatocytes (phagocytes)** are cells of variable shape and size, with a centrally placed, spherical nucleus surrounded by well vacuolated cytoplasm. The cells are capable of amoeboid movement and are phagocytic. **Granulocytes** are usually round or disc-shaped, with a relatively small nucleus surrounded by cytoplasm filled with prominent granules. Other types of hemocytes include **adipohemocytes**, **oenocytoids**, **spherule cells**, and **cystocytes**. As their name indicates, the **adipohemocytes** are cell whose cytoplasm normally contains droplets of lipid. In addition to lipid droplets, the cytoplasm may have non-lipidvacuoles and granules that contain carbohydrate material. **Oenocytoids** are spherical or ovoid cells with one, occasionally two, relatively small, eccentric nuclei. **Spherule cells** are readily identifiable cells whose central nucleus is often obscured by the mass of dense spherical inclusions occupying most of the cytoplasm. **Cystocytes** (coagulocytes) are spherical cells in whose small central nucleus the chromatin is so arranged as to give the nucleus a “cartwheel-like” appearance.

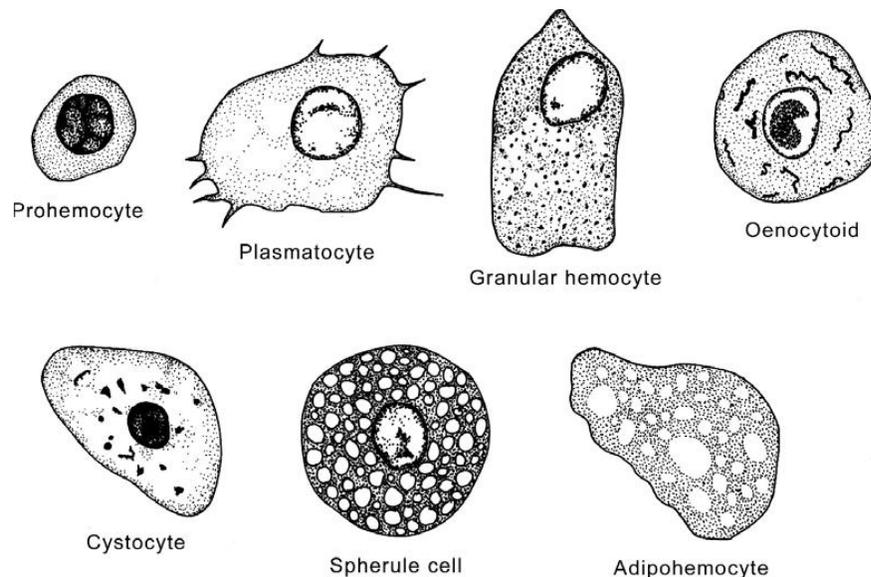


Fig.5. Different types of hemocytes.

Functions of blood:

- **Transport of minerals** or food materials: blood transports minerals, digested products, hormones to different parts of the body.

- Helps during the process of **moulting** for splitting up of the old cuticle.
- **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. This leads to the death of the foreign bodies due to lack of O₂ supply.
- **Phagocytosis** : to get protection from microorganisms like bacteria, viruses and fungi, the haemocytes completely engulf the foreign body and gets autolysed (this is the principal function of haemocytes)
- **Immunity**: blood gives immunity by producing antibodies to restrict further infections.
- Thermoregulation (heat distribution, protection against freezing).
- **Wound healing** (or) **coagulation** : haemocytes extend **pseudopodia** which forms a cellular network over the wounded site (or) **plasmtocytes** coagulate forming a plug over the wound (or) **haemocytes** are arranged in to multi layered sheaths over the wounded site, thus helping in wound healing.