Respiration in Arthropoda

(Gill and Trachea in Arthropods

- Respiration involves the exchange of gases between the body the environment. There are two types of respiration in arthropoda They are

1. Aquatic respiration

2. Aerial respiration

1. Aquatic Respiration

Aquatic respiration involves the utilization of oxygen dissolved in water. It occurs in aquatic arthropods. Aquatic respiration is car. ried out by the following organs:

1. Gills.
2. Epipodite.
3. Branchiostegite
4. Rectal gills
5. Tracheal gills
6. Blood gills
7. Book gills and
8. Bodysurface

1. Gills

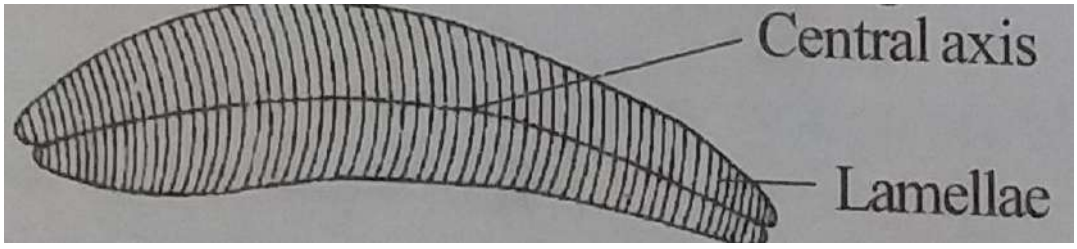
The gills are delicate feather-like outgrowths of the thoracic appendages.

Location

The gills are located inside the gill chamber. The gill chamber is located on the sides of the thorax. It is covered by branchiostegite.

Structure

The gills are crescent-shaped. Each gill has a central axis and two or more rows of lateral lamellae. The lamellae have different shapes in the different crustaceans. Based on the shape of lamellae, the gills are classified into three types. They are the following:



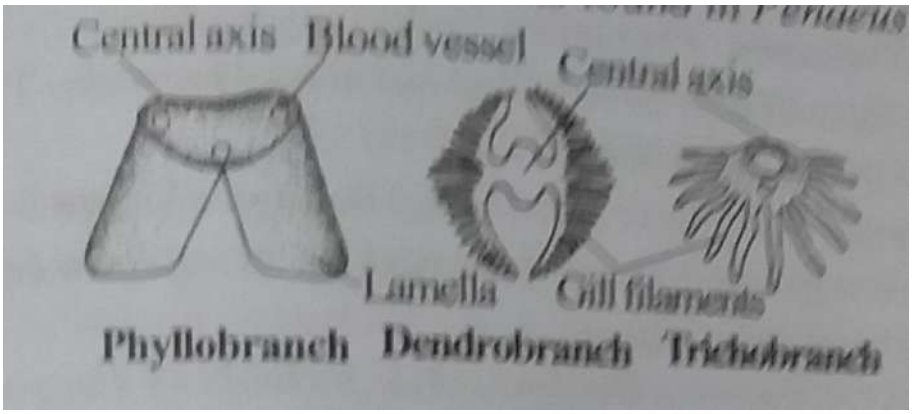
A gill of a crestacian

1. Phyllobranch

In this gill, the lamellae are broad leaf like and are arranged in two rows ,it is found in palaemon.

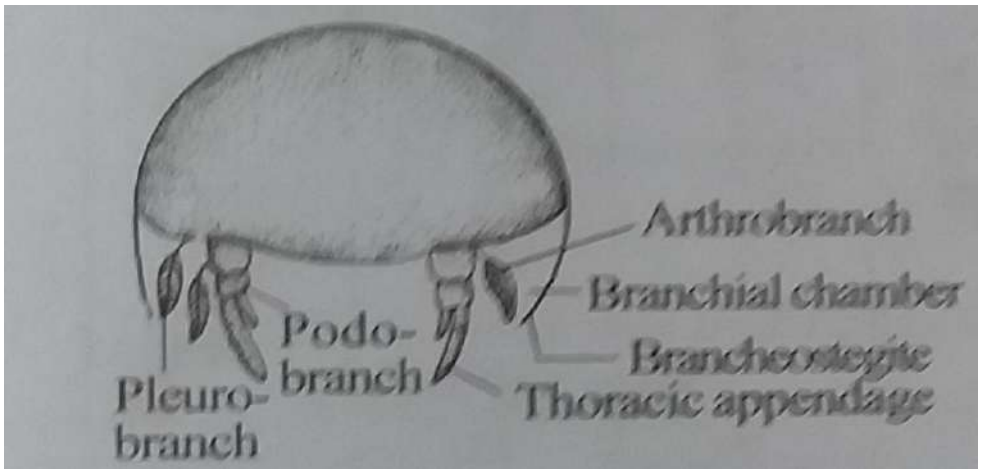
2. Dendrobranch

In this gill the leaf like lamellae are divided into many fine slender processes called gill filaments. It is found in Penaues.



Cross section of the gills of crustacean,

3. Trichobranch



Attachment of gills.

In this gill, the lamellae are in the form of large gill filaments. They are arranged on three sides. It is found in Astacus.

The gills of Penaeus is classified into three types based on their place of attachment. They are as follows:

1. **Podobranchs (Foot gills)**

These are the gills attached to the coxa of the appendages. Penseus Sone pair of podobranchs attached to Il maxillipedes.

2. Pleurobranchs (side gills)

These are the gills attached to the lateral wall of the thorax. There * pairs of pleurobranchs attached near the last six pairs of thoracic appendages.

3. Arthrobranchs (Joint gills)

These are the gills attached to the junction of the appendages and the body. There are eleven pairs of arthrobranchs.

Number of gills: The number varies in the different Penaeus has 24 gills. Palaemon has 16 gills. Homarus has 20 Pea crab contains 6 gills.

Branchial Formula: The number and arrangement of gills in are given in the form of a formula called branchial formula.

Blood supply: The gills receive blood through afferent branchii channels. The oxygenated blood is carried by the efferent branchini channels to the pericardial sinus.

Mechanism of Respiration: Gills lie in the branchial chambers. The gill chamber opens ventrally, anteriorly and posteriorly. Scaphognathite of II maxilla lies at the anterior entrance of the gill chamber. By its movement, it sends out water from the gill chamber through the anterior end. To make up the loss of water, water flows in through the posterior entrance of the gill chamber. So water flows in and out of the gill chamber freely. The gills are always immersed inside the water. Exchange of gases takes place between the water and the blood. The setose hairs present at the entrance of the branchial cham ber prevent the entry of foreign particles.

---

2. Epipodites

These are membranous outgrowths of the interanous outgrowths of the integument arising from the thoracic appendages. Penaeus has 6 pairs of epipodites. ated on the first 6 pairs of thoracic appendages. The first pair of epipodites is conical in shape. The remaining five pairs are Yshaped palaemon has 3 pairs of epipodites. They are highly vascular and they exchange gases between the blood and the water.

3. Branchiostegite

Branchiostegite is the gill-cover. It is the lateral extension of pace. It encloses a cavity between itself and the body. This is called gill chamber. The inner lining of the branchiostegite is richly supplied with blood. It is constantly bathed by the water-current. Hence exchange of gases occurs between the water and the blood.

4. Rectal gills:

The rectal gills are located in the inner surface of rectum. They are e form of soft lamellae. Water is drawn in and expelled out via for respiration, Rectal gills occur in the naiads of dragonfly.

---

5. Tracheal gills

These are the outgrowths of the body wall. They are finger-shaped or leaf-shaped. They contain a system of tracheae. The naiads (naiad = aquatic larva of insects) of mayfly contain 7 pairs of leaf-like tracheal gills on the sides of abdomen. The naiad of damselfly has three leaflike tracheal gills attached to the posterior end of the abdomen. In the naiads of stonefly, the tracheal gills are finger-shaped and are located around the bases of the legs.

6. Blood-gills

These are the gills of insect-larvae supplied with blood and not with tracheae. Blood-gills occur in Trichopeterus and Tipulid larvae.

7. Book-gills

Book-gills are book-like gills. These are the respiratory organs of Limulus. Limulus has 5 pairs of book-gills. They are found attached to the last five pairs of appendages. Each book gill is formed of 150 to 200 leaf-like lamellae. The lamellae are richly supplied with blood.

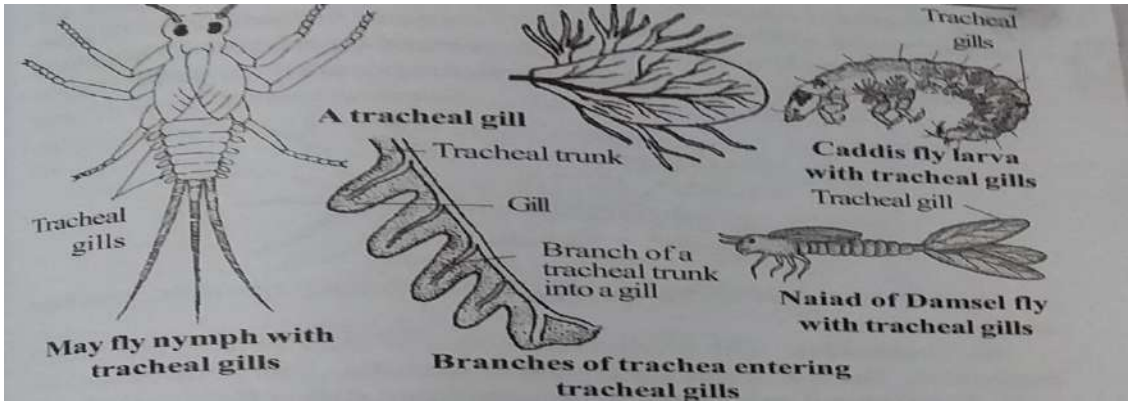
8. **Body-surface**

In many arthropods respiration occurs through the general body surface by diffusion. It commonly occurs in crustaceans. It also occurs in insects with small and soft body.

2. Aerial Respiration

Aerial respiration involves the utilization of oxygen present in the air. Aerial respiration occurs in terrestrial arthropods. The respiratory organs for aerial respiration are the following:

1. Tracheal system .2. Book-lungs 3. Simple-lungs 4. Spiracular gills 5. Plastron 6. Respiratory tubes



Tracheal Gills

1. **Tracheal system**

Tracheal system is found in insects, centepedes, millipedes and many rachnids. It is a system of tubes ramifying the body. The tracheal system consists of spiracles, tracheae, tracheoles and air sacs.

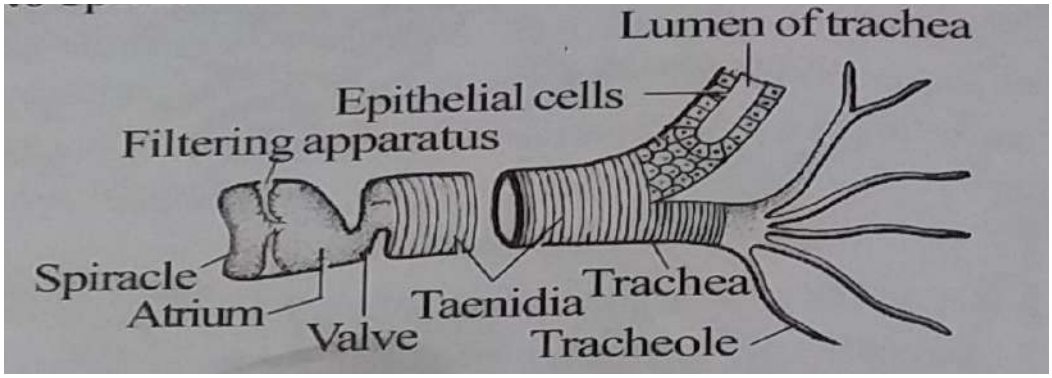
i. Spiracles: These are the openings of the tracheal system to the exterior. They are also called stigmata. They are located on the sides of the thorax. Insects have 9 or 10 pairs of spiracles. Of these, two pairs are located on the sides of the thorax and the remaining pairs are located on the sides of the abdomen.

In most insects the spiracle opens into a cavity called atrium from which the trachea arises. The atrium is provided with an air filtering apparatus. The filtering apparatus keeps away the dust and parasites.

A valve is also present in the atrium. The valve can close the spiracle when required

---

ii. Tracheae: Tracheae are highly branched tubes. The chea is formed of three layers, namely an inner intima, a mida of epithelium and an outer layer of basement membrane. The is produced into spiral thread-like thickenings called taenidia.



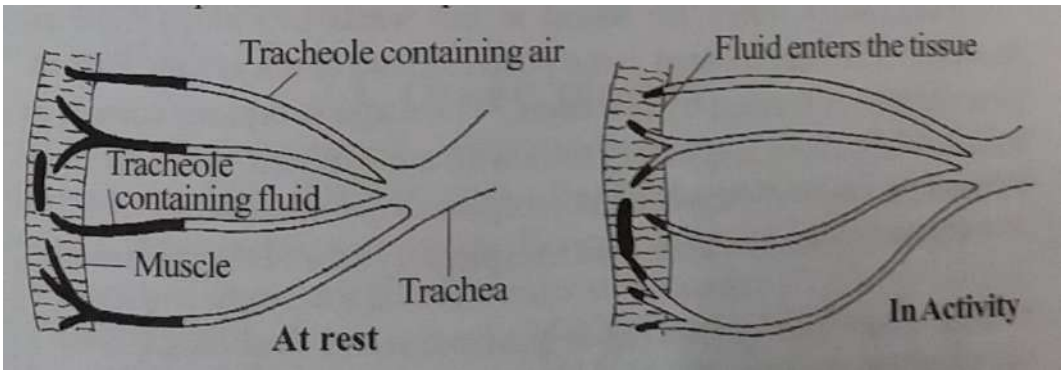
Part of tracheal system sowing spiracle trachea and tracheols

i. Tracheoles: The smallest branches of the tracheae are called tracheoles. The tracheoles are devoid of taenidia. They end in the tid sues. The terminal ends of tracheoles are filled with a fluid called tracheole fluid.

iv. Air sacs: In certain places, the tracheae are dilated to form air sacs. They help to store air and to circulate air in the tracheal system.

Types of Tracheal system: There are three main types of tracheal system, namely polypneustic, oligopneustic and apneustic tracheal systems. In polypneustic tracheal system, eight or more pairs of spiracles are functional. In oligopneustic, type one or two spiracles are functional. In apneustic type, there is no functional spiracle.

Mechanism of Tracheal Respiration: Air is drawn into and forced out of the tracheal system through the spiracle by alternate expansion and contraction of the body. The air enters the tracheoles. The tracheole fluid absorbs oxygen. This oxygen diffuses into the tissue. Similarly CO, from the tissues diffuses into the tracheoles.



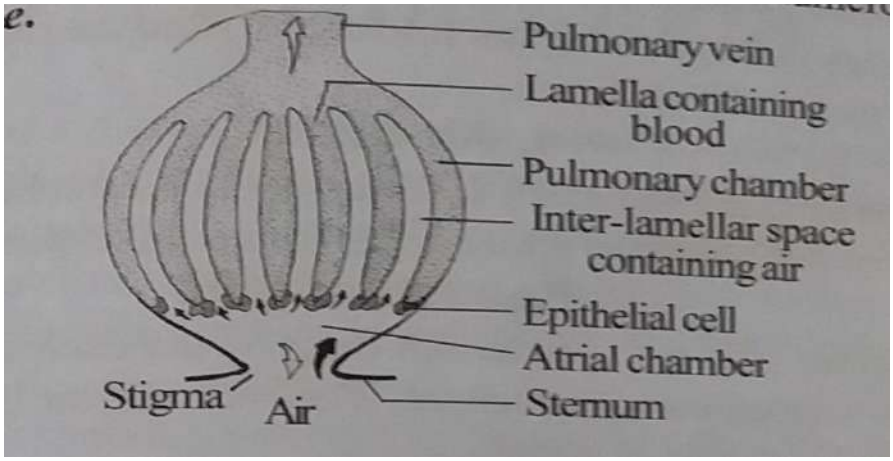
---

2. Book-lungs

are the respiratory organs of Scorpion. There are four pair of book lungs. They are found in the 3rd 4^{th} 5^{th} and the 6^{th} segment of the mesosoma, one pair in each segment. Each book-lung lique slit called stigma. The cavity of each bookthin cuticle which is formed into numerous folds.called lamellae.

. The lamellae are arranged parallel to one another giving the appearance of the leaves of a book. There are about 150 lamellae. They are hollow containing blood. Each stigma leads into a small chamber called atrial chamber. The atrial chamber leads into a large pulmonary chamber in which the lamellae are arranged. Air from outside enters the chamber and passes into the spaces between the leaves.

The blood flows continuously in the space inside the lamellae while the inter lamellaar spaces are filled with air so that exchange of gases lakes place through the thin walls of the lamellae. impure blood from the ventral sinus is sent to each book-lung The blood is aerated in the lamellae, The aerated blood is collected by the pulmonary vein, which opens into the pericardial sinus To tion and expiration of air in the book-lungs is controlled by th oventral and atrial muscles.



Book-Lungs of a Scorpion

3.Simple-lungs

In the terrestrial coconut crab Birgus, the upper part of the gillah ber is separated from the rest as an almost closed air-filled cavit lung. Highly vascular epithelial folds hang from the roof of this and carry on aerial respiration.

4. Air-tubes

The terrestrial crustacean Oniscus contains trachea-like resni tory tubes in its abdominal appendages for aerial respiration.

5. **Spiracular gills**

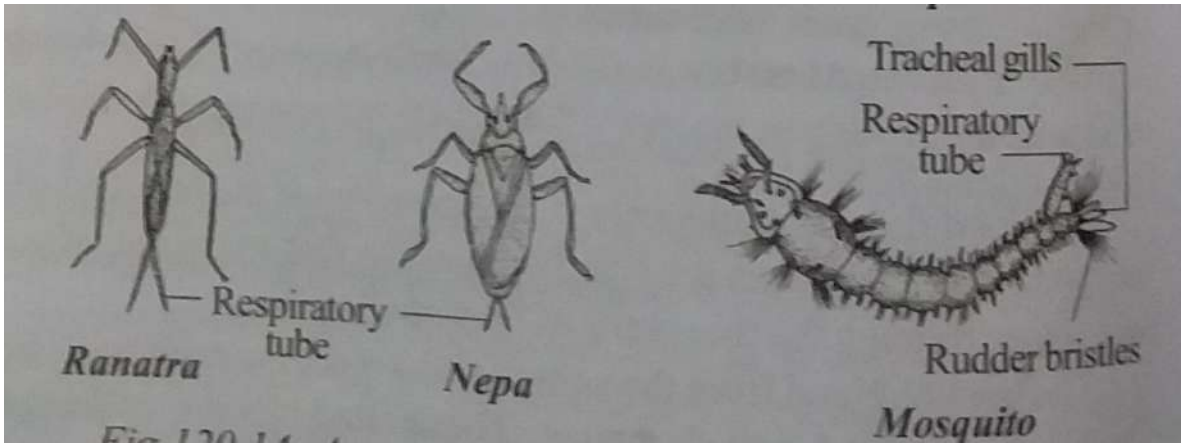
Spiracular gills are ectodermal outgrowths enclosing air Space They have connections with tracheae. They occur in the larvae of Teich mza and in the pupae of *Simulium*.

6. **Plastron**

Certain aquatic beetles like Haemonia, Phytobius, etc. have a kind of air store in the region of spiracle. This air store is called plastron. It is covered with hydrofuge hairs. It is communicating with the spiracle. This air-store helps the insect to remain under water for a long time.

7. Respiratory tubes

Respiratory tubes are found in the water-scorpions Nepa and Ranatra. They are located at the posterior end of abdomen. Each respiratory tube is formed by two cerci. The water scorpions come to the surface and fill the respiratory tube with atmospheric air. This air can be used for respiration when the scorpions are under water. The mosquito larva has also a respiratory tube at the posterior end.



Aquatic insect with respiratory tubes

Circulatory system in Arthropods and Mollusk

Circulatory system in animals

- The circulatory system is effectively a network of cylindrical vessels (the arteries, veins, and capillaries) that emanate from a pump (the heart).
- The circulatory system can either be open or closed, depending on whether the blood flows freely in a cavity or is contained in vessels.
- **A closed circulatory system**, found in all vertebrates and some invertebrates, circulates blood unidirectionally from the heart, around the body, and back to the heart.
- **An open circulatory system**, found in arthropods, pumps blood into a cavity called a hemocoel where it surrounds the organs and then returns to the heart(s) through ostia (openings).

Key terms:

- **ostium**: a small opening or orifice, as in a body organ or passage.
- **hemolymph**: a circulating fluid in the bodies of some invertebrates that is the equivalent of blood.
- **hemocoel**: the system of cavities between the organs of arthropods and mollusks through which the blood circulates.

CIRCULATORY SYSTEM IN ARTHROPODS:

- Arthropods, have an open circulatory system which he blood is pumped forward by the heart, but then flows through the body cavity, directly bathing the internal organs.
- Arthropods' primary internal cavity is a hemocoel, which accommodates their internal organs and through which their blood circulates. They have a dorsal heart and arteries. There are blood vessels that act as pumps to force the blood along.
- Instead of capillaries, blood vessels join directly with open sinuses.
- "Blood," actually a combination of blood and interstitial fluid called 'hemolymph', is forced from the blood vessels into large sinuses, where it actually baths the internal organs.

- Other vessels receive blood forced from these sinuses and conduct it back to the pumping vessels.

CIRCULATORY SYSTEM IN HORSESHOE CRAB (LIMULIDAE):

- The horseshoe crab's heart is a long tube that lies along the opposite side of the body from the nerve cord and extends almost the entire length of its body. On average, the heart rate of the horseshoe crab is 32 beats per minute.
- It has eight pairs of slit-like openings, or ostia, each opening having two valves through which the blood enters the heart from the pericardial chamber.
- The blood is pumped forward and escapes through three pairs of aortae, one pair of cerebral arteries, and a frontal artery.
- Unlike vertebrates, horseshoe crabs do not have hemoglobin in their blood, but instead use hemocyanin to carry oxygen. Because of the copper present in hemocyanin, their blood is blue.

CIRCULATORY SYSTEM IN SCORPION:

- The emperor scorpion consists of an open circulatory system.
- Their body contains blood vessels and the blood contains hemocyanin rather than hemoglobin.
- The tubular heart of the scorpion runs approximately the length of the metosoma.
- There are small arteries that carry blood to the nerve cord.
- The blood vessels pump the blood to the heart

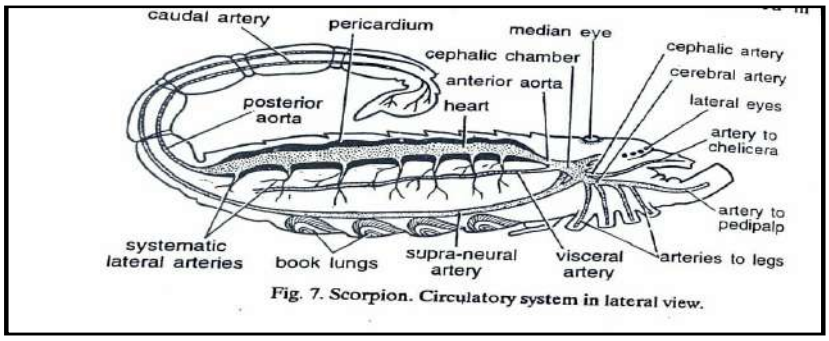
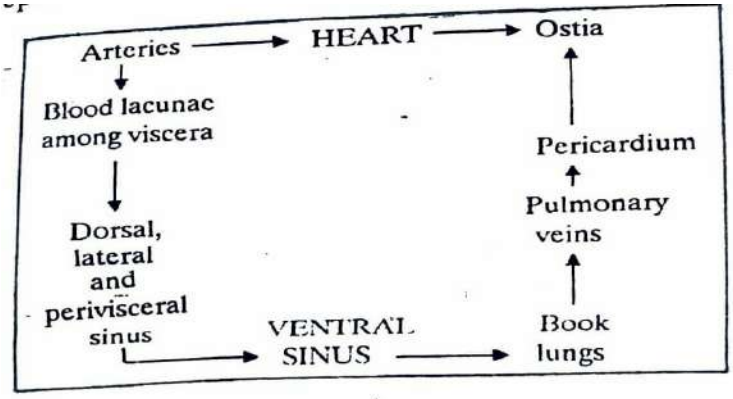


Fig. 7. Scorpion. Circulatory system in lateral view.

•



CIRCULATORY SYSTEM IN COCKROACH:

- The heart of the cockroach is elongated, thick, muscular, tubular and 13-chambered. It lies in the pericardial sinus of the haemocoel.
- Each chamber of the heart receives oxygenated blood from the dorsal sinus through one pair of slit like openings called ostia.
- The heart contracts in a postero anterior direction and the blood also flows posteroanteriorly.
- The alary muscles are responsible for the circulation of blood.
- The first chamber leads into an aorta, which opens in the head sinuses, which are connected to the pericardial sinus through perineural and perivisceral sinuses.

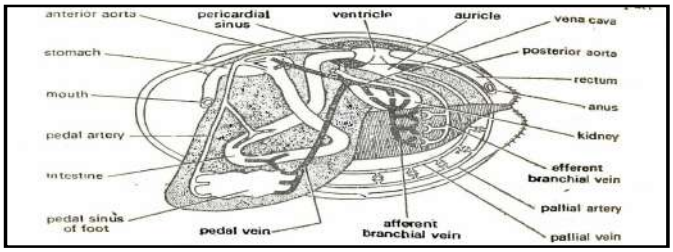
Circulatory System in Mollusca:

- Most animals within the Mollusca Phylum have an open circulatory system.
- Cephalopods have a closed circulatory system. Within a open circulatory system blood is not restricted to circulating within the blood vessels.
- Open circulatory systems which have evolved through species such as crustaceans, insects, mollusks, and other invertebrates, pump blood into a hemocel with the blood extending back to the circulatory system betweens the various cells.
- Blood within a open circualtory system is pumped by a heart into the body cavities, where tissues are surrounded by blood. There are various animlas that fit the requirments of the Mollusa Phylum.

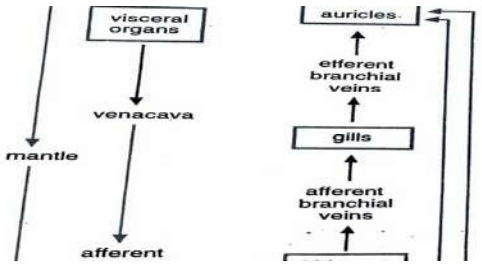
Circulatory system in Mussels:

- Mussels have an open circulatory system meaning that blood is not completely transported within blood vessels.
- Tissues in mussels are covered in hemolymph in order for the gas and nutrients exchange.
- The hearts of mussels have three chambers: one ventricle and two auricles.
- Blood flows around the body of the mussel. It is oxygenated in the gills and mantle, and them returns to the heart.
- Oxygenated hemolymph is pumped away from the heart through blood vessels to the bodies organs. It is then moved to hemoceols where gases, nutrients, and wastes are exchanged.

- The hemolymph is reoxygentated in the gills and mantle before going back to the he

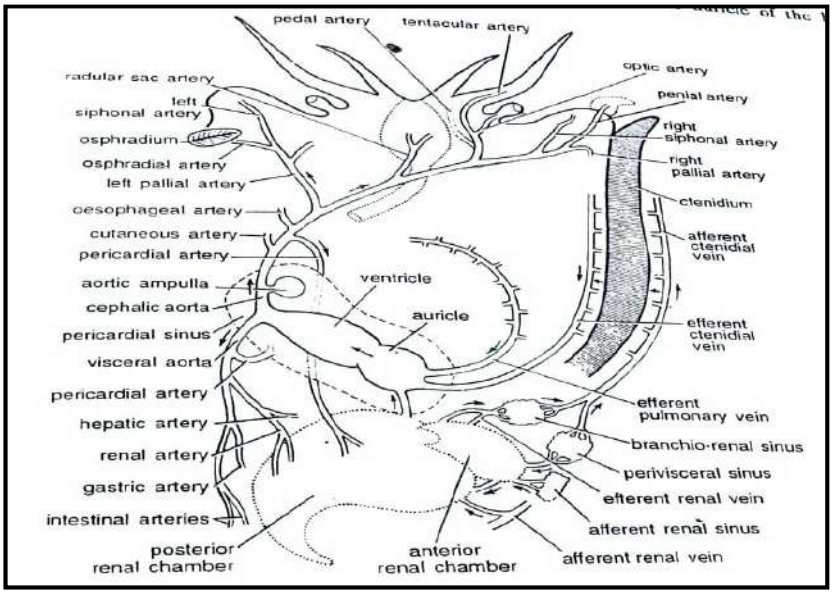


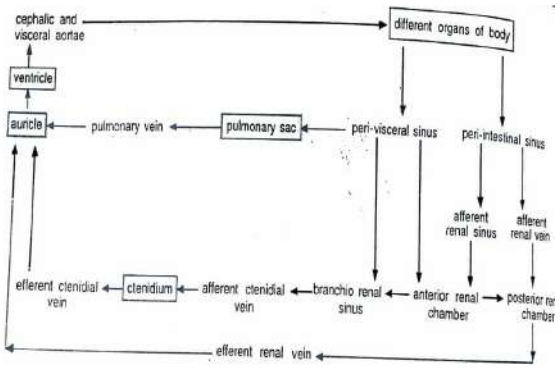
art.



Circulatory system in Snails:

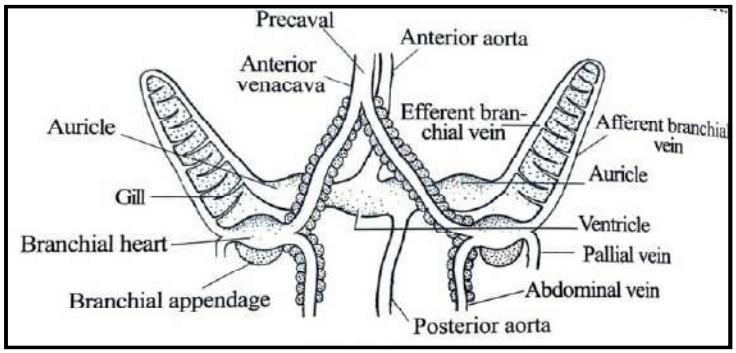
- - The snail has an open circulatory system with a two chambered heart.
- The heart pumps blood into the aorta, and then into small arteries. The blood then empties into a cavity called the haemocoel.
- Blood is then passed into vessels surrounding the heart where it gains oxygen and gets rid of carbon dioxide.
- The blood re-enters the heart through the pulmonary vein.


pedal artery
tentacular artery
radular sac artery
left siphonal artery
osphradium
osphradial artery
left pallial artery
oesophageal artery
cutaneous artery
pericardial artery
aortic ampulla
cephalic aorta
pericardial sinus
visceral aorta
pericardial artery
hepatic artery
renal artery
gastric artery
intestinal arteries
posterior renal chamber
optic artery
penial artery
right siphonal artery
right pallial artery
ctenidium
afferent ctenidial vein
efferent ctenidial vein
ventricle
auricle
efferent pulmonary vein
branchio-renal sinus
perivisceral sinus
efferent renal vein
afferent renal sinus
afferent renal vein
anterior renal chamber


cephalic and visceral aortae
different organs of body
ventricle
auricle
pulmonary vein
pulmonary sac
peri-visceral sinus
peri-intestinal sinus
afferent renal sinus
afferent renal vein
efferent ctenidial vein
ctenidium
afferent ctenidial vein
branchio renal sinus
anterior renal chamber
efferent renal vein

Circulatory system in Squids:

- The Squid has a more complex circulatory system compared to other invertebrates.
- The circulatory system here is a closed one, so blood is transported completely through vessels.
- The squid has three hearts: two branchial and one ventricular. The brachial hearts are locate right at the base of the gills.



- The branchial hearts pump unoxygenated blood through the gills in order to be oxygenated.
- The ventricular heart pumps this oxygenated blood throughout the body.