Government of Andhra Pradesh

Commissionerate of Collegiate Education

P.R GOVT COLLEGE (A), KAKINADA
DEPARTMENT OF
ZOOLOGY &AQUACULTURE

II SEMESTER AQUA CULTURE MAJOR

TAXONOMY AND FUNCTIONAL ANATOMY OF FIN FISH AND SHELL FISH

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Unit I:

General characters shell fish

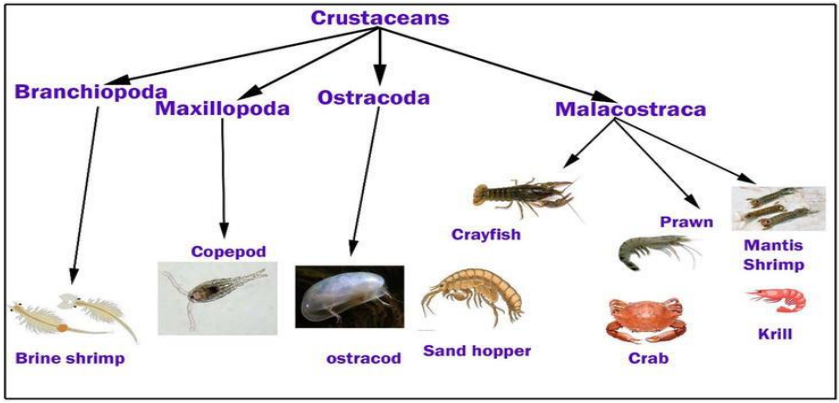
General Characters of Crustacea

Crusta (Latin)= a hard shell

- Mainly aquatic, generally marine but few freshwater and few live in moist places
- Generally free living but few are parasitic
- Head often fused with thorax to form cephalothorax covered dorsally by carapace
- Head bears a pair of compound eye and five pairs of appendages
- Thorax and abdomen often with a pair of biramous appendages in each segments
- Respiration either by gill or general respiratory surface
- Coelom greatly reduced, it is in the form of haemocoel
- Excretory organs are modified coelomoduct which may be either maxillary gland or antennary (green) glands
- Sex usually separate & sexual dimorphism is common
- Development includes metamorphosis with free larval stages
- General characters Triploblastic, bilaterally symmetrical, metabolically segmented
- Body is covered with a thick chitinous cuticle forming an exoskeleton.
- Body segments usually bear paired lateral and jointed appendages

- Body cavity is haemocoel.
- The true coelom is reduced to the spaces of the genital and excretory organs
- Digestive tract is complete; mouth and anus lie at opposite ends of the body
- Circulatory system is open with dorsal heart and arteries but without capillaries
- Respiration through general body surface, by gills in aquatic forms,
  tracheae or book lungs in terrestrial forms
- Excretion by coelomoducts or Malpighian tubules or green or coxal glands.
- Cilia are entirely absent from all parts of the body
- Sex are generally separate and sexual dimorphism is often exhibited by several forms
- Fertilization is internal.
- Development is usually indirect through larval stages
- Parental care is also often well marked in many arthropods.

1.2 Classification of Crustacea



Phylum: Arthropoda

Sub phylum

1. Trilobitomorpha
2. Chelicerata
3. **Mandibulata**

(Mandibula = mandible + ata=group)

- Body divisible into cepahlothorax and abdomen or head, thorax and abdomen
- Appendages of head consist of one or two pairs of antennae, one pair of mandible and one or two pairs of maxillae
- Eye usually compound, respiration through gills or tracheae, excretion by malpighian tubules or green glands
  exual dimorphism
- Development usually involves larval stages.

Mandibulata

6- Class

1. Crustacea **2.Chilopoda** **3. Symphyla** 4.**Pauropoda** **5.Diplopoda** **6.Insecta**

Sub Class (08)

1.Cephalo-cardia -- Ex : Hourse shoe shrimp
2.Branchio-poda -- Ex :Calm shrimp

3.Ostra-coda -- Ex : Sheed shrimp
4.Mystaco-cardia -- Ex :Dero cheilocaris
5.Cope-poda -- Ex :Cyclops
6.Branchi-ura -- Ex :Argulus
7.Cirri-pedia -- Ex : Brancles

8.Malacostra -- Ex : crabs, lobsters, crayfish, shrimp, krill, prawn

Malacostraca

General Characters of sub class Malacostraca (Malakos = soft + ostrakon=shell)

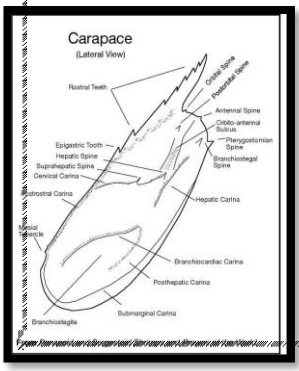
Largest subclass of crustacea including most crabs, lobster, shrimps, crayfish, krill, sow bugs and beach flies

Large marine and fresh water crustacean

Thorax comprises eight segments, abdomen six segment, rarely seven.

Exoskeleton of head unite with few or more thoracic segment to form cephalothoracic carapace.

Compound eye usually stalked.



Malacostraca
Order (06)
1.Nebaliaca
2.Mysidace

Dr. NS

3.Isopoda
4.Amphipoda
5.Stomatopoda
6.Decapoda

Decapoda

Dendrobranchia **Pleocyemata**

Branching form of gills Divided into two **super family** **1.Penaeoidea** **2.Sergestoidea**	**Contain lamellar gills** Divided into **07 infraorder** **1.Caridea** (True Shrimp) **2.Stenopodidea** (Boxer shrimp) **3.Astacidea** (clawed lobster & crayfish) **4.Thalassinidea** (ghost & mud shrimp) **5.Palinura** (spiny & slipper lobster) **6.Anomura** (Hermit, porcelain & King Crab) **7.Brachynura** (true crabs)

1.3 General Characters of fishes

Characteristics of Pisces

1. They are found in fresh, marine, and brackish water.
2. The body is usually streamlined. Some have a spindle-shaped or elongated body as well.
3. Their body is distributed into a head, trunk and tail.
4. They swim with the help of their tail.
5. Paired and unpaired fins represent the appendages. These help the fish to balance while swimming.
6. The lateral line system functions as a sensory organ to sense the disturbances in the nearby environment.
7. The body is covered with thick-seated scales, which helps by providing protection to the internal organelles.
8. The gills help in respiration.
9. Closed type blood circulation is observed.
10. The internal skeleton is bony or cartilaginous.
11. These are cold-blooded organisms.
12. They may be herbivores or carnivores, oviparous or ovoviviparous.
13. The sexes are separate.
14. Fertilization may be external or internal.

15. They lack extra-embryonic membranes.
16. The digestive system is well-developed.
17. The nervous system comprises of the brain and ten pairs of the cranial nerves
18. Presence of unpaired and paired fins. Unpaired Fins are Dorsal, Anal and Caudal fins, Paired Fins are Pectoral and Pelvic fins.
19. They are homodont, Polyphyodont and Acrodont animals.
20. Presence of Pair of external nostrils which opens into blind nasal sacs.
21. Inner Ears primarily serve as organs of Equilibrium.
22. Presence of Gills (Branchial respiration) covered by operculum or gill slits, and lungs/ an Air bladder or Swim bladder (Lung fishes etc.), these are respiratory organs.
23. These two are separated by a Septum Transversum.
24. Presence of two chambered heart with one atrium and one ventricle.
25. Heart is termed Branchial heart as it pumps blood only to gills, seen the Venous heart (
26. Presence of nucleated erythrocytes in the blood.
27. Presence of Ten Pairs of Cranial nerves.
28. Lateral line well developed, to their presence of lateral glands or Neuromast organs which act as Rheoreceptors.
29. They are generally the mesonephric and also seen the pronephric in few teleost species.

30. They are generally Ammotelic and Ureotelic (Cartilaginous fishes).
31. Absence of Urinary Bladder in fishes. Fertilization is either Internal
32. These are Oviparous and Viviparous (Sharks).

1.4 Classification of Fishes

Major groups up to subclass and their important characters

Classification of Fish

Fish, the member of the Animalia Kingdom is classified into Phylum Chordata and Vertebrata Subphylum. Fishes poses notochord, tubular nerve chord, paired gills, segmentation of the body parts, post anal tail, ventral heart, and an endoskeleton to be the member of the Chordata. In order to be a vertebrate, it poses backbone. This back bone supports and protects the spinal cord.

All Species of the fish found in the world are classified into the following three groups. They are:

- Agnatha - jawless fish
- Chrondrichthyes - cartilaginous fish
- Osteichthyes - bony fish
  - Ray finned group
  - Lobe finned group

About 50 species of Agnatha fish, 600 species of Chrondrichthyes fish and 30,000 species of Osteichthyes fish are found in the world. Most of the fishes in the bony group belong to the ray finned group. According to the biologist there are about 70 fish orders are found in the world.

Sharks and rays; sturgeon and gars; herring-like fishes; trout and salmon; eels, minnows, suckers, and catfish; flying fish and relatives; cod-like fish; flatfish; seahorses and relatives; mullets, silversides, and barracuda; and mackerels and tunas are the main group of fishes.

Agnathan

Phylum: chordate
Subphylum vertebrata
Agnathan are jawless fish and lack paired fins. They also lack the internal skeleton system. They have a

circular tooth mouth (cyclostomic) by which they bore the body of their victim and suck their blood. These are classified in to two major types. They are Hagfish and Lampreys.

Characteristic of Agnatha

- Jaws are absent
- Paired fins are absent
- Bony scales and skin plates were present in the ancient species but are absent in the living species
- Gill pouches are present. They have seven or more pouches
- Stomach is absent in the digestive system

Chrondrichthyes

Phylum: chordate

Subphylum vertebrata

Fearsome predators and harmless mollusc eaters are the members of the Chrondrichthyes. The member of the cartilaginous fish poses true bone and also poses a skeleton made up of cartilage. Only the teeth of this species and rarely the vertebrae are calcified. Sharks, Skates, and Rays make up the group of chrondrichthyes

Osteichthyes

Phylum: chordate

Subphylum vertebrata

About 30000 species of bony fish are found in this class. Fishes that belong to this species are spindle shaped, oval in section and flattened. Skins are protected by protective scales. Some fishes of this category have actual lungs to breathe and also have sharp eyesight. These bony fishes have a special gas filled chamber called airbladder housed under the skeleton to allow them to remain buoyant. Another adaptation is operculum, a bone on the sides of the fish to protect the chambers that house the gills.

Bony fish are again classified into ray finned and lobe finned fish. Ray finned fish have thin, flexible skeleton rays. Lobe finned fish have muscular fins supported by bones. Bony fish fertilizes either internally or externally. Two types of eggs are laid by the bony fish. They are the eggs that float and the eggs that sink.

Characteristic of Osteichthyes

- Have more or less bony skeleton and numerous vertebrae
- Mucous glands and embedded dermal scales are present in the skin
- Have paired fins
- Jaws are present
- Gill arches support the gills and are protected by the operculum

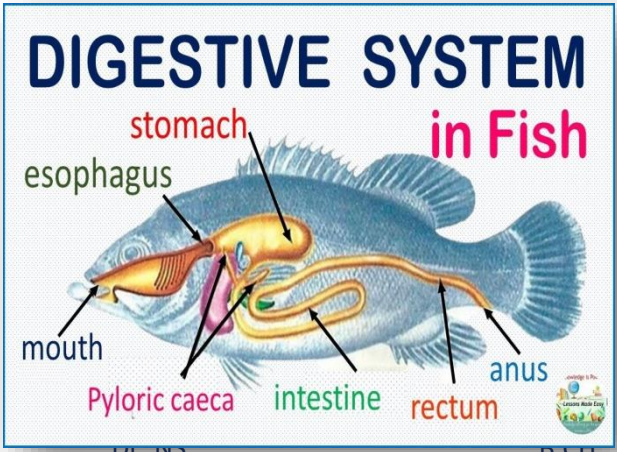
Lungfish, Eels, Acrp, Lizardfish, Silversides and Salmon form the class of bony fish

UNIT -2

2.1 Digestive system of fish

Introduction

The structural components of a fish's digestive system include the mouth, teeth and gill rakers, esophagus,



stomach, pylorus, pyloric caeca, pancreatic tissue (**exocrine** and **endocrine**), liver, gall bladder, intestine and anus. Not all components are present in all fish A fish's digestive system is adapted to their food habits. In predatory (carnivorous) fishes, The mouth is usually large for engulfing prey whole, or in large chunks, and teeth are present on the jaws and tongue for grasping live prey .

Gill rakers are short in carnivorous fish and pharyngeal teeth are short and pointed for moving prey down the throat. In omnivorous and **planktivorous** fishes,

The mouth is smaller and is usually devoid of teeth except for pharyngeal teeth that may be blunt and flat (molariform) for grinding or sharp and long for shredding.

Gill rakers in these fish are typically fine to prevent the escape across the gills of small food particles.

2.1. Gastro Intestinal TractPage

Esophagus

Esophagus forms the beginning of the gastro intestinal tract/ In general the oesophagus is no distensible that it

can accommodate anything the fish can get into the mouth and sometimes even accommodate the item if it happens to double on itself two or three times, on its way to the stomesh.

The ocsgtagus is a short and narrow to be in a no. of Herbivorus and omnivorus fishes. (*Cyprinus corpio, L.rohito,Tor tor* etc. A large no. of mucus – secreting cells are scattered in the mucosa at taste buds are also present in some or species.

2.2. Stomach

Frequently in literature the fishes are classified as stomach or stomach less fishes. 85% telecast have stomach 15% had no stomach.

The stomach too shows various adaptations one of which is shape. In carnivore the stomach typically is straight, elongate for example in gars (lepisosteus), bowfins (Amia), Pikes (Esox) and barracudas (sphyraena).

In omnivorous species, the stomach is most often sac-shaped. A very special adaptation is the modification of the stomach into a grinding organ as in the sturgeons (Acipenser) gizzard shads (Dorosoma) and mullets (Mugil). Here the stomach is reduced in overall size but its wall greatly thickened and muscularized. The lining too is heavily strengthened with connective tissue and the lumen is very small. The organ is not for storage, mixing and primary digestion but rather a food grinder. Great dispensability is the adaptation of the stomach in the predatory deep sea swallowers (saccopharyngidae) and gulpers (Eurypharyngidae) enabling these fishes to take relatively huge prey.

A remarkable modification of the stomach exists in the puffers (Tetradontidae) which can inflate themselves with water or air to assume often on almost globular shape. The adaptive value of this modification of the digestive tract is probably mainly one of defense, for many puffers and porcupine fishes have spines all over the body which can thus be created.
Not all fishes have a stomach that is a portion of digestive tube with a typically acid secretion and a distinctive epithelial lining different from that of the intestine.

2.3. Intestine

he intestine too has many variations. It is shortened in carnivores such as in the pike (Erox), perhaps because meaty foods can be digested easily.

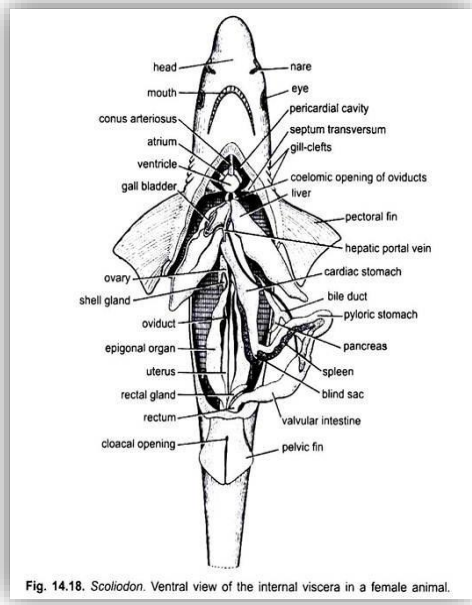


Fig. 14.18. *Scoliodon*. Ventral view of the internal viscera in a female animal.

Where as in herbivores the intestine is highly elongated and several times the body length of the fish and in carps and certain catfishes. In sharks and other elasmobrachs the intestine has a coiled layer of absorptive tissue called spiral valve which increase absorptive surfaces for the relatively in short intestine.

2.4. Pyloric caeca

(Fishes are only vertebrates that have appendages (Caeca) at the gastro-intestinal junctions). On the intestine of most bony fishes at the pyloric end of the stomach. There may be from one to many blind sacs or pylonic caeca or intestinal caeca. A few groups such as cat fishes (Ictaluridae) topminnows (Cyprinidae) and pikes (Esocidae) lack these structures. In such groups as flat fishes (Pleuronectiformies) the pyloric caeca are few usually not more than five (5). In others such as Mackerels (Scombridae), Salmons (Salmonidae) the number of these caeca may range to 200 or more. Generally caeca of different species vary considerably in size, state of branching and the connection with the gut. In sturgeons (Acipenseridae) the many caeca forma large mass, but only a single duct leads to the intestine. In salmon, each caecum communicates directly with the gut, the functions of pyloric caeca probably involve both digestion and absorption.

2.5. Rectum

Morphologically there is no distinction between the rectumad intestine, the ilio-rectal valve is present in sciana, tetradon and muracnosox.

2.6. Anus

It is the posterior opening of the alimentary canal or digestive system. The internal surface of the region near the rectum is covered with an epithelium rich mucous cells. The anus is made up of an inner circular and outer longitudinal muscle layer. The circular muscle is thick developed forming sphincter. The region of anus

facing the anterior has the epithelium continues with the skin.

Associated digestive glands Page

Liver

Like other vertebrates, liver is an important organ in fishes which has both “secretary” and “storage” function. This is a large gland in all fishes, but sharks and rays may have extremely large livers comprising about 20% of the body weight especially in some pelagic sharks. The liver usually lies over or partially surrounds the stomach. It is typically bi-lobed, but may have only one lobe as in salmon or three as in mackerel. In Hag fishes the liver is in two distinct parts, with separate ducts leading to the gallbladder. Adult lamprey have no bile ducts or gall bladder, gall bladder is also absent in burbot (lota) but in most other fishes the gall bladder is present and function to store liver secretions. Ordinarily one hepatic ducts originates from each lobe of the liver and joins the cystic ducts from the gall bladder to form the “bile ducts”
Liver function includes bile secretion and glycogen storage in addition to several other biochemical processes. Apart from their function fish liver also stores fats, vitamin “A” and “D” and the weary RBCs releasing hemoglobin for recycling into the body liver also helps production of urea and other nitrogenous compounds.

Pancreas

Hag fishes have a small – pancreas with several ducts that empty into the bile duct. Lampreys have pancreatic

tissue located through out the liver and intertinal wall. Among bony fishes the pancreatic tissue is usually diffused in or around the liver. This is especially true of spiny rayed fishes, in which the pancrease and liver incorporate in a “hapatapancrease”, in many of soft rayed bony fishes Pancreas is a distinct organ, in sharks and rays also the pancrease is a compact organ with two lobes. The pancreatic duct may reach the small intestine separately from the bile duct as in the sharks or may discharge into the bile duct as in the gar (lepisosteus). The pancreas secrets several enzymes, that are active in digestion. In addition the pancreatic islets have the endocrine function of producing insulin.

Spleen

The spleen is usually recognized as a dark red structure lying on or behind the stomach to which it attaches by a band like ligament. Although it is associated with the digestive organs it has no digestive function, but rather is instrumental in blood cell formation (The function of red blood cell distraction is ascribed to spleen of higher bony fishes). In lampreys and Hag fishes, which do not have a compact spleen, spleen like tissue is diffused along the intestine.

Gas bladder

he Gas bladder is a thin walled sac typically found in the upper part of the body cavity immediately below the kidney. In many fishes the shape is simple, usually some what torpedo shaped, but there are many variations, minnows and carps (cyprinidae) have anterior and posterior chambers, connected by an opening controlled by a splinter. Feather backs (Notopteridae)

have air bladder divided laterally, but two chambers communicate anteriority most croackers (scieanidae) have unusual air bladders in that variously shaped sacs or branching caeca may be arranged along each side of the organ. In Herrings (chupeidae) the gas bladder has a posterior opening to the exterior near the anus. In the embryology of bony fishes the gas bladder originates as an outgrowth of the alimentary canal and remains attached to the esophagus or stomach via the pneumatic ducts such fishes are known as physostomes. Some groups of fishes lose the connection to the alimentary tract. These fishes are known as physoclistous. Some of such fishes may retain the connection till larval or juvenile stages. Some bottom-dwelling stream fishes such as darter (Etheostoma) and Sculpin (cottus) lack the gas bladder. Various other bathy pelagic fishes have also lost gas bladder. Agnathus and cartilaginous fishes also lack gas bladder.

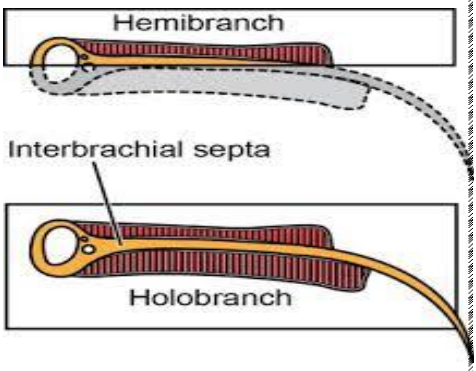
2.2 Respiratory system of fish

Respiratory System of Fish

The respiratory organs are the gills which are borne by the gill-pouches. The structure of gill-pouches differs in different dogfishes. the organisation of gill-pouch of Brachaelurus, a related genus of Scoliodon. There are five pairs of gill-pouches, each of which communicate with the pharyngeal cavity by a large

internal branchial aperture and opens to the outside by exterior gill-slits

The mucous membrane lining the gill- pouches gives a series of horizontal branchial lamellae. The branchial lamellae are highly vascularized structures. Each gill-pouch has an anterior and a posterior set of branchial lamellae. The gill-pouches are separated by interbranchial septum which projects beyond the branchial lamellae

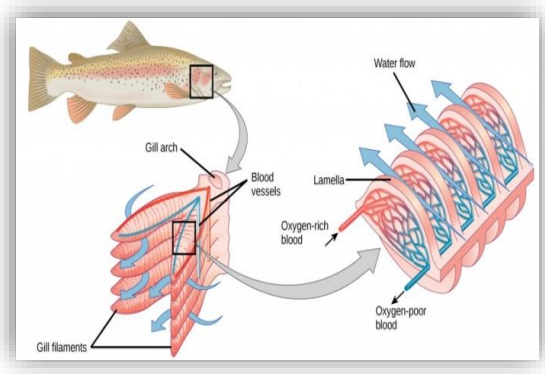


The pharyngeal end of each inter-branchial septum is supported by a visceral arch. Each arch supports the anterior set of lamellae of one gill-pouch behind and the posterior set of lamellae of the next gill-pouch. The first gill- pouch lies between the hyoid and the first branchial arches and the last one is present between the fourth and fifth branchial arches.

There are two types of gills:

(i) Holobranch or complete gill when a branchial arch bears two sets of gill lamellae.

(ii) Demi branch or hemi branch or half gill when single set of gill lamellae is present. The hyoid arch supports only a demi branch and the first four branchial arches support holobranchs. The last branchial arch is gillless.



Mechanism of Respiration:

During respiration the floor of the buccal cavity is lowered and the mouth is opened. Then the water rushes in to fill the greatly expanded buccal cavity. The mouth is now closed and the pharynx contracts.

The water then enters the gill-pouches and goes out after gaseous exchange through gill-slits. The spiracles are occasionally used as accessory pathways for the entry of water for respiration, instead of the mouth when it is otherwise occupied.

Respiratory System in Bony Fishes

Respiration is performed by four pairs of gills, situated in the gilichambers. These two chambers are covered externally by the operculum and the branchiostegal membrane which is attached to the posterior margin of the operculum. The wall of pharynx is perforated by

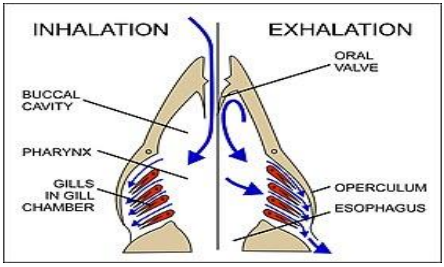
five gill-slits on each side and are separated by four gill-arches or interbranchial septa.

Each gill-arch is provided with teeth- like gill-rakers on the inner concave border and two rows of comb-like gill-filaments on the outer convex border. The gill-rakers present in the inner borders of the gills prevent the escape of food materials from the pharyngeal cavity to the gill-chamber. The gills are holobranchs, i.e., each gill-arch bear's two rows of gill-filaments.

Physiology of respiration:

Bhetki utilizes the oxygen dissolved in water.

The physical mechanism of respiration can be described under the following sequences:



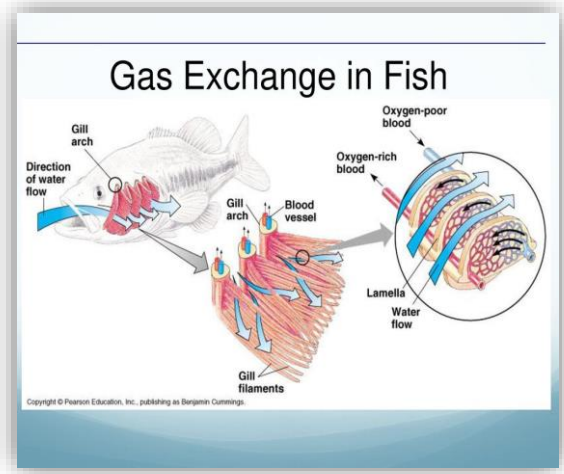
(a) Inspiration: During inspiration, the outer opening of the gill-chamber remains tightly closed to the body wall by the branchiostegal membrane and the two opercula bulge out to increase the accommodating capacity of the pharyngeal and buccal cavities. As a consequence, water from the exterior rushes inside through the opened mouth and fill in the buccopharyngeal cavity.

(b) Expiration:

Immediately with the entry of water, the pharyngeal and the buccal cavities contract and exert pressure to the contained water. As the mouth, by this time, becomes closed by oral valves, the contained water finds the way out through the gill-slits.

The operculum as well as the branchiostegal membrane are lifted by this time and the water from the gill-chambers goes out through its openings. The dilatation and contraction of the pharyngeal cavity are caused by the alternate retraction and protraction of the hyoid arch supporting the buccopharyngeal cavity.

(c) Physiology of gaseous exchange:



The gills are highly vascular structures and are supplied by afferent and efferent branchial arteries. The afferent branchial artery carrying the deoxygenated blood is situated very superficially on the outer edge of the gill. The afferent branchial artery breaks-up into capillaries in the gills.

During the transit of water through the gill-slits, the deoxygenated blood in the capillaries of the gill-filaments takes up the oxygen dissolved in water and gives out carbon dioxide by diffusion. The blood thus aerated is collected by efferent branchial arteries and is conveyed to the different parts of the body.

2.3 Digestive system of Prawn

PALAEMON (PRAWN) DIGESTIVE SYSTEM

Palaemon's digestive system contains a long alimentary canal and large hepato pancreatic gland.

Digestive System of Prawn: The digestive system consists of an alimentary canal and a hepatopancreas or digestive gland

Alimentary Canal:

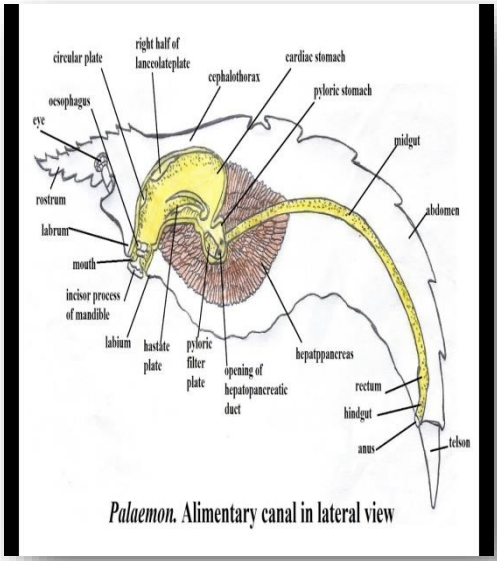
It has three distinct zones—an anterior foregut ending in stomach, a midgut, the constituent of which is intestine and a hind- gut or the rectum. The fore and hindgut are lined by a layer of thick cuticle.

Foregut:

Following structure constitute the foregut.

Mouth:

A slit-like opening situated ventrally in the head region. It is bounded by labrum anteriorly, mandibles laterally and a two- lobed labium posteriorly.



Palaemon. Alimentary canal in lateral view

Buccal cavity:

A small, anteroposteriorly compressed chamber, next to mouth, bearing irregular internal folds. Oesophagus. A wide, vertically oriented tube, joining the buccal cavity with the cardiac stomach. The inner lining bears one anterior, one posterior and two lateral folds.

Stomach of Prawn:

A spacious, horizontally oriented sac, divided into two chambers:

A. Cardiac stomach:

Large, bag-like, constitute the

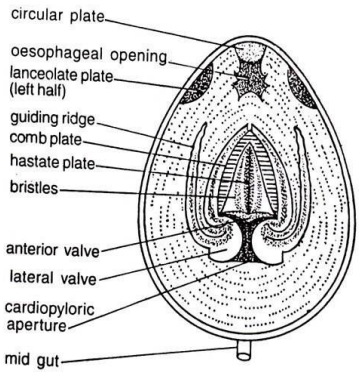


Fig. 25.6. Macrobrachium sp. Floor of the cordiac stomach (dorsal wall removed)

dorsal part, bearing following plates on its walls:
a. A circular plate anteriorly, just behind the oesophagus.
b. A lanceolate plate dorsally in the posterior part.
c. A hastate plate resembling the head of a spear in the mid-ventral region.

i. The slightly convex upper part of the hastate plate gradually slopes laterally, forming a median ridge in the middle.

ii. Delicate setae are present on both the upper and posterior surfaces of the plate,

iii. An elongated lateral groove is present on either side of the plate.

iv. Each lateral groove is bounded by a supporting rod and a ridged plate, both cuticular, on the inner and outer side, respectively.

v. A Comb plate, bearing rows of comb-like setae is present on the inner side of each ridged plate.

vi. The comb plates join at the anterior end but remain free posteriorly, close to the cardio- pyloric opening.

vii. A longitudinal guiding ridge is formed by the folding of the inner wall of the cardiac stomach, lateral to each comb plate.

viii. The two guiding ridges guide the food to the pyloric stomach through cardio- pyloric opening.

The cardiac stomach opens into the pyloric stomach through a narrow X-shaped cardio-pyloric opening, guarded by an anterior, one posterior and two lateral valves.

B. Pyloric Stomach:

a. Small in size, the lateral walls form prominent folds, imperfectly dividing the cavity into two — a small dorsal and a large ventral chamber.

b. The ventral chamber is subdivided into two lateral compartments and receive the ducts from the hepatopancreas.

c. A rectangular filter plate bearing alternate ridges and grooves is present on the floor of the ventral chamber.

d. The filter plate and the bristles of the lateral walls of the ventral chamber act as a pyloric filtering apparatus and permits only liquefied food to pass.

Midgut or Intestine in Prawn:

It is a long, slender tube. Arising from the posterior end of the pyloric stomach it runs backward, ascending between the two lobes of the hepatopancreas to reach the dorsal groove in the

abdomen beyond cephalothorax and runs posteriorly to end in the rectum in the last segment.

Hindgut or Rectum in Prawn:

The last part of the alimentary canal. It is a small chamber, wider anteriorly and narrows down posteriorly to open on the ventral surface, at the base of the telson.

Hepatopancreas of Prawn:

A large, yellow-orange mass, consists of two lobes and occupies major portion of the cephalothorax. The whole of the pyloric stomach, a pail: of the cardiac stomach and the anterior part of the intestine are embedded in it.

A duct arises from each lobe of the hepatopancreas and the two open separately into the ventral chamber of the pyloric stomach, just after the pyloric filter plate. The hepatopancreas plays an important role in digestion and also acts as a storage organ.

2.4 Respiratory system of Prawn

PALAEMON- RESPIRATORY SYSTEM

Palaemon is a fresh water Prawn. It performs respiration by 3 organs.

1. Gills or Branchiae

2. Epipodites

3. Lining of branchiostegites

1. Gills or Branchiae :

1. There are eight pairs of gills.
2. They show semi-lunar shape.

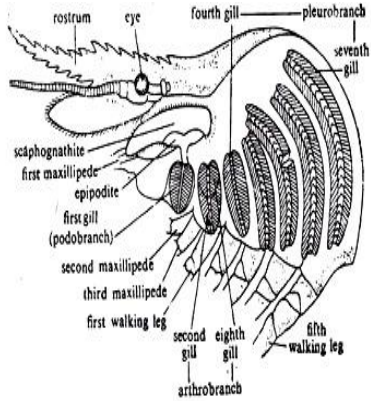


Fig. 2.57 : Respiratory organs (Gills) of *Palaemon*. Note that the branchiostegite of one side has been removed to expose the gill-chamber.

3. They are arranged vertically one, behind the other in a row.
4. The third pair of gills are the smallest.
5. The gills are attached by their middle part to the body, which is called root.

According to their attachment three types of gills are seen in Palaemon.

i) Podo branches : The gills are attached to podomere.

Ex : The first pair of gills are attached to the coxae of the second maxiiii pedes.

ii) Arthro branches : These are attached to the arthrodial membrane which concects the appendage to the body.

Ex : The second and third pairs of gills are attached to the arthrodial membrane joining a limb with the body.

iii)Pleuro branch: The gills are attached to the lateral walls of the body.

Ex.- In Palaemon 5 pairs of gills are attached to the lateral walls of the thorax, one above each walking leg.

Structure of gill:

1. A gill consists of a narrow *'vertical axis'* with two rows of thin *"gill plates".*
2. The gill plates of each row are arranged like the leaves of a book.
3. Such gills are called phyDobranches.

1. Axis and Blood Supply:

1. The axis of the gill contains a central core of connective tissue.
2. It has three longitudinal blood channels. Two are lateral longitudinal channels.
3. The third one extends beneath are groove between the rows of gill plates and is called median longitudinal channel.
4. The lateral longitudinal channels are connected together at intervals by transverse channels.
5. The transverse channel present opposite to the root of the gill receives the afferent braftchial channel which brings deoxygenated blood from the body.
6. Each lateral channel gives off a slender marginal channel to each gill plate of its side.
7. It opens into the median longitudinal channel.
8. The median longitudinal channel gives of the efferent branchial channel that carries oxygenated blood to the pericardial sinus and the heart.

2. Gill Plate:

1. It is made by a single layer of cells.
2. A marginal blood channel is present in it.
3. The gill plate is covered by cuticle.

Working:

1. The balers [Scaphognathites] by their movement produce a constant current of water which passes through the gill chambers.

2. The current Of water enters the gill chambers from behind and passes upwards and leaves at the anterior end.
3. The lining of the gill plate has very thin cuticle which contains blood.
4. Therefore, the oxygen of the water diffuses into the blood and $C0_2$ from blood diffuses into the water.
5. The oxygenated blood returns to the heart is and supplied to the body parts.

2. Epipodites:

1. Three pairs of epipodites are present.
2. They are present in the anterior part of the gill chamber.
3. They are thin and leaf-like.
4. They are the outgrowths of integument of the coxae of the maxilhpedes.
5. The first pair of epipodites are larger and bi lobed.
6. The epipodites regarded as simple gills. They are supplied with blood.
7. They are in contact with water.
8. They take up respiratory function.

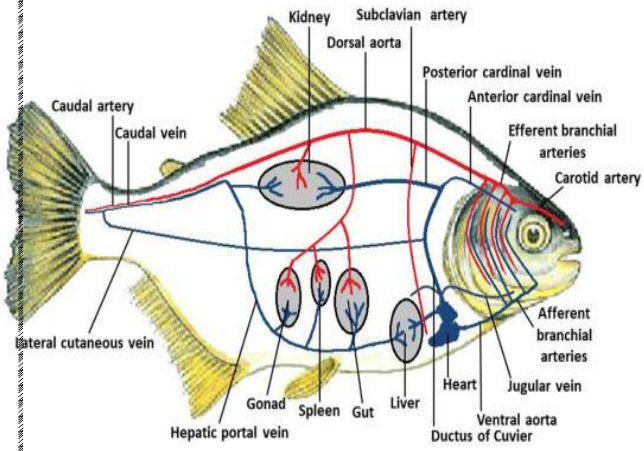
3. Lining of Branchlostegites :

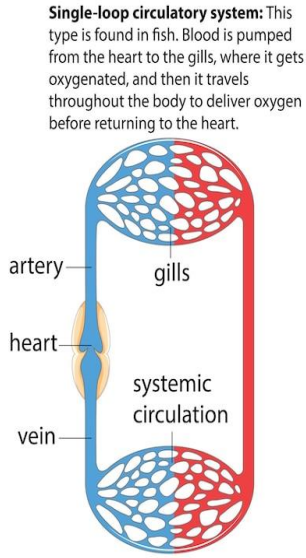
1. The inner fining branchlostegites is thin. It contains blood lacunae.
2. It is in contact with fresh water.
3. Because of which lining of branchiostegite is respiratory in function

UNIT-3

3.1 Cardio vascular system

Structure of heart in fishes





Introduction In fish, the system contains only one circuit, in which blood is pumped through the capillaries of the gills and into the capillaries of body tissues. This is known as a single cycle. Thus, the fish heart is only one pump (consisting of two rooms). Fish have a closed circulatory system.

The heart pumps blood into one loop throughout the body. In most fish, the heart contain four parts, include two chambers, an entrance and an exit, the first part is the venous sinus, a thin-walled sac that collects blood from the veins of the fish before being allowed to flow into the second part, the atrium and is a large muscle

room. The atrium acts as a one way waiting room and sends blood to the third part, the ventricle. The ventricle is another muscular chamber with thick walls and pumps blood, first to the fourth part, an artery bulb, a large tube and then exits from the heart. The arterial compass connects to the aorta, through which blood flows into the gills of oxygen.

Fish cardiovascular system

The cardiovascular system can be considered as the transportation system in the body.

This system contains three main components: the heart, blood vessels and blood itself.

The heart is the system and vascular pump similar to the methods of birth.

The blood can be considered as a liquid that contains the oxygen and nutrients the body needs and carries the waste that must be removed.

The coming information describes the structure and function of the heart and the cardiovascular system.

The heart

Fish have what is often described with a two-chambered heart, consisting of the atrium to receive blood and the ventricle to pump it.

The fish heart contains entry and exit chambers which may be called chambers, so they are also sometimes described as three or four chambers

The atrium and ventricle are sometimes considered “real rooms”, while others are “attached rooms”.

The four parts are arranged as follows:
1. The venous sinus, a thin-walled sac or reservoir with some cardiac muscle that collects deoxygenated blood through the incoming hepatic and cardinal veins.
2. Atrium, which is a thicker muscle room, and sends blood to the ventricle.

3. The ventricle, a thick-walled muscle room that pumps blood into the fourth part, which is the flow stream. Usually tubular in fish with elongated bodies, pyramidal with a triangular base in another, or sometimes a sac-like in some marine fish.

4.The outlet tract (OFT) to the ventral aorta consists of the conical tubular artery, bulbous artery or both. Conus arteriosus, which is usually found in the most primitive species of fish, is found to help blood flow to the aorta, while arteriosus does not occur.

Bone valves, consisting of connective tissue similar to the flap, prevent blood from flowing back through the parts. The valve between the sinuses and the atrial atrium is called the atrial valve that closes during ventricular contraction.

Between the atrium and ventricle there is a bone valve called the atrioventricular valve, and between the arterial ventricle and the ventricle is a bone valve called the ventricular valve. Conus arteriosus contains a variable number of half-moon valves .

In fish, the heart pumps blood first to gills where gases are exchanged, and then the blood fellow to the rest of the body. This is a good balance, as the gills of the fish must be thin-walled to facilitate gas exchange, and therefore cannot tolerate high blood pressure.

At the same time, the blood pressure will decrease when the blood cells press through the platelets, and the blood pressure that remains after the blood passes through the gills must be high enough to push blood around the body.

The fish heart needs to generate the driving pressure for both the gills (lungs in mammals) and the body since they are connected in series.

Vascular system "blood vessels"

The ventral aorta delivers blood to the gills, where it oxygenates and flows through the dorsal aorta to the body.

Fish have the simplest circulatory system, consisting of only one circuit, in which blood is pumped through the capillaries of the gills and into the capillaries of body tissues. This is called a single cycle.

Veins and capillaries

The diameter of the arteries is almost identical throughout the body and circulates blood to the entire body, losing very little pressure. The veins collect blood from the capillaries and carry it to the heart, and act as

a reservoir where the blood can accumulate, creating a low blood pressure system.

The walls of the veins and arteries consist of three layers: the outer sheath (the outer tunic), the middle lid (the middle tunic) and the inner lid (the endothelial tunic), with various degrees of development depending on the type of vessel.

The arteries branch into capillaries at each gill, and through the psoriatic branching arteries converge to the dorsal double aorta that connects to one dorsal aorta extending back to the tip of the tail. Each aortic pair sends my back a branch that goes to the front end. To irrigates the members and muscles of the head. All of these arteries distribute oxygen-rich blood to organs and muscles while the venous system returns carbon-rich blood to the heart.

The caudal vein, coming from the tail, is divided into two branched renal veins into the capillaries in the kidney (excretory system). Blood comes out of the kidneys through the posterior cardinal veins, which open in the Couvre ducts that open in the venous sinus of the heart. The hepatic portal system consists of veins that collect blood from the digestive tube, bladder, and spleen and turn into a hepatic vein that enters the liver where it is divided into capillaries in the sinuses. Blood is collected from the sinuses by the hepatic veins leaving the Liver and opening in the venous sinus. From the front of the body. Blood flows through the cardinal veins of the anterior and the jugular veins to the Cover ducts

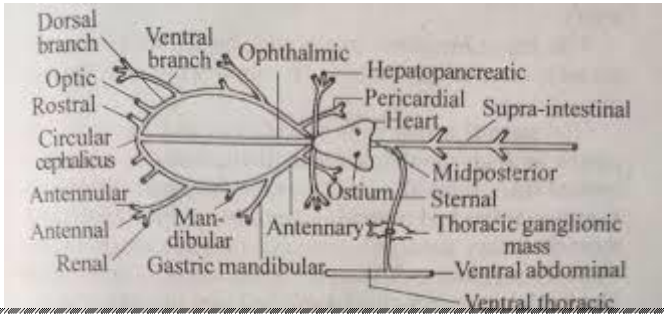
Blood Blood is a tissue made up of a phase of solid cells, including different types of cellular components or blood cells. The fluid or humoral stage at the plasma. It is an aqueous substance with a complex composition. Blood cells account for 30 - 50% of the total blood volume. And they are divided into [9]:

1. Red blood cells or erythrocytes: Red blood cells are oval shaped and nucleated. Red blood cells carry respiratory gases.

2. White blood cells or leukocytes: White blood cells are classified into granular leukocytes or granulocytes (basophils eosinophils end neutrophils) and agranular leukocytes (lymphocytes, monocytes and macrophages) Lymphocytes are the most numerous leucocytes in general terms.

3. Platelets: Lymphocytes generally work in the immune response, and thrombotic cells participate in blood clotting. The latter is a functional equivalent of platelets in mammals as well in immature forms in the bloodstream of red blood cells where maturation is completed. Plasma is usually not found in the bloodstream but rather in secondary vascular tissues.

3.2 Blood vascular system in prawn



In Palaemon the circulatory system includes blood, dorsal sinus, heart, blood vessels, blood sinuses, blood channels. The circulatory system is open type.

The arteries open into blood sinuses in the body.

Blood:

1. It is colorless watery fluid.
2. It contains amoeboid cells.
3. The respiratory pigments is haemocyanin, hence the blood is bright blue in color when combined with oxygen. It is colorless when de-oxygenated.

4. Blood distributes digested food, oxygen to all body parts.

5. Blood has the capacity of clotting.

Dorsal sinus: The heart is dorsally placed in the posterior part of thorax. It is enclosed in a chamber called the dorsal sinus or pericardium. It is present above the hepato pancreas and the gonad. It shows a thin septum on the floor. The septum is attached to the dorsal body wall and to the thoracic wall.

Heart: It is a muscular organ. Its apex is directed anteriorly. Broad base is directed posteriorly.

Cardio-pyloric strand and two lateral strands will keep the heart in position inside the pericardium. On the wall of heart five pairs of valvular Ostia are present. Blood

from dorsal sinus can enter into the heart through Ostia.

i) First pair of Ostia - Mid dorsal.

ii) Second pair of Ostia - Mid ventral.

iii) The third pair - Posterior.

iv) The fourth pair - Antero laterally,

v) The fifth pair-Postero laterally.

Blood vessels or arteries:

The heart sends blood to the body through the arteries. They are.

a) Median ophthalmic arteries: It arises from the apex of the heart. It runs forward mid-dorsally to head. It joins the two antennary arteries above the oesophagus in cephalic region.

b) Antennary arteries: A pair of antennary arteries arises from the apex of the heart on both sides of the median ophthalmic artery. Each artery runs forwards along the outer border of the mandibular muscle. Its branches are

1) Pericardial branch goes to pericardium.

2) Gastric branch goes to cardiac stomach in prawn digestive system.

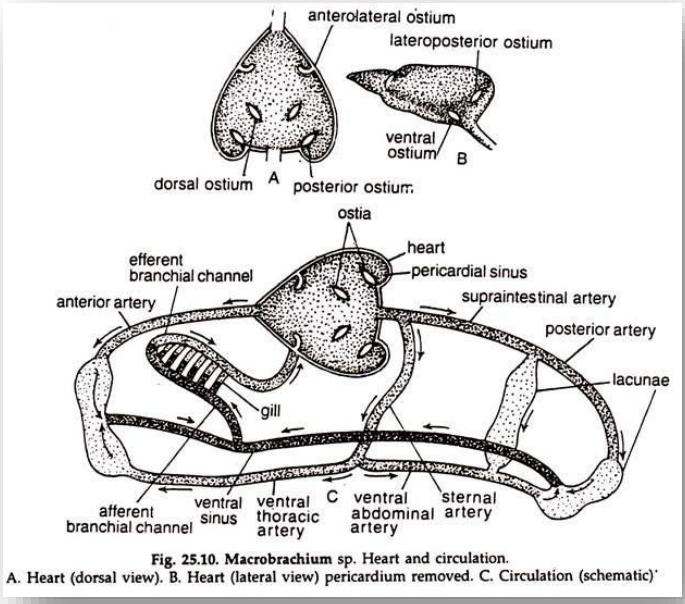


Fig. 25.10. Macrobrachium sp. Heart and circulation.
A. Heart (dorsal view). B. Heart (lateral view) pericardium removed. C. Circulation (schematic)'

mandibular branch goes to mandibular muscle. Then it divides into a dorsal branch and a ventral branch. The ventral branch gives branches to antennule, the antenna and the renal organ. The dorsal branch gives branches to the eye and then divide. It unites with the same opposite branch and the median ophthalmic to form a circular loop like artery or circulus cephalicus. It gives a pair of rostral arteries to the-rostrum.

Hepatic arteries : They arise' from heart ventro-laterally one on each below the antennary artery. They go to the hepatopancreas.

Median posterior artery : A short stout artery arises from the postero -ventral surface of the heart. It bifurcates into a supra-intestinal artery and a sternal artery. The supra intestinal is also called dorsal abdominal artery which supplies blood to the midgut and the dorsal abdominal muscles. The sternal artery runs downwards through the hepatopancreas and then pierces the ventral thoracic ganglionic mass and go to the ventral side. It divides into ventral thoracic branch and ventral abdominal branch. The ventral thoracic branch supplies blood to the sternal region, the first three pairs of walking legs, the maxillae and the maxillulae. The ventral abdominal branch runs posteriorly up to the anus and supplies blood to ventral abdomen, the last two pairs of legs, the hindgut etc.

Blood sinuses : True capillaries and veins are absent. In Palaemon arterial branches end in blood sinuses of the haemocoel. All the sinuses of the body open into a pair of ventral sinuses. It is present below the hepatopancreas.

Blood channels: These have no proper walls. Six afferent bronchial channels carry blood from ventral sinus to the gills on both the sides. Oxygenated blood from the gills of both sides is brought to the pericardium by six afferent bronchial channels.

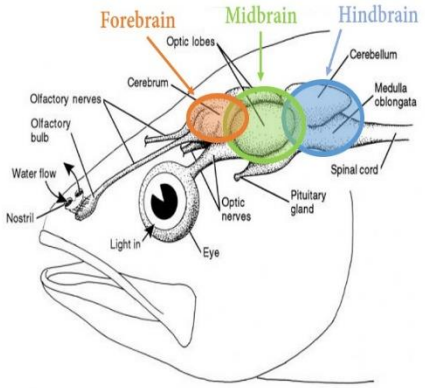
Circulation of blood: The heart because of contractions forces the blood through the arteries to all parts of the body. Blood from all sinuses will return to two ventral sinuses. From there the blood is distributed to the gills

by afferent bronchial channels and then it reaches the pericardial sinus through efferent bronchial channels and reach hea

UNIT-4

4.1 Structure and functions of Fish Brain

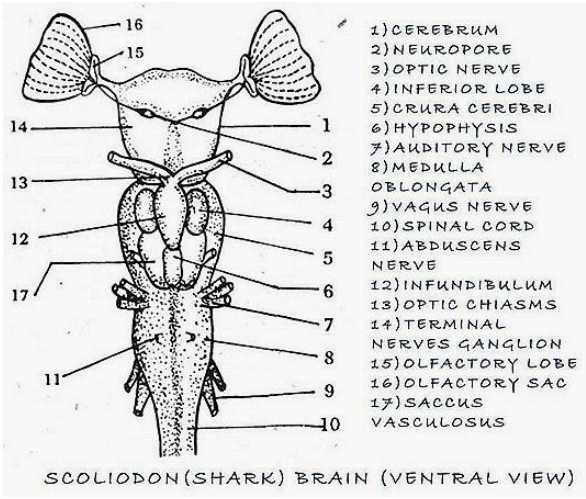
- ✓ The brain lies in a cartilagenous cranium.
- ✓ A single outer membrane - 'Meninx primitiva' covers the brain.
- ✓ All the ventricles in the brain are spaceous



FISH
PROSENCEPHALON

- ➢ The olfactory lobes are highly developed. These help much reliance on smell in detecting the prey .
- ➢ Olfactory lobes extend forward and outward from antero lateral angles of cerebrum. So these do lie side by side.
- ➢ Each olfactory lobe is differentiated into a siende; olfactory tract and a bilobed olfactory bulb. The olfactory bulbs are closely applied to olfactory sacs.

- The cerebrum is some what rectangular, large and undivided.
- There is a median neuropore on the ventral sides of the cerebrum for the terminal nerves.
- Pallium and corpora striata are poorly developed.
- There is no cerebral cortex. The grey matter is restricted to the lining of lateral ventricles.



SCOLIODON(SHARK) BRAIN (VENTRAL VIEW)

- Diencephalon is short and narrow and almost fully covered dorsally by cerebrum.
- 12. Pineal stalk is long and slender extending forward and upward.
- Infundibulum consists of a large median lobe associated with a pair of small lateral lobes - 'Lobi inferiores'.
- 14. Median lobe of infundibulum and hypophysis form 'pituitary body'.
- A pair of hollow outgrowths 'Sacci vasculosi' present on the sides of hypophysis. These are pressure receptors.

MESENCEPHALON

- Optic lobes are highly covered by the cerebellum.
- Crura cerebri are largely covered by lobi interiores and sacci vasculosi.

RHOMBENCEPHALON

- Cerebellum is a very large rhom-boidal structure. It divides into three lobes by two 'deep transverse furrows.
- A pair of irregular, thin -walled sacs 'Corpora restiformia' present on the sides of the anterior part of cerebellum.
- Medulla oblongata is partly covered infront by cerebellum.
- There are three commissures- 'anterior'm lamina terminalis' 'dorsal in front of pineal stalk and 'posterior1 between diencephalon and optic lobes.

4.2 The Nervous System Of Prawn

Prawns are crustaceans and have a relatively simple nervous system compared to vertebrates.

Their nervous system is composed of a brain, a ventral nerve cord, and a series of ganglia. The brain is located above the oesophagus and is composed of three fused segments: the protocerebrum, deutocerebrum, and tritocerebrum.

The ventral nerve cord runs along the ventral side of the body and is composed of a series of ganglia that are connected by nerves. The first ganglion is located in the head, and the rest are located along the ventral side of the body.

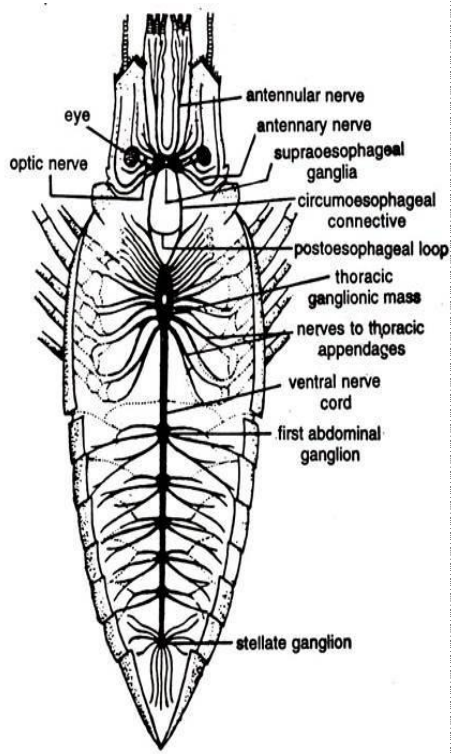


Fig. 25.12A. Macrobrachium sp. Nervous system
A. Nervous system. B. Visceral nervous system

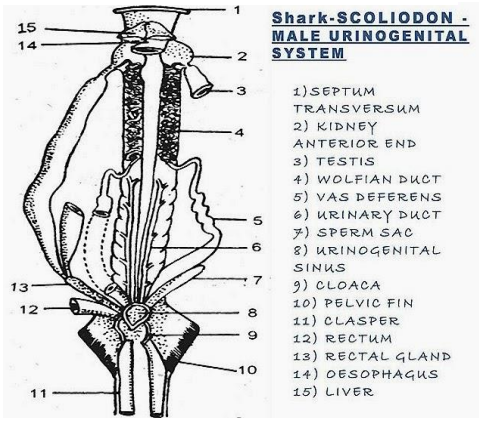
The nervous system of prawns is responsible for controlling various physiological processes such as movement, sensation, and feeding. The sensory organs of prawns, such as their eyes and antennae, are connected to the nervous system and provide information about the environment. The nervous system then processes this information and generates appropriate responses.

Overall, the nervous system of prawns is well adapted to their environment and allows them to efficiently navigate and survive in their aquatic habitats.

5.1 Urino genital system in fishes

PALAEMON (PRAWN) -REPRODUCTIVE SYSTEM

INTRODUCTION



Urine producing kidneys and gamete producing testes deliver their products into ducts where sperm and urine are mixed and stored for a period of time.Palaemon is a unisexual animal. Male and Female animals shows many morphological differences

S.No.	Male	Female
1	The second pair of chelate legs are longer and stronger.	The second pair of chelate legs are smaller and thin,
2	The thoracic legs are closely arranged.	The thoracic legs are less closely arranged.
3	Second pair of pleopod has appendix masculina.	Absent.
4	The male genital openings are present on the arthroidal membrane of the last pair or walking legs.	The female genital openings are on the coxa of the third pair of walking legs.
5	The male prawn is	The female prawn

	bigger when compared with female prawn of the same age.	is smaller than the male of same age.

Male reproductive system:

The male prawn has a well-developed male reproductive system, it has the following parts.

a) Testis: They are two in number. They are long and narrow. They are present on the posterior half of the hepato-pancreas and beneath the pericardial sinus and heart. Anteriorly they extend up to the renal sac and posteriorly they run upto the first abdominal segment. In between the two testes a gap is present in the middle. Through this gap cardio-pyloric strand passes.Each testis is composed of a many lobules and which are connected by connective tissue. The lobule is fined by germinal epithelium.

b) Vasa deferentia: From each testis a vas deferens arises, k is a long narrow duct. It coils near the hepato-pancreas. It runs vertically downwards.

c) Seminal vesicle: The lower part of the vas deferens is

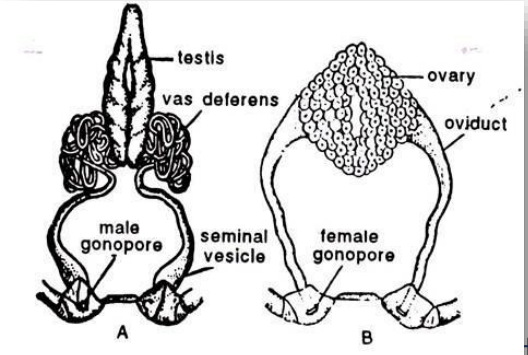


Fig. 25.15. Macrobrachium sp. Reproductive system. A. Male. B. Female

expanded. It is club shaped and muscular. It is called seminal vesicle. It stores the spermato-phores.

d) Male genital openings : The seminal vesicles open out through male genital pores. These openings are situated on the arthrodial membranes of the last pair of walking legs. Each opening is guarded by a small flap.

B. Female Reproductive system:

It contains a pair of ovaries and a pair of oviducts.

a) Ovaries: These are present on the posterior half of the hepatopan-creas below the pericardial sinus and heart. They extend anteriorly up to the renal sac and posteriorly up to the first abdominal segment. In a mature female, the ovaries are sickle shaped and lie side by side, with a big gap between them in the middle. Cardiopybric strand passes through it. In the breeding season the ovaries enlarge and may extend into the first abdominal segment. Each ovary has a large number of ova surrounded by a membrane. The ova are in the different stages of development in the ovary.

b) Oviducts: These are slender and curved tubes. They have a wide proximal end. Each oviduct starts from the middle of the outer border of the ovary. It runs vertically downwards.

c) Female genital aperture: The oviducts open out through female genital opening. They are present on the coxa of the third pair of walking legs.

Copulation and fertilization: During copulation the male deposits the spermatophores near the female genital openings of the female. Near the female genital opening ova are present attached to the pleopods. Fertilization *is external*

Development: In Palaemon the devebpment is direct. The larval stage is absent. The eggs hatch and give small prawns which undergo many moultings before becoming adults.

Conclusions and general considerations

The anatomical relationship of the urinary and genital systems varies among fishes. These morphological variations are associated with taxonomic position of fish species and represent evolutionary selection for different levels of connection between kidneys and testes. Generally, there are two conditions which affect physiological significance:

THE END

Government of Andhra Pradesh

Commissionerate of Collegiate Education

P.R GOVT COLLEGE (A), KAKINADA
DEPARTMENT OF
ZOOLOGY &AQUACULTURE

II SEMESTER AQUA CULTURE MAJOR

TAXONOMY AND FUNCTIONAL ANATOMY OF FIN FISH AND SHELL FISH

Prepared by

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