Invertebrates 2 Zoo357

(Theoretical Part)

First semester

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Phylum : Arthopoda

The largest phylum in the Animal kingdom.

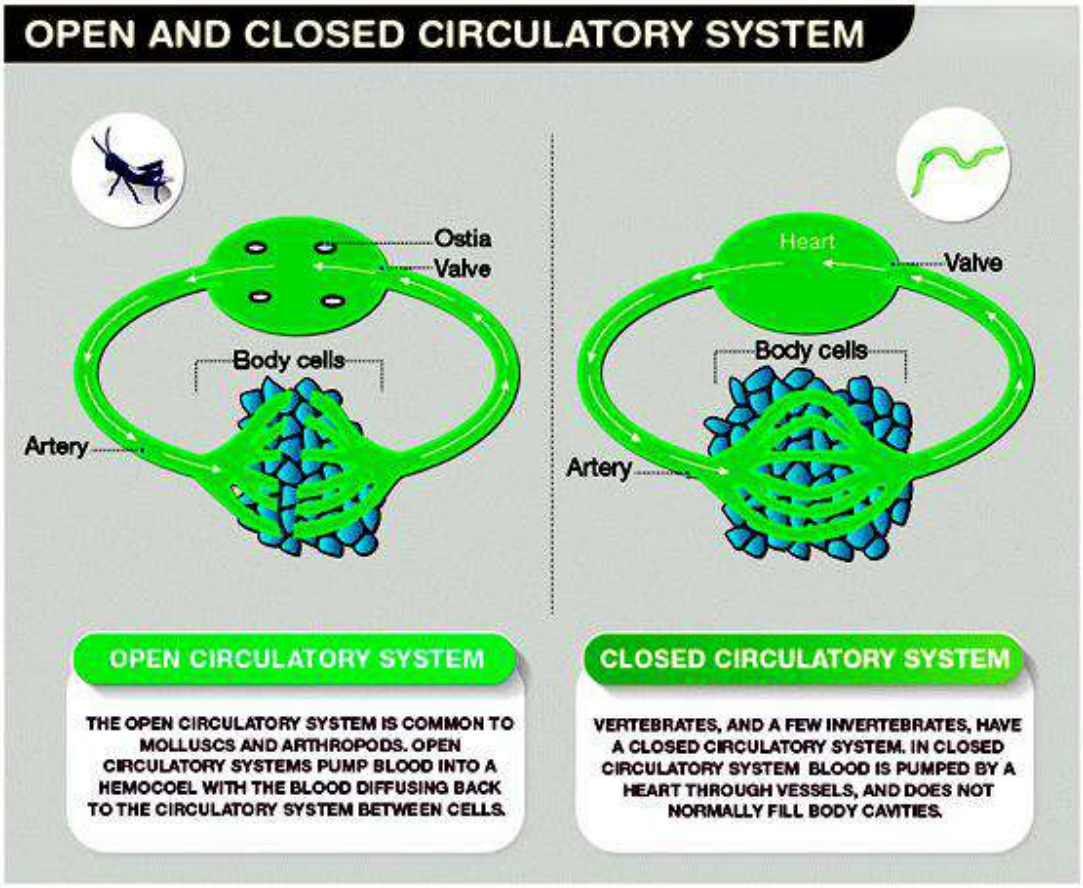
General characters

- Cosmopolitan in distribution, found as aquatic, terrestrial and aerial forms. Some are ectoparasites and vectors of disease.
- Body is triploblastic and bilaterally symmetrical.
- Body is segmented. Number of segments are less than those in Annelida and form certain regions. It is divisible into head, thorax and abdomen. NOTE: In some forms, body is divisible into cephalothorax (head and thorax are fused) and abdomen, or head and trunk.
- Body has jointed appendages or legs (which modified to different structures to perform different functions like jaws, walking legs, paddles).
- Body is covered with chitinous exoskeleton formed by epidermis. The exoskeleton forms internal projections useful for muscle attachment. The exoskeleton casts off periodically and a new one is secreted. That is called molting or ecdysis.
- True coelom is greatly reduced. It is represented only by the cavities of the reproductive and excretory organs. The general body cavity (haemocoel) is filled with blood.
- Digestive system is complete, straight and well developed. The mouth bears mouth parts for ingestion of food.

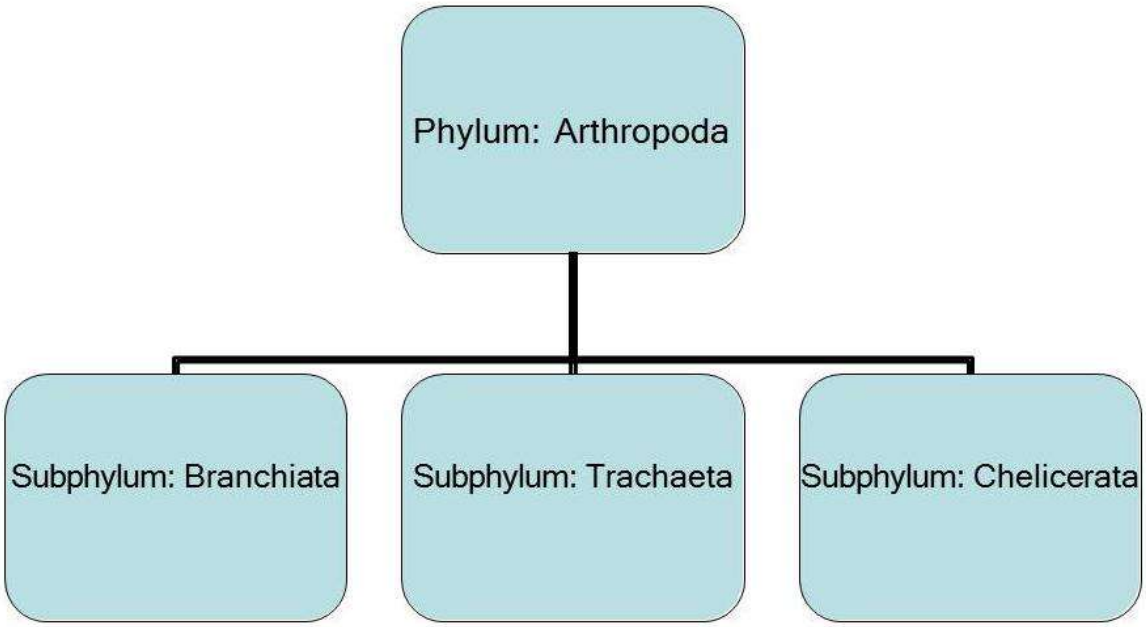
- Respiration takes place by general body surface or gills, trachea, booklungs or bookgills.
- Circulatory system is of opened type i.e. do not have blood vessels and the blood enters directly into the body chambers or (haemocoel), and returns back to the heart through ostia.
- Excretion takes place through Malphigian tubules (in terrestrial form) or green glands (in aquatic forms).
- Nervous system is of annelidian type, which consists of a brain and a ventral nerve cord.
- Sensory organs include antennae, sensory hairs for touch and chemoreceptor, simple and compound eyes, auditory organs (in insects) and statocysts (in crustacean.(
- Striated muscles are presented segmentary.
- Unisexual i.e. sexes are separated. Fertilization is internal or external. They are either oviparous or ovoviviparous. Development may be direct or indirect.
- Oviparous: lying eggs hatch out of the female body.
- Ovoviviparous: form eggs but still inside the female till hatching.

Indirect Development	Direct Development
It is a type of development that involves asexually-immature larval stage, having different food requirement than adults.	It is a type of development in which an embryo develops into a mature individual without involving a larval stage.

Difference between open and closed circulatory system



Classification of Arthropoda according to respiration



Subphylum: Branchiata

Class: Crustacea

General characters:

1-Mainly aquatic, few live in moist places. Few are parasitic forms.

2-The body is divided into head, thorax (usually fused in one part : cephalothorax) and abdomen or head and trunk.

3-The head contains 6 segments

- The first segment has no appendages.
- The second bears the first antennae or (antennules)
- The third bears the second antennae or (Antennae)
- The fourth bears the Mandibles

- The fifth bears the first maxillae or (Maxillules)
- The sixth bears the second maxillae or (Maxillae)

4-The thoracic and abdominal segments differ from one crustacean animal to another, but generally each segment with a pair of appendages and sometimes disappear from abdomen.

5- The digestive tract is almost straight. It consists of an anterior foregut and a posterior hind gut, both lined by chitin and separated by the unchitinised midgut which often give rise to digestive glands.

6- The opened circulatory system includes a contractile heart enclosed in pericardial cavity.

7-Respiration takes place by general body surface or gills.

8- Excretion takes place through coxal or antennal glands (green glands).

9- The sexes are usually separated. Development usually indirect forming (Nauplius larva).

The Prawn

Subphylum: Branchiata

Class : Crustacea

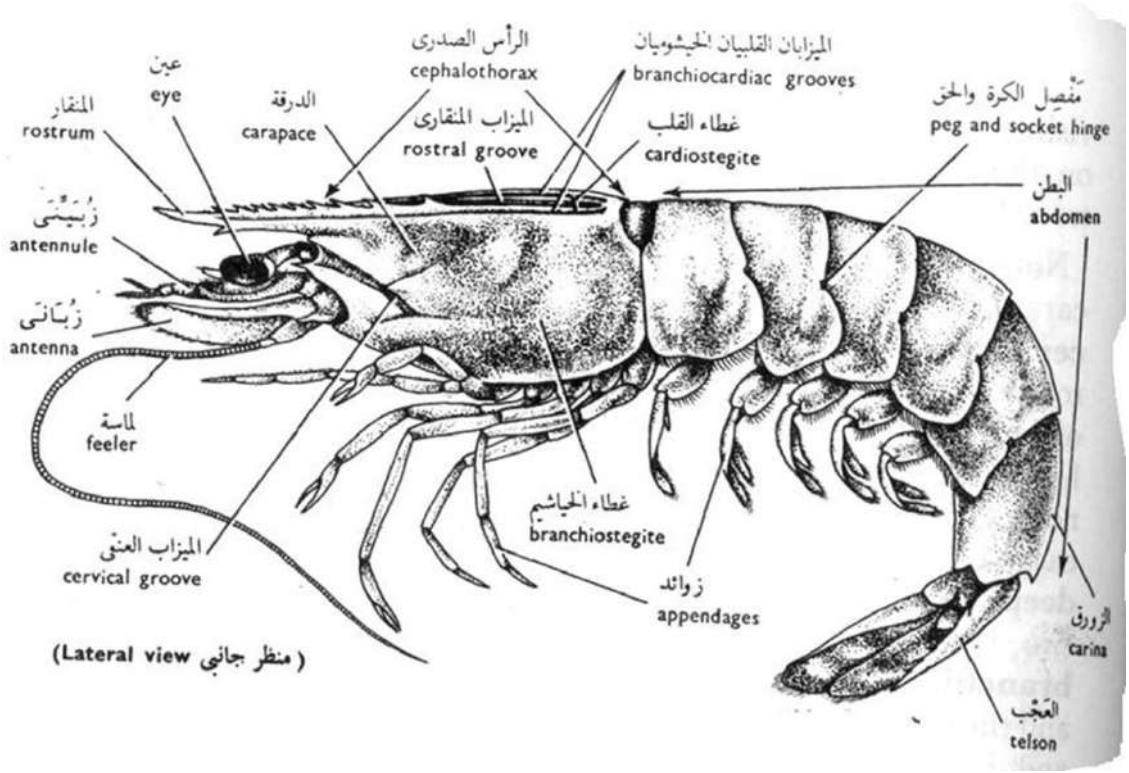
Subcalss : Malacostraca

Order : Eucarida

Suborder : Decapoda

Family : Macrura

e. g. : *Penaeus japonicas*



External features of *Penaeus japonicus*

- It is a prominent member of our marine fauna.
- The body is divided into an anterior cephalothorax and a posterior abdomem.
- The cephalothorax (6 cephalic + 8 thoracic segments) is covered on all sides except ventrally by carapace which extended anteriorly into a long serrated pointed rostrum.
- No external signs of segmentation on head and thorax.
- On each side of the carapace, a V-shaped cervical groove that demarks between head and thorax. Also note 3 dorsal grooves two of these are branchiocardiac grooves and the third is the rostral groove.
- The dorsal part of carapace is called cardiostegite and the sides are called branchiostegite.
- On both sides of rostrum two compound eyes are present carried on long stalks. Each eye made up of a large number of structural & functional units called ommatidia
- The abdomen with (6) segments ended with a small telson and the anus opens on its ventral surface.
- The segments of abdomen can be moved upon one another according to the presence of the peg and socket hinges on each side.
- A pair of appendages arise on each segment of the body. So 19 pairs of appendages are present in the adult animal.

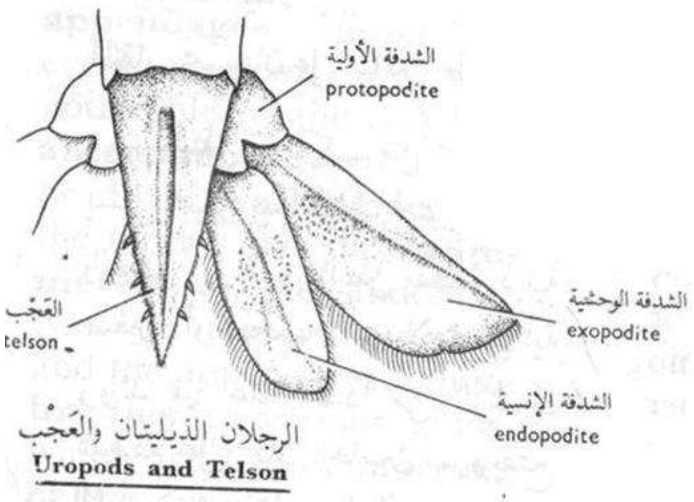
The appendages

The typical appendage consists of a basal part called protopodite formed of 2 parts; coxopodite and basipodite, which carries 2 rami: an endopodite nearer to the mid-line and an exopodite to the outer side.

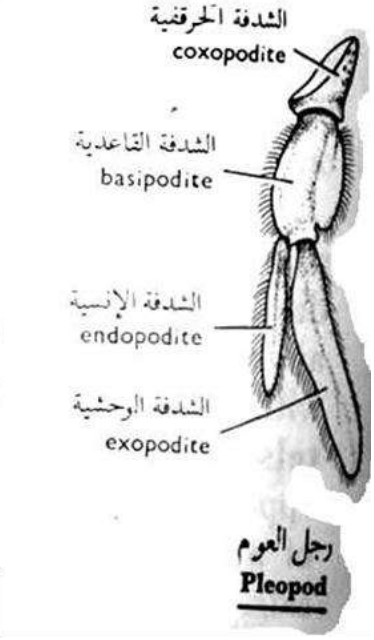
All appendages are believed to be similar to the typical appendage but show a great variety of modifications to serve various functions. This phenomenon knowing as Serial homology.

The appendages can be studied in succession starting from behind (the least modified) towards the anterior end (the most modified).

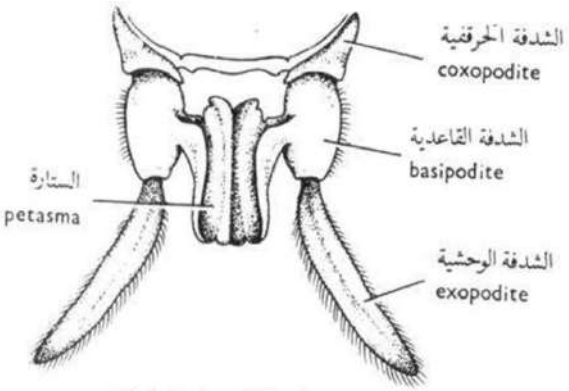
The abdominal appendages



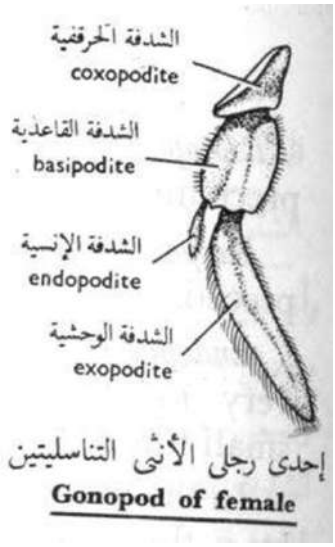
الرجلان الذيليتان والعَجْب
Uropods and Telson



رجل العوم
Pleopod



رجلا الذكر التناسليتان
Gonopods of male

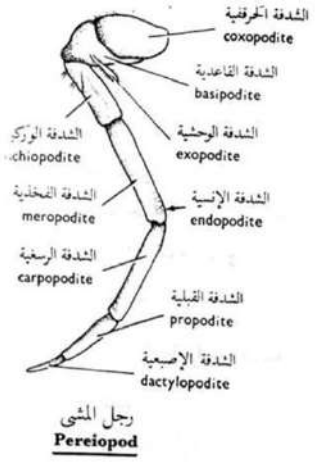


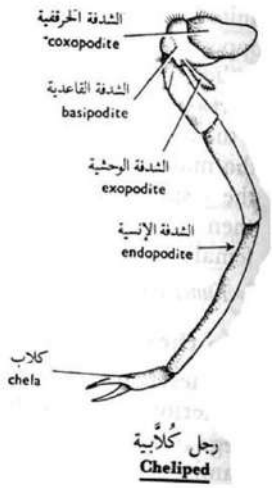
إحدى رجلي الأنثى التناسليتين
Gonopod of female

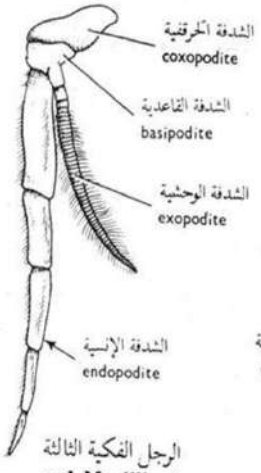
Functions

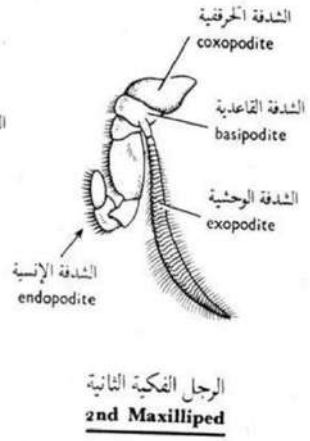
- Uropods (6th abdominal), for backward swimming.
- Pleopods or swimmerets (5th -2nd abdominal), for swimming.
- Gonopods (1st abdominal), to distinguish between the male and female and during reproduction**.**

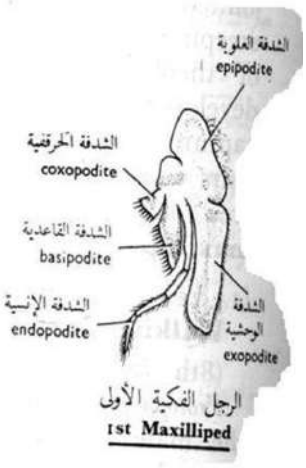
The thoracic appendages







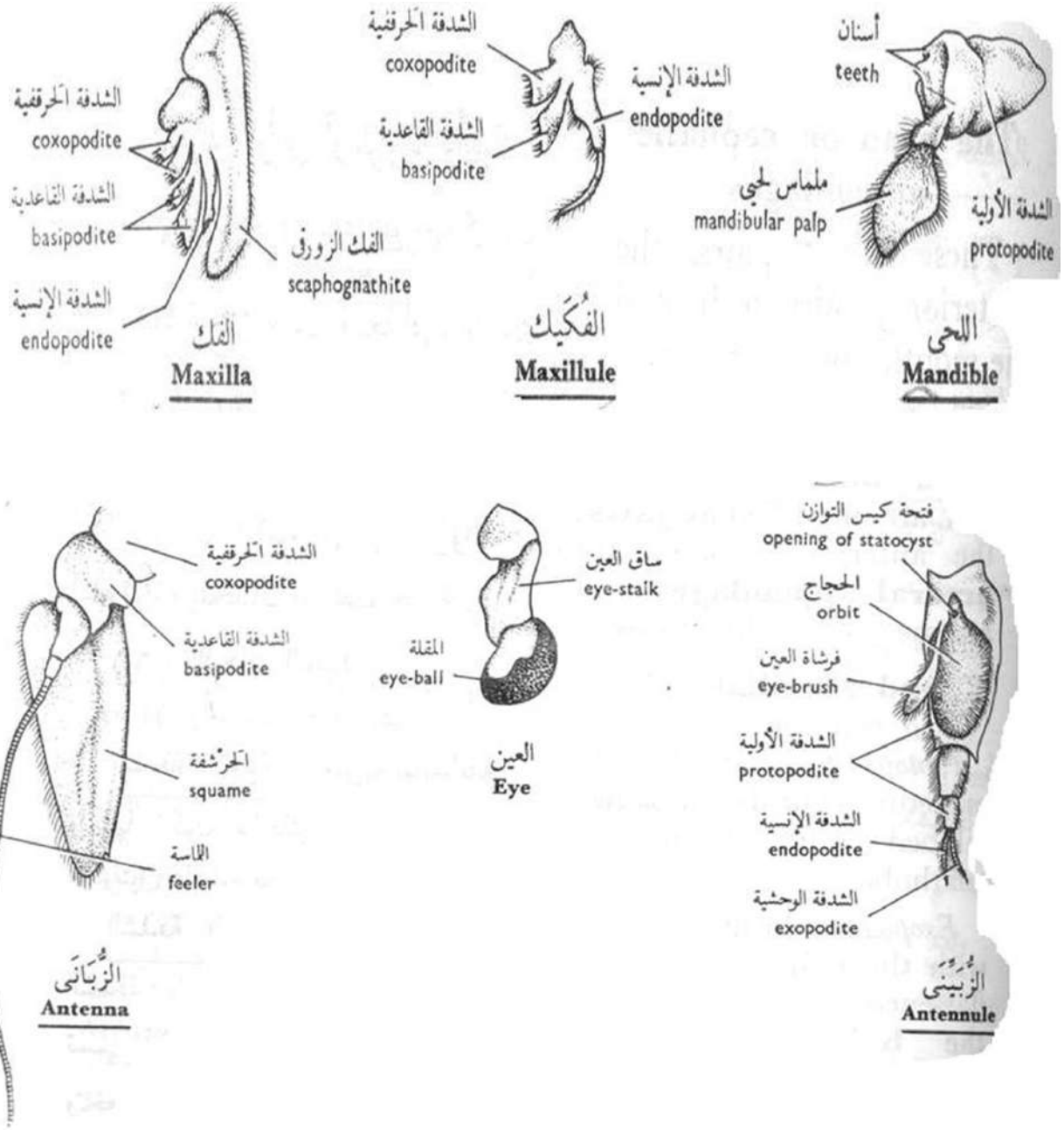




Functions

- Pereiopods (8^{th} &7^{th} thoracic) for walking.
- The male genital openings lie on the coxopodites of the 8th pair.
- Chelipeds (6^{th}-4^{th} thoracic) for walking, food capture and defence.
- The female genital openings lie on the coxopodites of the 6th pair.
- 3^{rd} maxillipeds (3^{rd} thoracic) for holding food while it is shredded with anterior appendages.
- 2^{nd} maxillipeds (2^{nd} thoracic) for shredding and straining food.
- 1^{st} maxillipeds (1^{st} thoracic) for shredding food.

The cephalic appendages



Functions

- 2nd maxillae (5th cephalic) for manipulation food and production of respiratory current.
- 1st maxillae or maxillules(4th cephalic) for manipulation of food.
- Mandibles (3rd cephalic) for grinding food and forcing it into the mouth.
- 2nd antennae (2nd cephalic) for tactile.

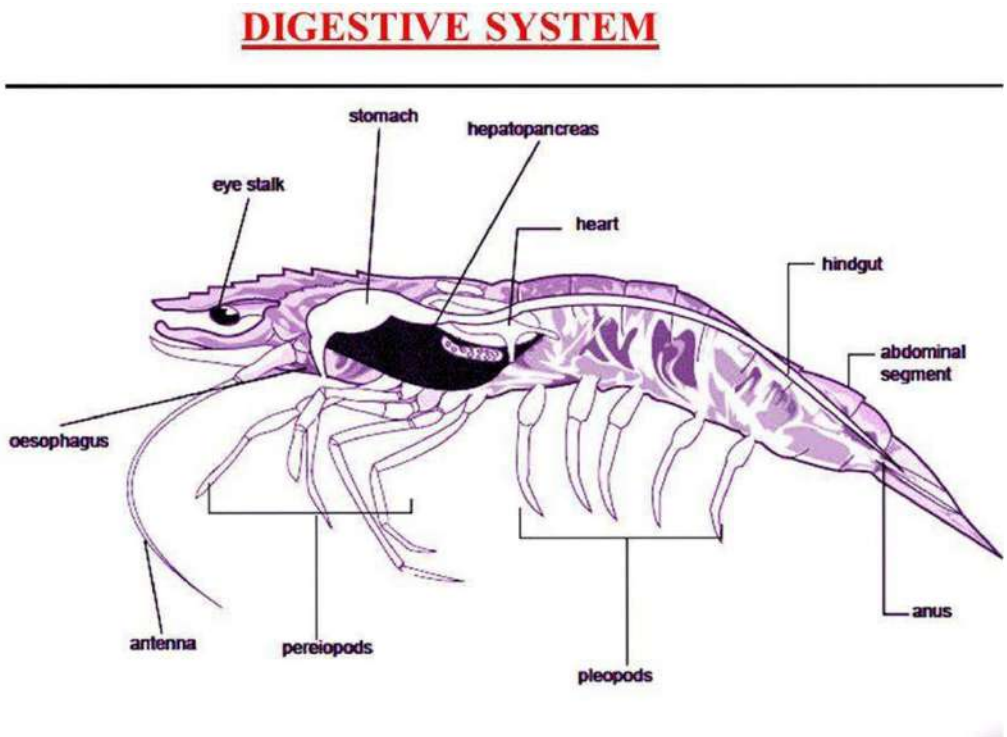
- The green glands (execratory glands) lie on the coxopodites of this pair.
- 1st antennae or antennules (1st cephalic) for tactile, chemical sensation, balancing and auditory (bear the statocysts).

Digestive system

❖ **Fore-gut:** starts with the mouth, leads into short oesophagus and stomach. The latter is divided into the cardiac or grinding stomach and the pyloric or sifting stomach. Chitin in the grinding stomach forming crushing teeth, but it forms sieving setae in the sifting stomach.

❖ **Mid-gut:** is a short tube without chitin. Two large lobed masses called the digestive glands lie on each side of mid-gut. They are for secretion and absorption.

❖ **Hind-gut:** is a straight long tube extends along the abdomen, and ends with anus on the ventral side of telson



Feeding

Ingestion: Intake of food is aided by cephalothorax appendages. The mandibles cut the food into small pieces. The maxillae and maxillipeds aid in swallowing the food. In the buccal cavity food is masticated and then passes into the cardiac stomach through peristaltic movements of oesophagus.

Digestion: Digestive juice secreted by hepatopancreas met with masticated food in stomach. It contains amylolytic, lipolytic and proteolytic enzymes that digest the starches, fats and proteins respectively.

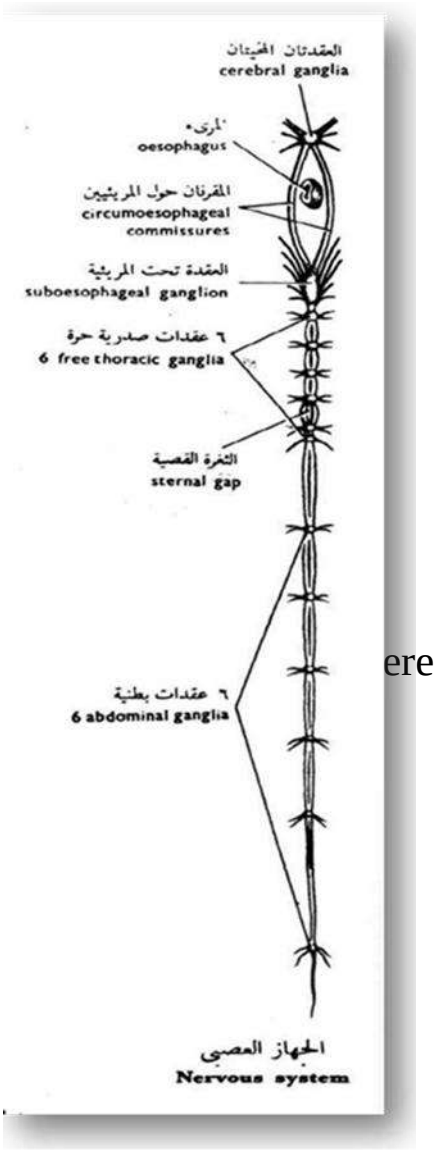
Absorption: Absorption takes place in the hepatopancreas and the intestine.

Egestion: The hindgut forms faecal pellets, which are then passed out through the muscular anus.

Nervous system

1. The supraoesophageal ganglia: found in front of the oesophagus, from this 3 pairs of nerves are given off (for eyes, antennules and antenna).
2. The suboesophageal ganglion found behind the oesophagus and connected to the supraoesophageal ganglia by the two circumoesophageal commussures. From this 5 pairs of nerves are given of (for mandibles, maxillules, maxillae, 3rd and 2nd maxillipeds)

3. The nerve cord carries 12 pairs of nerves (6 for remain thoracic appendages and 6 for the abdominal ones). The cord is doubled except in between the 4th and the 5th thoracic ganglia where the two halves separated and form the sternal gap where the sternal artery pass.



Sense organs

Compound eyes: ere are two

There are two compound eyes, one on each side of the base of the rostrum. They are at the ends of movable stalks. Each eye is made up of many optical units called simple eyes or ommatidia. Each ommatidium consists of an outermost layer called cornea, it is formed by the transparent cuticle and innermost layer called retina, it is composed of 8 pigment-sensitive retinal cells. Mosaic image is formed.

Statocysts: There is a pair of statocysts. They are organs of orientation and equilibrium. Each statocyst lies at the basal segment of the antennule. It is a sac- like structure filled with sand particles which function as statolith. The sand particles are surrounded by elongated delicate receptor setae. This sets up a nerve impulse which is conveyed to brain by nerve.

Tactile organs: Antennae are the important tactile sense organs. Many sensory setae are located over the body surface especially the appendages.

Olfactory setae: They are present in antennules.

Circulatory system

- Blood circulation is open type.
- Blood flows through the body spaces, called haemocoel.
- The circulatory system consists of heart, arteries (blood vessels), pericardial sinus, haemocoel, blood or haemolymph.

Heart: The heart is a triangular chamber. It lies in the pericardial space. It is provided with paired openings called ostia (contractile structures and work as valves to permit only flow of blood from pericardial sinus to the heart). The heart is located beneath the carapace and above the gonads.

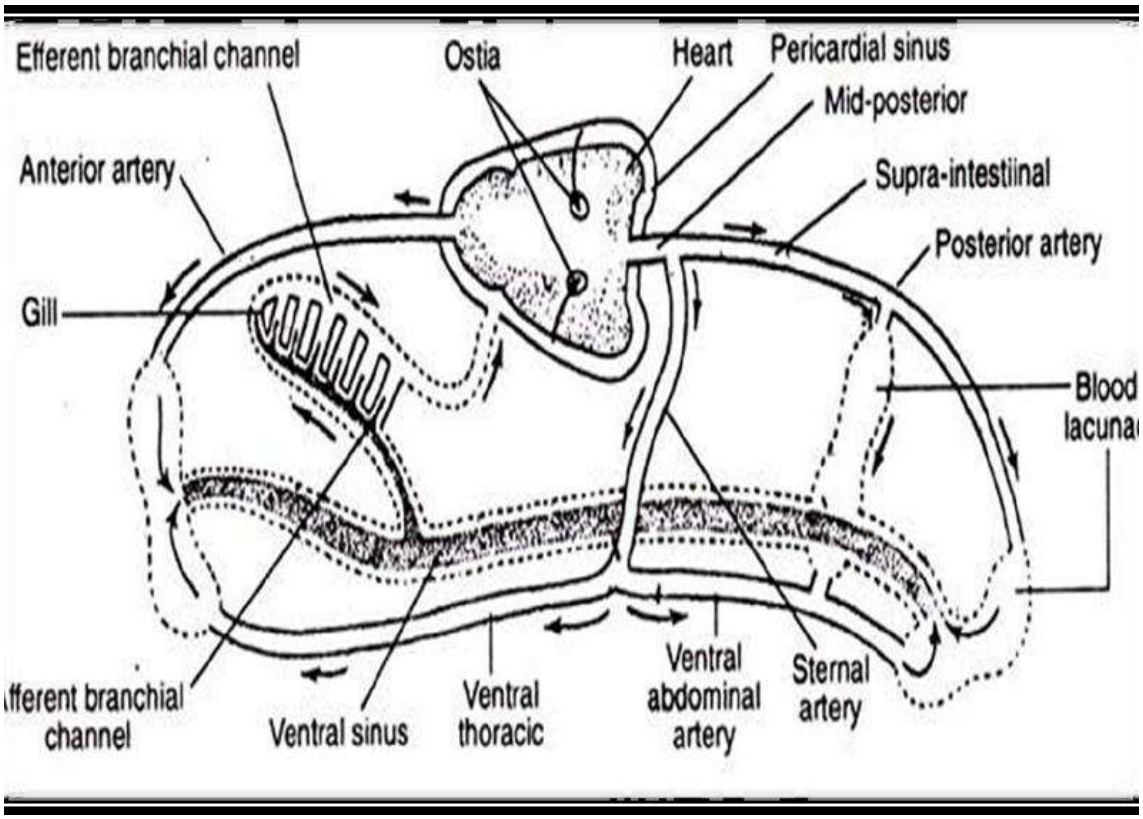
Arteries: Arteries are the main tubes which arise from the anterior and posterior regions of the heart.

Pericardial sinus: It is a large space in the dorsal part of thorax and contains the heart in it.

Haemocoel: The spaces between the visceral organs form the haemocoel. It contains blood or haemolymph. From the haemocoel blood goes to the gills through the blood channels. From the gills blood goes to the heart through blood channels. The blood contains plasma, haemocytes or blood cells and the respiratory pigment haemocyanin.

Mechanism

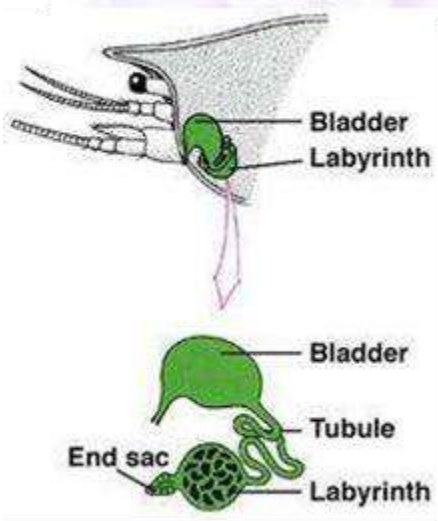
The heart contracts to drive the oxygenated blood to the different parts of the body through arteries. Arteries open directly into the haemocoel. From the haemocoel, deoxygenated blood is collected within paired ventral sinuses. Then, blood is sent for oxidation to the respiratory organs through the afferent branchial channels and returned to the pericardial sinus through the efferent branchial channels.

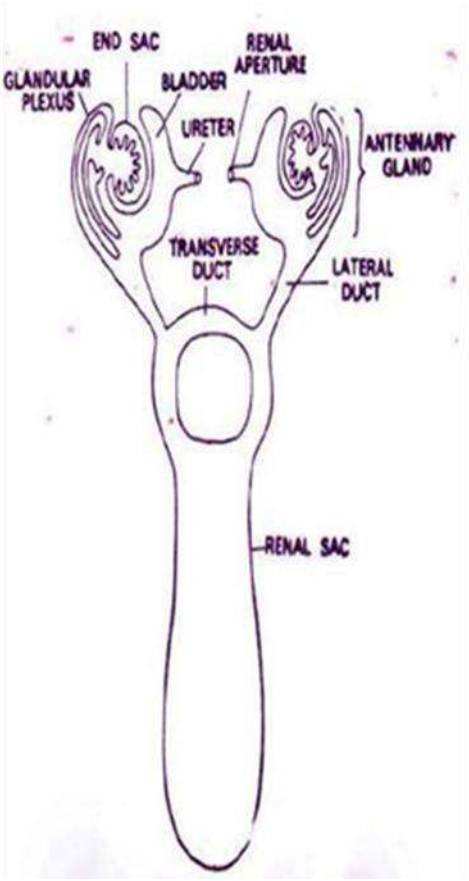


Excretory system

The excretory system consists of

1.Antennal or green glands: There is a pair of antennal or green glands. Each lies enclosed in the proximal segment (coxa) of the antenna. Its parts are an end sac, labyrinth, a coiled tube and a bladder.





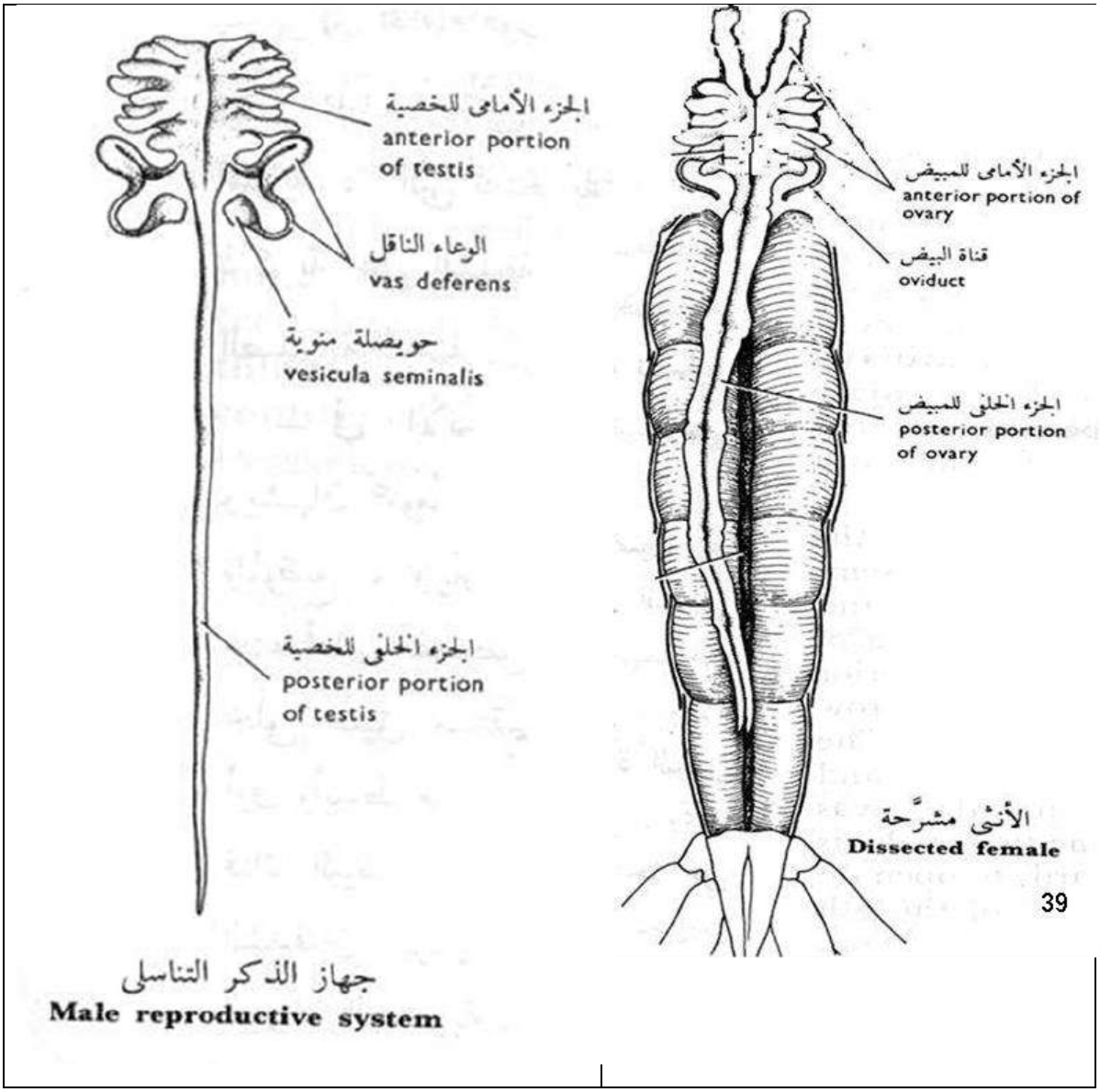
2.Renal sac: The renal sac is large, blind. It cover the cardiac stomach and reach the gonads. Anteriorly, it communicates with the green gland.

The labyrinth part is glandular and the bladder is thin walled. The bladder opens to the exterior by the excretory pore**.**

Male genital system

1. Testes: There are two testes, each one consists of a broad lobed anterior portion and a long narrow posterior one. The two posterior portions are united together across the middle line.

2. Vasa deferentia: arise near the junction of the portions of each testis, each one has a narrow anterior region, a swollen and convoluted middle region and a narrow posterior region.
3. Vesiculae seminalis: These are club shaped posterior ends of the vasa deferentia. They store spermatozoa and opens with the male genital openings.

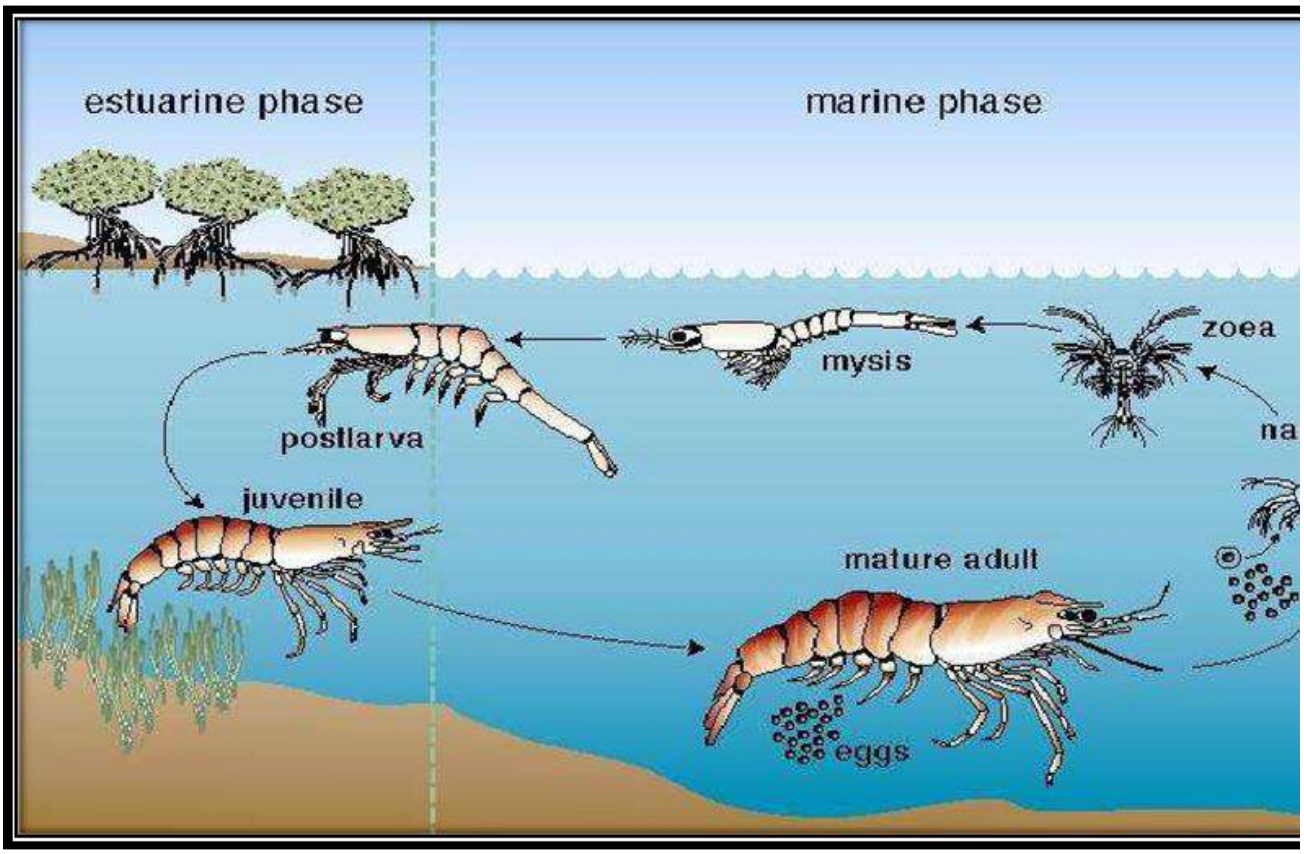


Female genital system

1.Ovaries: There are two ovaries, each one generally resemble the testis in shape (a broad lobe and a narrow lobe)

2.Oviducts: These are slender curved tubes with wide proximal ends. From the middle region of each ovary arises an oviduct. They are simpler and thinner than vasa deferentia and open with the female genital openings.

Life History



The female releases the eggs in the water. Nauplius larva emerges from the egg. It passes the metanaupleus, zoea, mysis, postlarval, juvenile stages and becomes the adult.

Larval stages

Nauplius: This larva distinguishes crustaceans from other arthropods. It consists of a head and a telson. The head provided with a simple median eye and three pairs of cephalic appendages. Telson usually bears spines or setae.

Metanauplius: It follows the nauplius stage, thoracic segments are defined and their shape is more elongated.

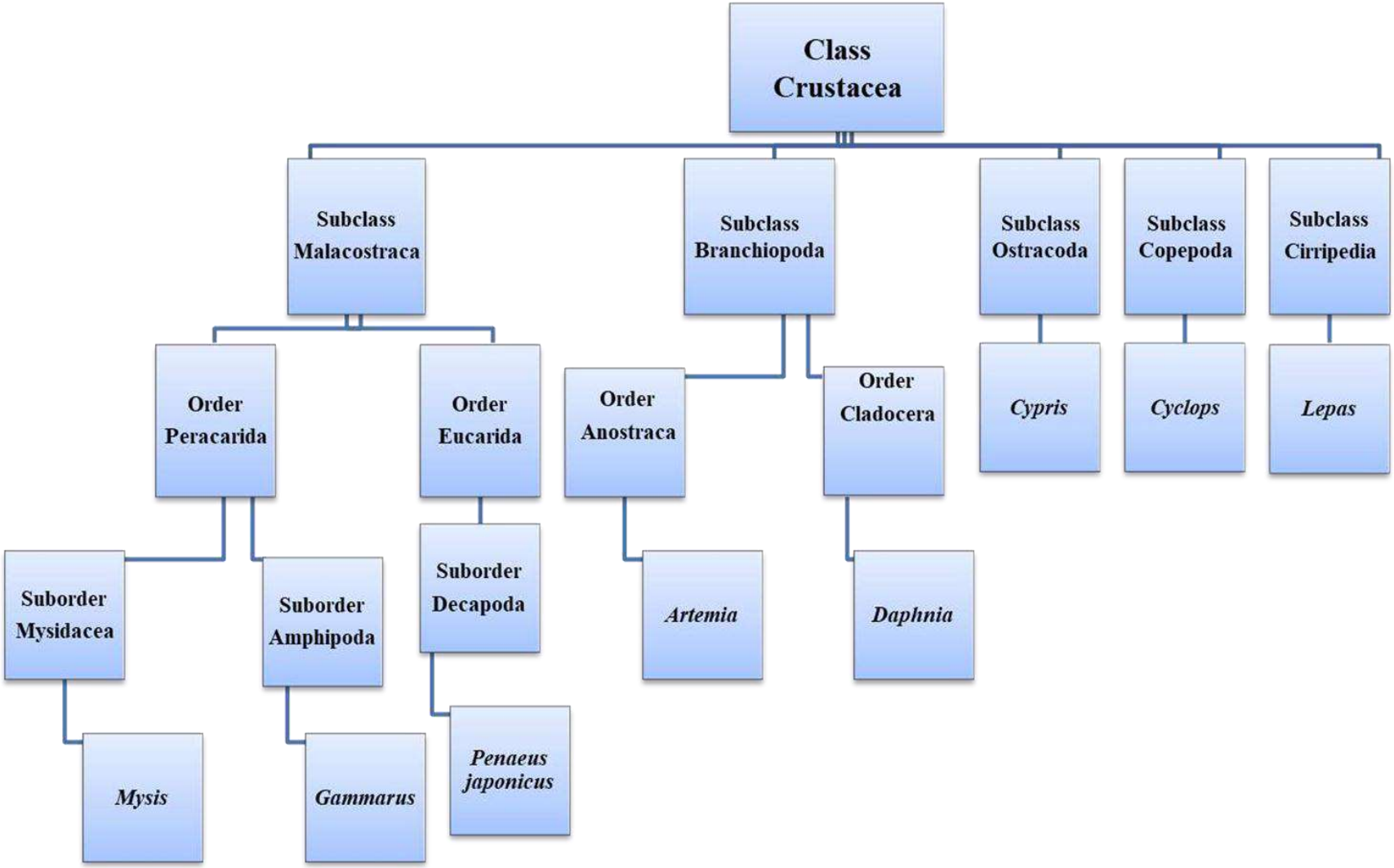
Protozoea: It follows metanauplius, thoracic segments are formed, it has a complate set of head appendages and first two maxillipeds. Upon acquiring its functional thoracic appendages, the protozoea becomes a zoea

Zoea: It bears maxilla, the third maxillipeds, the beginning of five pairs of the thoracic appendages and the abdominal segments bearing the beginning of abdominal appendages.

Mysis: It forms a carapace with a rostrum, and its thoracic and abdominal appendages are all well-developed.

Post larva: All segments and appendages are completed. It still small, does not closely resemble the adult, and is not sexually mature. It finally develops and gives the adult.

Classification of crustaceans

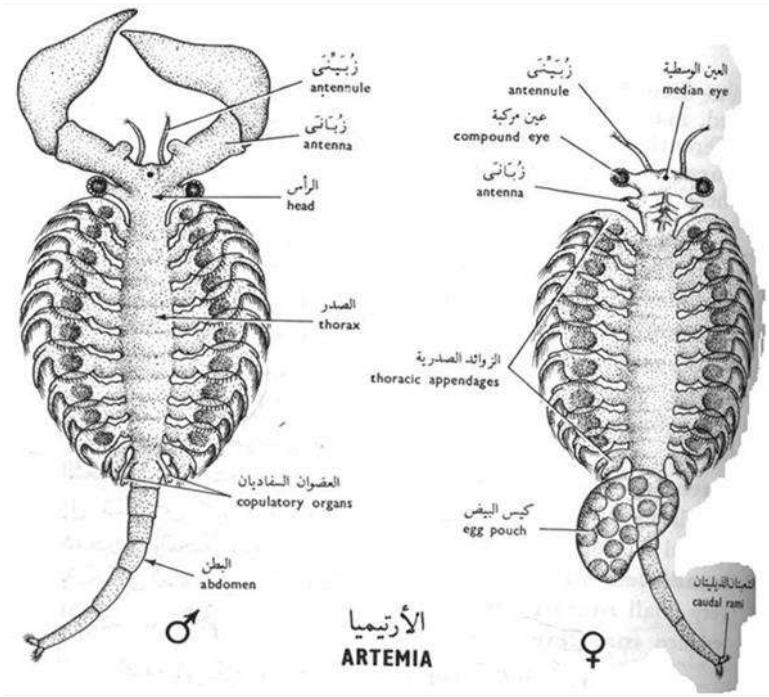


Class: Crustacea

Subclass: Branchiopoda

Order: Anostraca

e.g.: Artemia sp. (The Brine Shrimp)

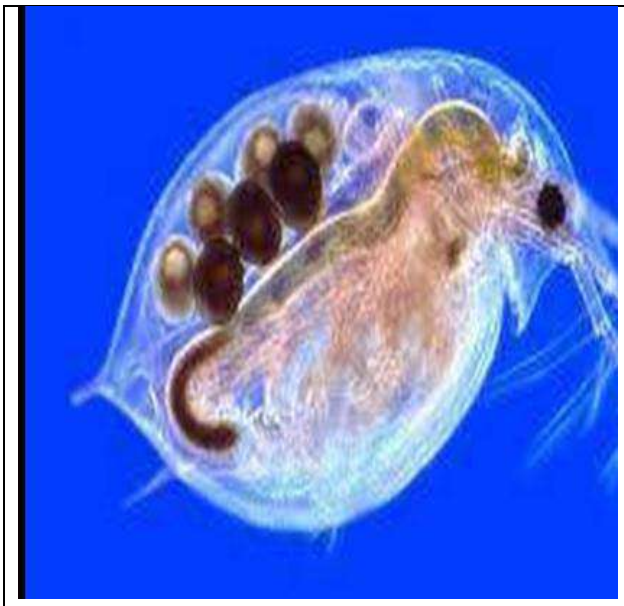


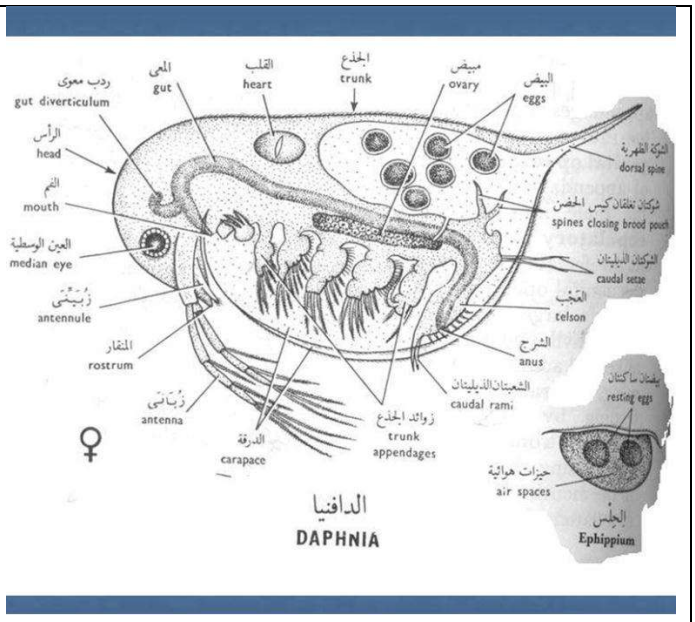
General features of Artemia

- It lives in salt lakes and marshes. It displays sexual dimorphism.
- The body consists of head, thorax and abdomen. There is no carapace. The head carries two stalked compound eyes, sessile simple eye, antennules and antennae. Antennae in female are vestigial but converted into large powerful claspers in male.
- The thorax is formed of 12 segments and carries 11 pairs of leaf-like appendages. The 12th segment bears the genital opening and a pair of copulatory organs in male and an egg pouch in female.
- All appendages are the same and adapted for swimming, respiration and filter feeding (sieving food particles from water.(
- The abdomen is formed of 6 segments without appendages and ends with two caudal rami.

Order: Cladocera

e.g.: *Daphnia* sp. (Water-flea)





General features of Daphnia

- Lives in freshwater.
- The body is egg-like, bilaterally compressed and divisible into head
- and trunk.
- A carapace of one folded piece cover only the trunk. This carapace form posteriorly a long dorsal spine.
- The head is flexed downwards and produced a beak-like rostrum. It carries a median compound eye, antennules and two long biramous antenna. The two antennae stroke the water causing jumping of the animal like flea.
- The trunk is unsegmented bears 5 pairs of leaf-like appendages and ends with the telson which bearing two caudal rami.
- The internal organs can be seen through the transparent carapace such as alimentary canal, dorsal heart, brood pouch and two ovaries (in female) or two testes (in male). The brood pouch usually contains eggs or embryos and closed by two spines.

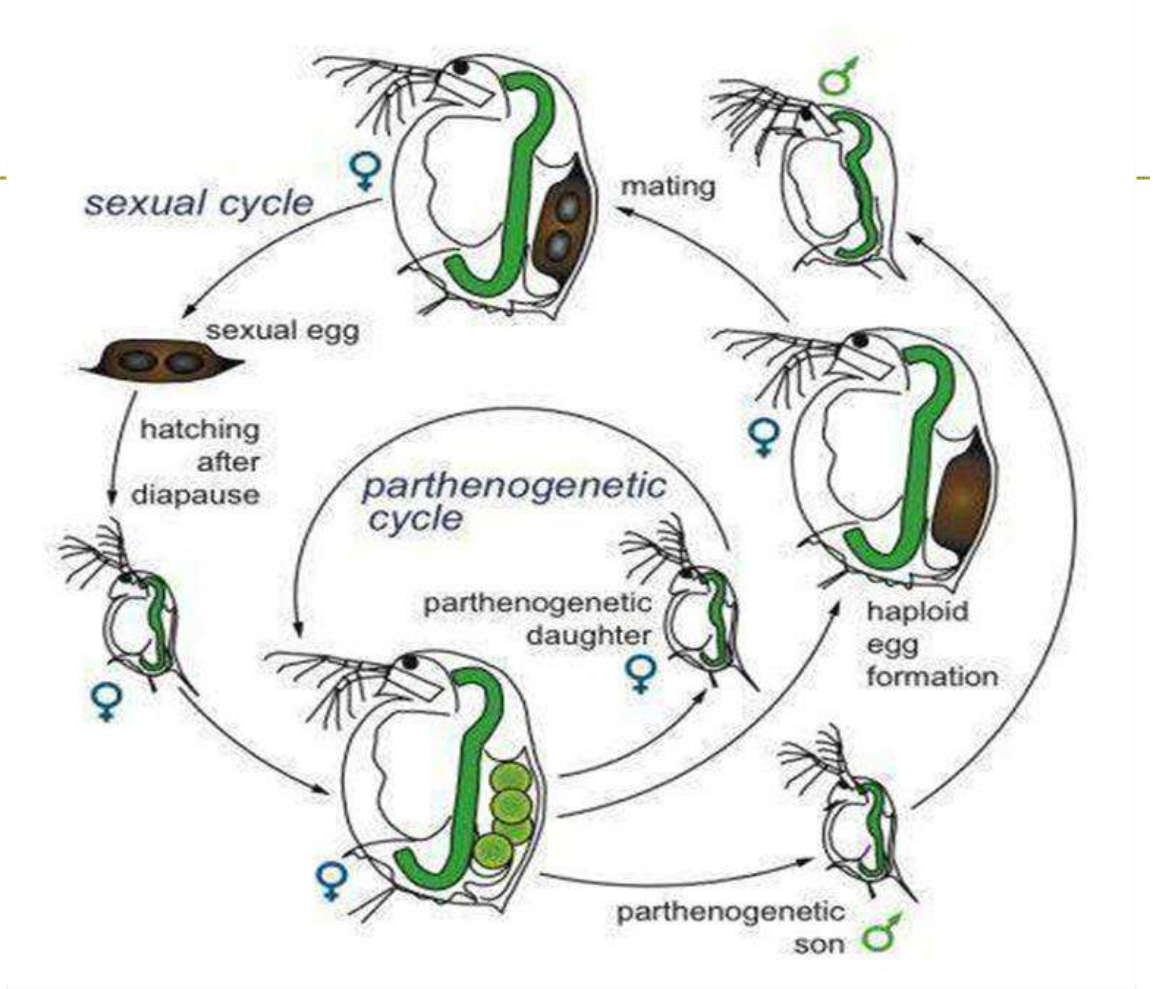
Reproduction in Daphnia

Reproduction cycle in Daphnia consists of two kinds: asexual and sexual reproduction.

1-During the favorable seasons, the female produces unfertilized eggs (with little yolk). They develop rapidly by parthenogenesis into females, hatch out in the brood pouch and escape after that to begin a new life.

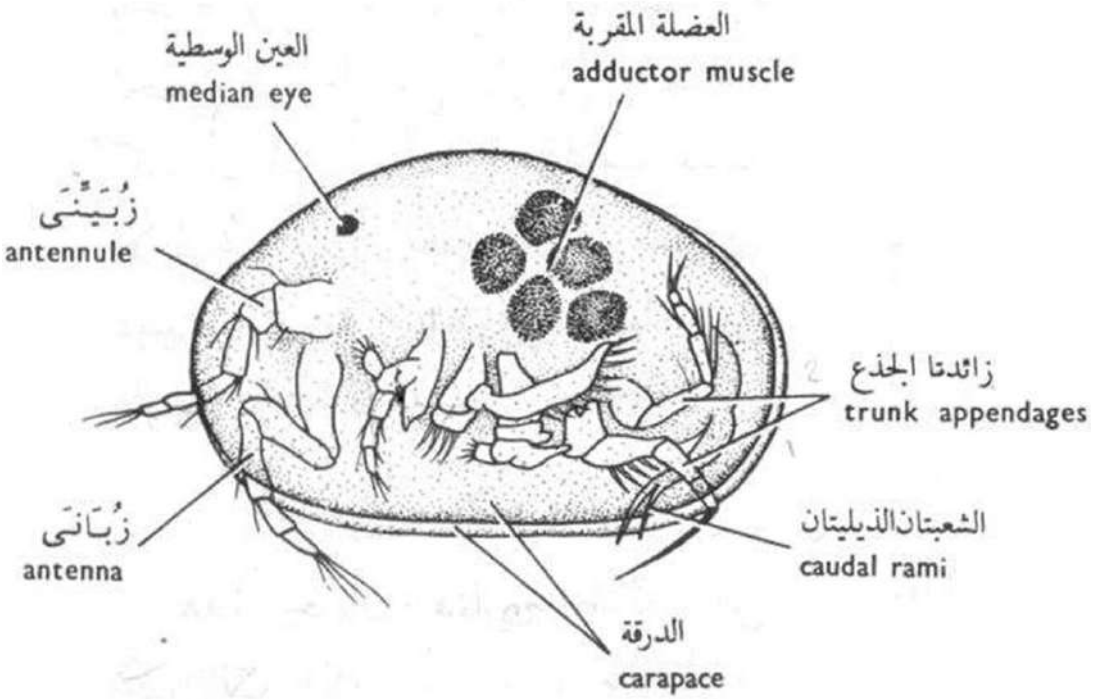
2-During the unfavourable seasons (lack of food, desiccation or low temperatures), some parthenogenetic eggs hatch out into males. Sexual reproduction takes place between the new males and females. The new fertilized eggs have plenty of yolk and each one or a pair of eggs surrounded in the brood pouch by a protective cover called ephippium.

Ephippium contains air spaces and remain dormant and withstand severe conditions, until next favorable seasons**.**



Subclass: Ostracoda

e.g.: *Cypris* sp.

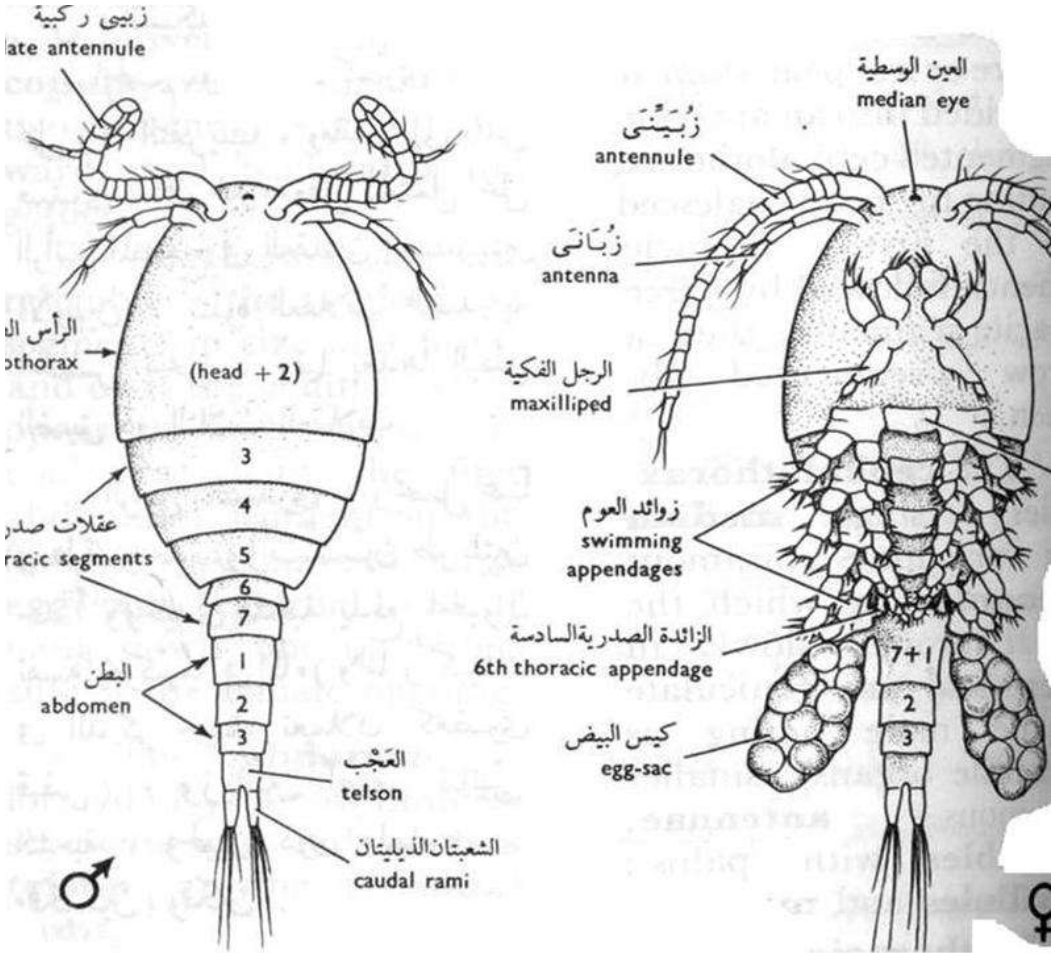


General features of *Cypris*

- Lives in freshwater.
- The body is remarkably short and indistinctly segmented.
- The carapace is formed of two valves connected by a dorsal hinge and an adductor muscle, and encloses the whole body.
- The appendages are very few, only 7 pairs are recognizable: the antennules, antennae, mandibles, maxillules, maxillae and only 2 pairs of trunk appendages.
- The posterior region of the body is limbless and ends with 2 caudal rami.
- A median eye is located near the bases of the antennae.

Subclass: Copepoda

e.g.: *Cyclops* sp.



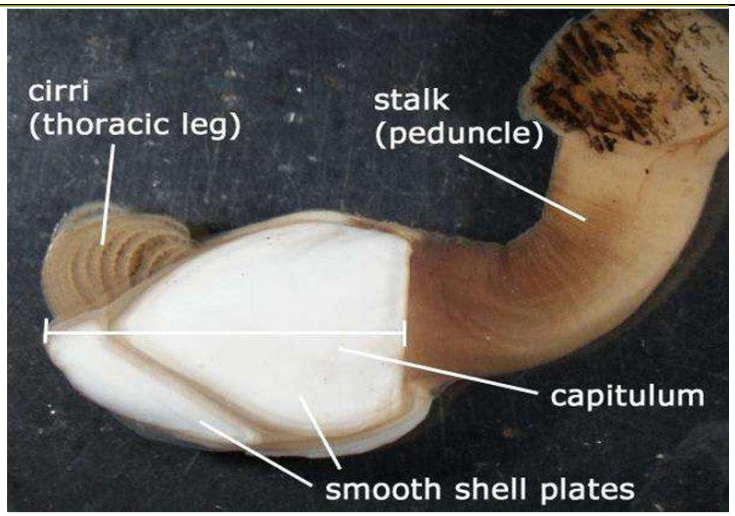
General features of *Cyclops*

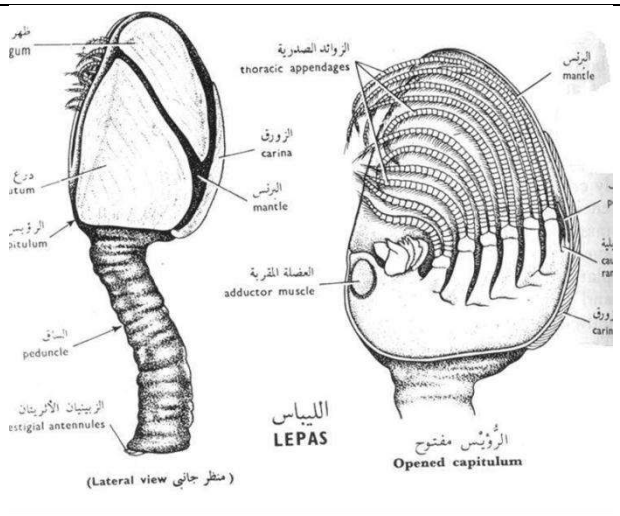
- Lives in freshwater usually with Daphnia.
- *Cyclops* is intermediate host of flatworms, fish tapeworms and nematodes..
- The body is pear-shaped and divided into an anterior unsegmented cephalothorax (head + 2 thoracic segments), 5 free thoracic segments and a narrow 3-segmented abdomen.

- The cephalothorax carries one median eye, long antennules by which the animal move in water (they are geniculate in male) and smaller antennae.
- The thoracic appendages are 6 pairs: the 1st pair uniramous maxillipeds) and the 2nd pair (swimming limbs) carried on the cephalothorax. The other 3 pairs (swimming limbs) carried on free thoracic segments from 3- 5. The 6th pair of appendages are uniramous and reduced, on the 6 thoracic segment.
- The swimming appendage is biramous and each pair connected to each other by a plate (the copula), which make the two appendages move together.
- The 7th thoracic segment resembles the abdominal segments in size and form, and on it the genital system opens in both sexes. It fused in female with the 1st abdominal segment and a pair of egg-sacs hang down on the sides.
- The abdomen bears no appendages and ends with telson bearing 2 caudal rami.

Subclass: Cirripedia

e.g.: *Lepas* sp.





General features of *Lepas*

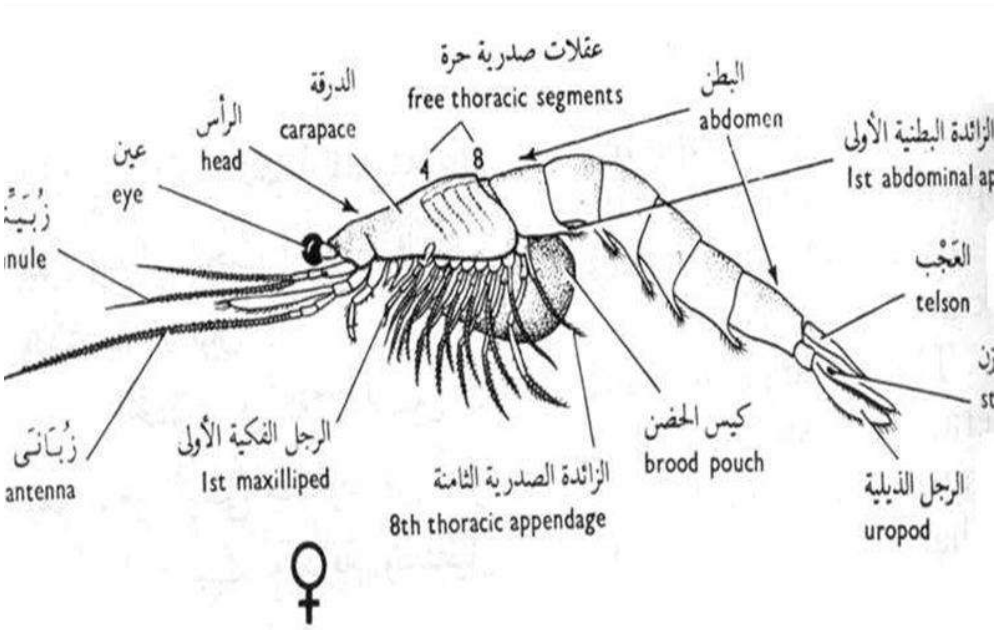
- It lives attached to the bottom of ships or floating things in the sea.
- The body is divisible into peduncle and capitulum. The peduncle represets the anterior region of the body. It is a long flexible extension contains two cement glands opens on vestigial antennules by which the peduncle fastened to the substratum.
- The capitulum is consisting of the rest of head, the thorax and the reduced abdomen. It is bilaterally compressed and enclosed in a fold of skin called the mantle except ventral slit. The mantle with 5 calcareous plates: a median carina, two anterior scutum and two posterior tergum.
- Internally, the head without antennae or eyes. The thorax carries 6 pairs of cirriform appendages, each one with two long cirri with bristles filter the food from water and driving them to the mouth.
- The abdomen is indistinct and limbless. Two caudal rami and a long Penis project at its end.

Subclass: Malacostraca

Order: Peracarida

Suborder: Mysidacea

e.g.: *Mysis* sp.

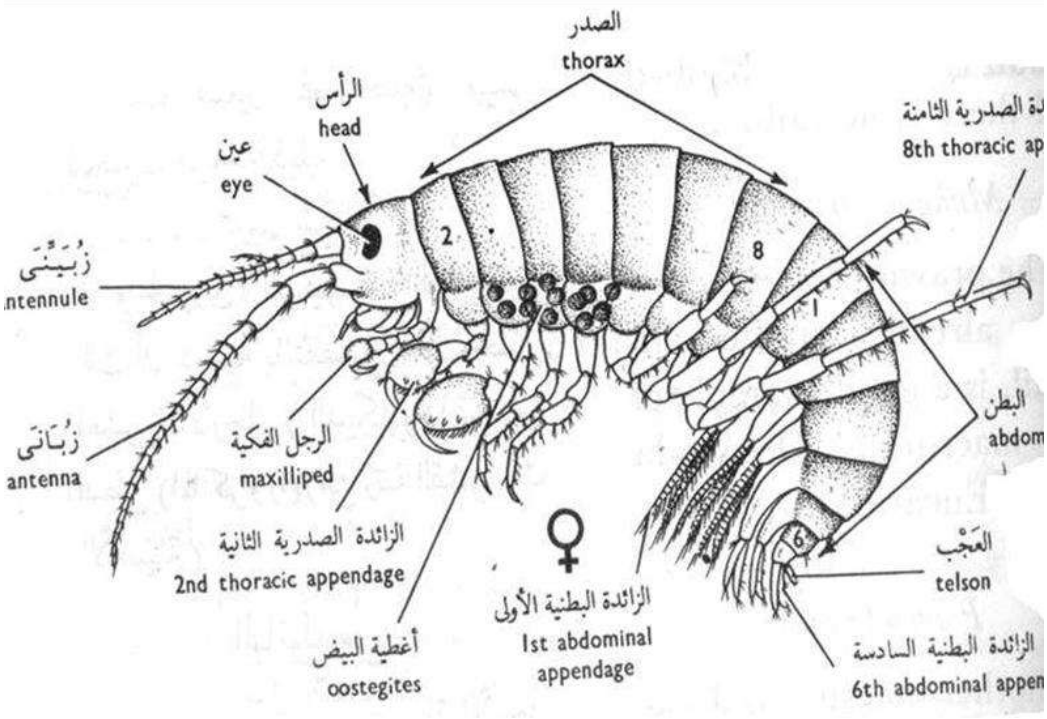


General features of *Mysis*

- Members of this genus inhabit the sea and freshwater.
- The body is small and bilaterally compressed. The carapace fuses with 1-3 thoracic segments.
- On the head, note the stalked eyes and the biramous antennules and antennae.
- All the thoracic appendages are biramous, the first two pairs are maxillipeds, each of the rest has two long jointed rami with bristles and adapted for swimming and food capture. In the females, some thoracic appendages bear flattened oostegites which form a brood pouch.
- The abdomen with 6 segments. The abdominal appendages are biramous swimmerets (vestigial in the female).

Suborder: Amphipoda

e.g.: *Gammarus* sp.



General features of Gammarus

- Common in shallow brackish and freshwater.
- The body is elongated bilaterally compressed without carapace and the 1st thoracic segment fused with head.
- On the head, note the sessile eyes, two antennules and two antennae. There is a pair of maxillipeds (the 1st thoracic appendages(
- The other 7 thoracic segments bear 7 pairs of appendages. The 2nd and 3rd pairs are prehensile, the 4th and 5th pairs turned forwards and help in feeding, the last pairs turned backwards and used in creeping. Some thoracic appendages bear coxal plates acting as gills and oostegites in the female.
- The abdomen with 6 segments. The first 3 pairs of appendages are swimmerets and each has two bristled segmented rami. The last 3 pairs with two unsegmented rami, used in jumping. The telson is small.

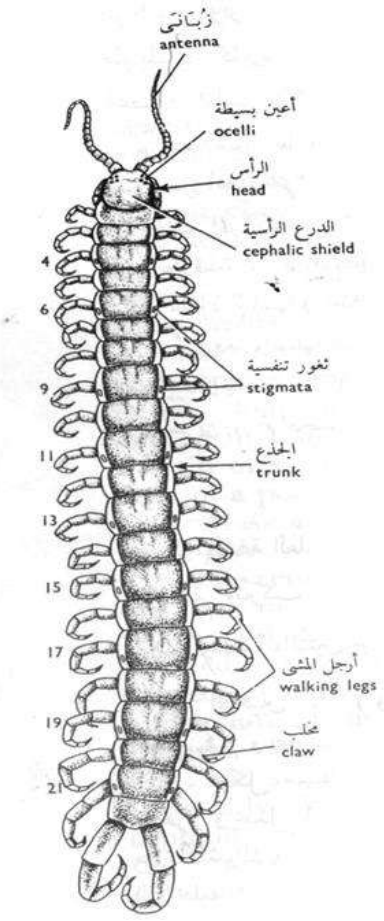
Subphylum: Trachaeta
Class: Myriapoda

General features:

1. All are terristrial.
2. The body is elongated with a consicous head and a trunk consisting of many segments between 11-177 segments, each one bears one or two pairs of appendages.
3. Each appendage with 7 segments and a claw.
4. The head bears two antennae, two or three pairs of jaws and simple eyes.
5. Respiration through spiracles which connected internally with the tracheal system.
6. Excretion through Malpighian tubules which open in the hind- gut.
7. Sexes are separated. Development usually direct.

Subclass: Chilopoda

e.g.: Scolopendra morsitans



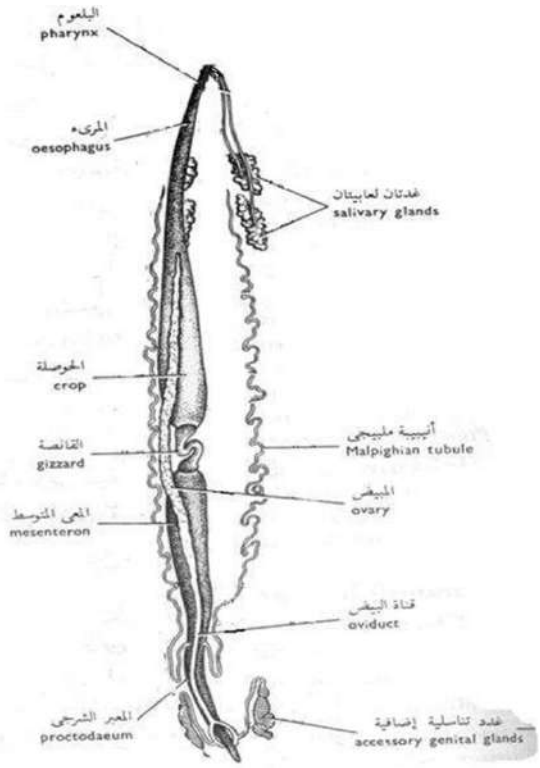
General features of *Scolopendra*

- Hides by the day below stones or plant leaves and runs faster at night to prey insects and earthworms.
- The body is elongated, dorsoventrally flattened and divided into head and trunk.
- The head consists of 6 segments covered by a cephalic shield. There are two lateral groups of simple eyes (ocelli), each group of 4 ocelli. The head bears two segmented antennae (the main sensory organs.(
- The trunk with 22 segments, each segment covered by a dorsal tergum, ventral sternum and 2 lateral pleura.

- The first segment has no separate tergum (maybe fused with the cephalic shield), this segment bears ventrally the maxillipeds or two poison claws, each ends in a sharp claw on which opens the poison gland.
- Each segment from 2-22 carries one pair of walking legs (which together with the 2 antennae make the 44 appendages). Each leg is built up of 7 segments named from the base: coxa, trochanter, femur, tibia and 3 tarsi ending in a claw.
- Paired respiratory openings or stigmata lie on the pleural shields of the segments 4, 6, 9, 11, 13, 15, 17, 19 and 21. Note that these segments longer than the other segments. The anus opens ventrally on the last segments.

The digestive system

1. The fore-gut starts with mouth- pharynx, short oesophagus, thin-walled crop then gizzard. The gizzard is tubular and twisted like S. There are two salivary glands open anteriorly in the buccal cavity.
2. The mid-gut is dilated straight tube.
3. The hind-gut is short and opens with anus.



The execretory system

is a pair of long tubules (Malpighian tubules) open at the junction between mid-gut and hind-gut.

The nervous system

- ❖ The 2 cerebral ganglia: lie dorsal to the pharynx. And give off nerves to the eyes and antennae.
- ❖ The suboesophageal ganglion: is large and connected to the cerebral ganglia by a pair of circumoesophageal commissures . It gives off nerves to the rest of the head segments and the first trunk segment carrying the maxillipeds.
- ❖ The nerve cord: extends from the suboesophageal ganglion, along the mid-ventral line to the posterior end of the body. It carries 21 ganglia and its two halves are separated from one another between the ganglia.

The female genital system

- The ovary: is single extends on the dorsal side of the gut. It is a slender tube enclosing the eggs.
- The oviduct: is straight, biforked around the hind-gut into two tubes, recieves some accessory genital glands and opens ventrally with the genital opening on the last segment**.**

The male genital system

- The testis: is single extends on the dorsal side of the gut. It is formed of 8-10 paired, spindle- shaped, straight tubules which are connected by fine connections.
- Vas deferens: is wide and highly convoluted. This tapers posteriorly and bifurcates into 2 ducts and receive on each side a long U-shaped vesicula seminalis and an accessory genital gland. The two ducts open on the last segment by a median genital opening.

Subphylum:Chelicerata
Class: Arachnida

1. Most are terristrial and some are aquatic.
2. The body is divided into two regions: the prosoma and the opisthosoma.

- The prosoma includes head and thorax and in adult consists of 6 segments: the first bears a pair of chelicera, the second bears a pair of pedipalps and the 4 other segments with 4 pairs of walking legs.
- The opisthosoma consists of 12-13 segments and divided to mesosoma and metasoma (or not divided) and usually without any appendages.

3. The exoskeleton is strongly chitinized.
4. The eyes are sessile and mostly simple.
5. Respiration by lung-books, tracheae or by gill-books in aquatic forms.
6. Excretion by coxal glands or Malpighian tubules.
7. Open circulatory system.
8. Sexes are separate and development is usually direct.

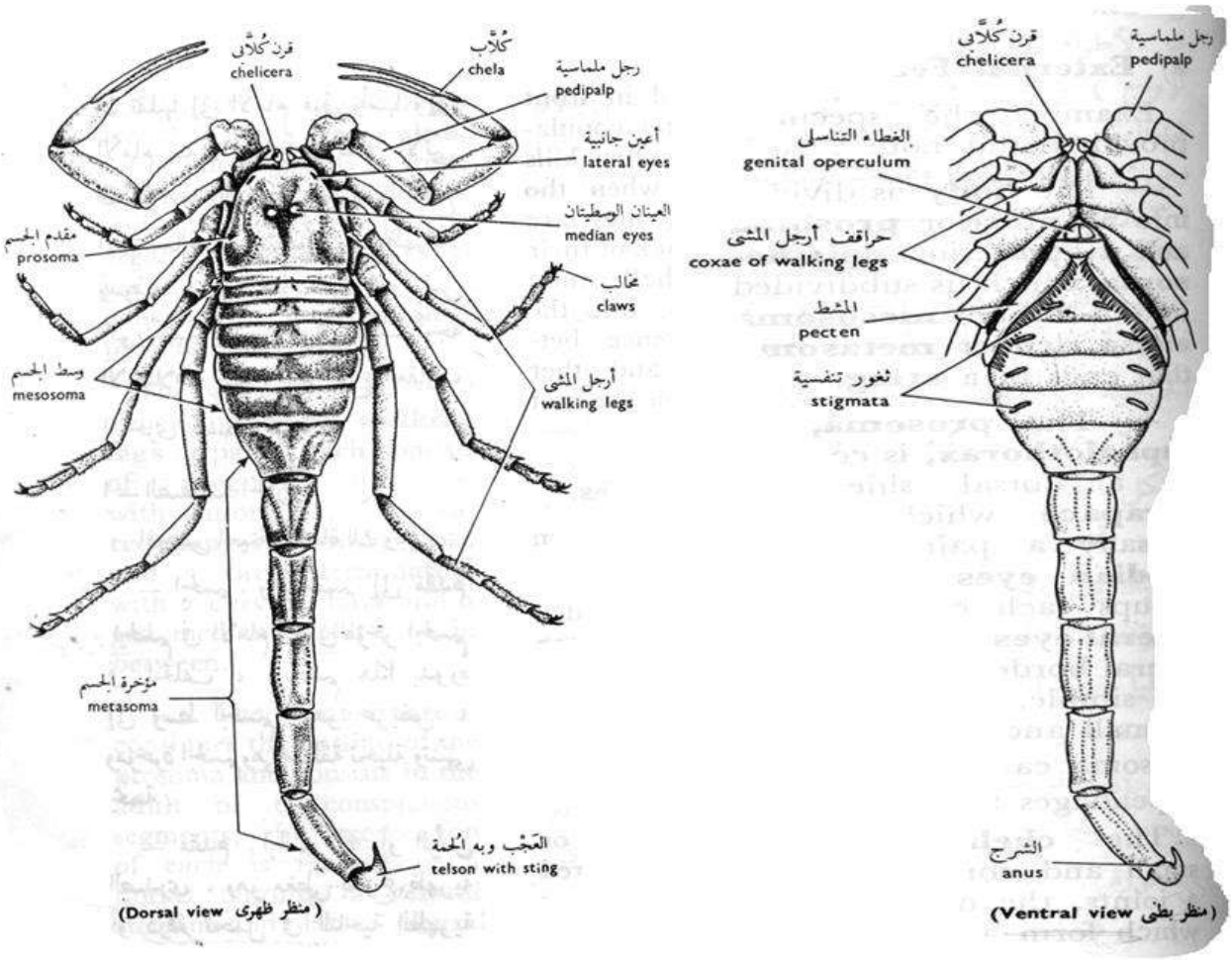
Order: Scorpionidea

e.g.: ***Buthus quinquestriatus***

General features of Buthus

- It is a dangerous animal, spread in tropical and temprate regions. It is nocturnal (active at night), feeds on juice of insects and spiders.

- The body is divided into prosoma and opisthosoma which is subdivided to a broad mesosoma and a slender matasomaends in a sting.



- The mesosoma in adult consists of 6 segments, the first segment carries on its ventral side a divided genital operculum covers the gental opening. The second segment carries a pair of comb-like structures (the pectens) act as tactile organs (longer in the male). The 4 other segments with 4 pairs of stigmata on their ventral side, lead internally into the lung-books.
- The metasoma consists of of 6 narrow cylindrical segments jointed to one another. The last segment terminates with the telson which

forms the sting. Two poison glands are found within the sting and open near the spine.

The digestive system

The mouth is located at the front of the body and followed by a muscular pharynx that absorbs prey juice and blood. The pharynx leads to an esophagus in which a pair of salivary glands opens and followed by the midgut, which is a long tube with glandular walls, and in its several narrow tubes connected to the digestive gland or liver. The midgut leads to the hindgut, which is a narrow tube, and the hindgut opens to the anus.

The excretory system

Excretion in scorpion is carried out by:

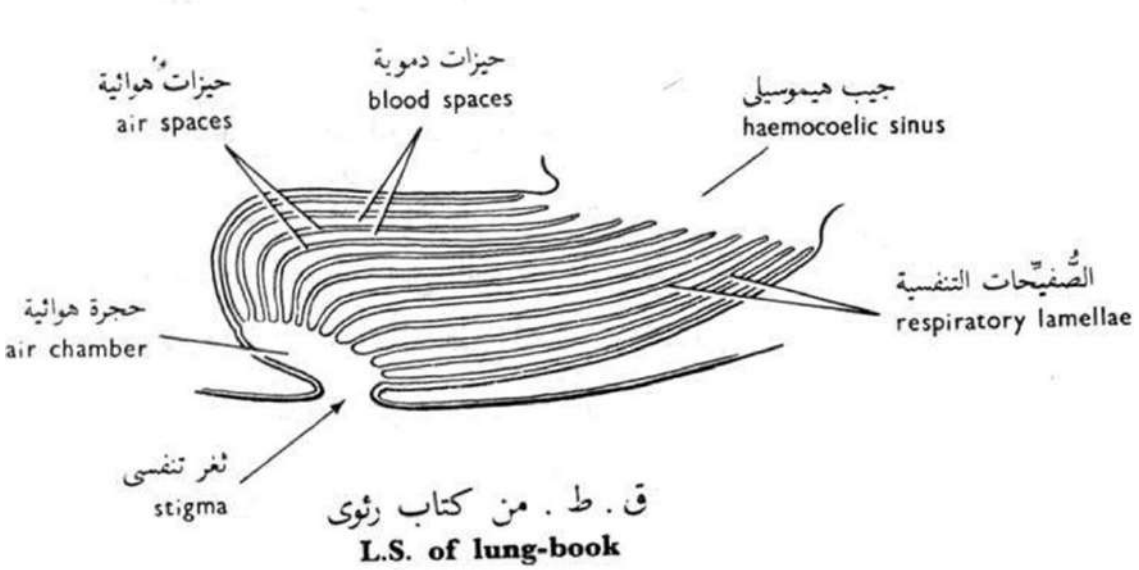
A pair of coxal glands found in the posterior part of prosoma and each opens externally on the coxopodite of the third walking leg.

Two pairs of Malpighian tubules (or maybe one pair) open in the gut at the posterior end of mesosoma.

The nervous system

- The 2 cerebral ganglia: lie dorsal to the pharynx and give off nerves to the eyes.
- The suboesophageal ganglion: is large and connected to the cerebral ganglia by a pair of circumoesophageal commissures . It gives off nerves to all segments and appendages of the prosoma as well as the first 4 segments of the mesosoma.
- The nerve cord: is distinctly double and carries 8 ganglia, one in each of the last 2 mesosomatic and all metasomatic segments.

The respiratory system



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L.S. of lung-book

There are four pairs of lung-book in the scorpion. Each lung- book consists of stigma which leads into a wide air chamber. The respiratory lamellae are numerous hollow ingrowths of the body which are set up parallel to one another like the papers of a book. Each lamella encloses a narrow air space. The haemocoelic sinus is a spacious cavity filled with blood and all the lamellae project into it. The blood from this sinus circulates in the compressed blood spaces between the lamellae, and thus respiratory exchange take place through the thin walls of the lamellae.

The male genital system

It consists of a pair of testes, each of them consists of two longitudinal tubes. Each tube is connected to the other with transverse branches. The vas deferens is a common median tube, and it connects to the testis. There are two seminal vesicles, two additional glands in addition to a double intromittent penis connected with the vas deferens.

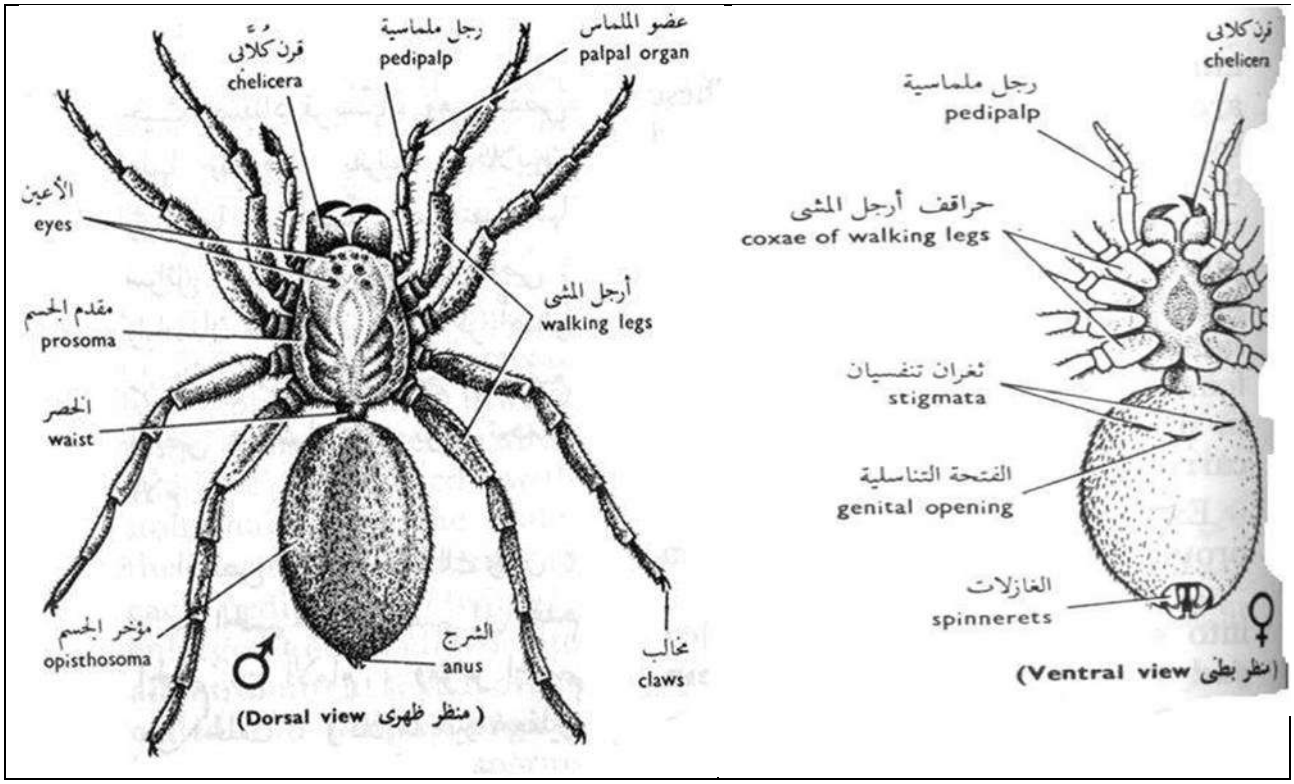
The female genital system

It consists of one ovary located in the posterior half of the mesosoma. The ovary consists of 3 longitudinal tubes that are connected to each other by transverse branches. There are two seminal reservoirs (each one is tubular in shape) connected to the ovary. Then, the vagina is a short median tube that opens to the exterior through the genital opening on the genital operculum.

Fertilization in scorpions is internal. The male meets the female for a long time, and after fertilization, the female kills the male and eats it. They are ovoviviparous and the eggs hatch during her reproductive period and development is direct. The little offsprings go up on the mother's back and the mother surrounds them with a silk tissue to protect them, and they stay on her back (about a week) until they grow up a little, then the little ones leave the mother.

Order: Araneida

e.g.: *Lycosa ferox*



General features of *Lycosa*

- It is a large ground spider, spins no web but lives on the ground and hunts its prey.
- The body is divided into an anterior prosoma and a posterior opisthosoma, both unsegmented and connected to each other by a narrow soft waist.
- The prosoma covered dorsally with the shield and bears 8 simple eyes arranged in three rows: 4 small eyes in the anterior row and 2 large eyes in each of the second and third rows. There are 6 pairs of appendages: the chelicerae (with a claw opens with the poison

gland), the pedipalps (with a swollen genital organ called the palpal organ in male) and 4 pairs of walking legs.

- The opisthosoma is cylindrical and unsegmented covered with hairs. The anterior ventral side with two lateral stigmata and a median genital opening. There are 3 pairs of movable organs called the spinnerets (2 large superior, 2 small middle and 2 large inferior) which bear the spinning glands.

The digestive system

- The mouth is located at bases of pedipalps ventrally and leads to pharynx and followed by a narrow esophagus that expands backward, forming a special sucking stomach. The midgut extends and gives rise to diverticula. The midgut is followed by the rectum, which is a thin tube and comes out of it dorsally a large sac known as the stercoral pocket.

The excretory system

Excretion is carried out by:

- A pair of coxal glands opens in the strocoral pocket on the top of the rectum.
- A pair of Malpighian tubules such as those found in crustaceans.

The respiratory system

There are a pair of lung-books in the wolf spiders. Each lung-book consists of about 15-20 thin respiratory lamellae, containing blood vessels where air exchange takes place.

Some spiders have developed tracheal systems similar to those seen in many insects.

The male genital system

It consists of two tubular testes, each leads to a narrow convoluted tube. The 2 tubes communicate medially and lead to a short vas deferens, opens in the genital opening.

The female genital system

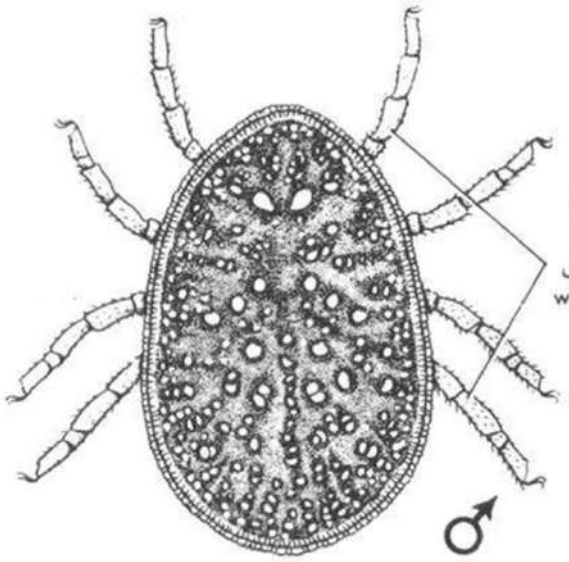
It consists of two ovaries. There are two short oviducts, unite in the middle and form the vagina, which opens to the outside with the genital opening. One, two or three seminal receptacles open in the vagina or open independently on the surface.

Fertilization is internal. The male produces semen, and hold it in their palpal organs until they find a female. The semen is inserted into the female genital opening. They are oviparous, the eggs are placed inside silk cocoons and development is direct.

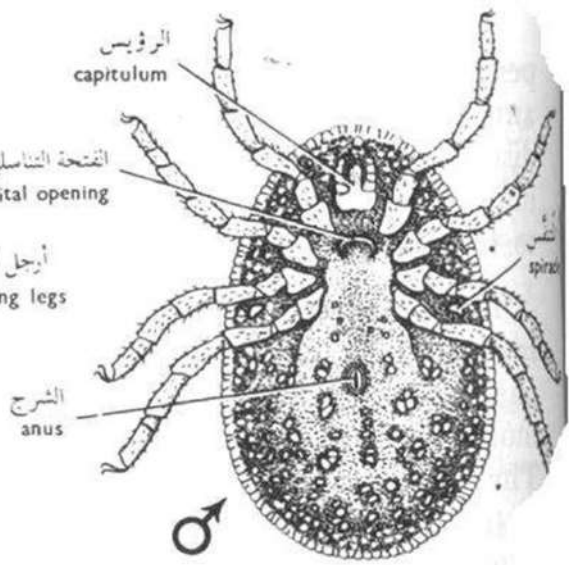
Order: Acarina

Family: Argasidae

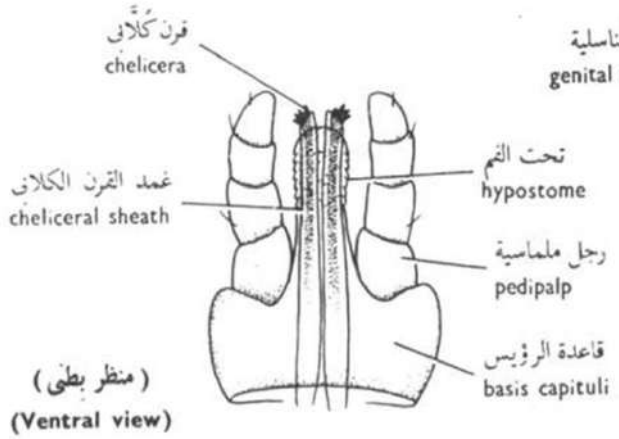
e.g.: *persicus Argas*



(منظر ظهرى Dorsal view)

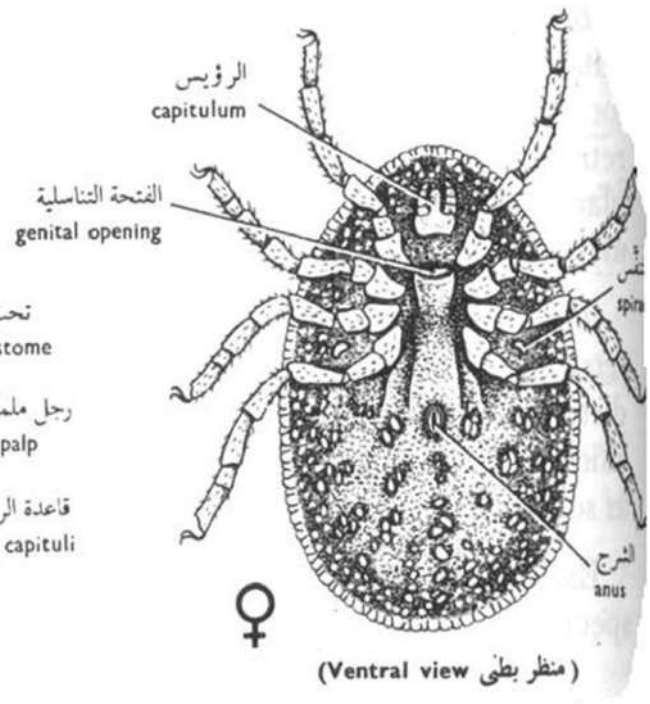


(منظر بطنى Ventral view)



(منظر بطنى)
(Ventral view)

الرُّؤيس مكبَّر
Enlarged capitulum



(منظر بطنى Ventral view)

General features of *Argas*

- It is an ectoparasite of birds, causes many diseases and feeds on the blood.
- The body is ovoid, unsegmented and dorsoventrally flattened. It is covered with soft spotted integument.
- The capitulum is a head-like strutcure, found in the ventral side and does not project in the front. It cosists of the basis capituli bearing 4-segmented pedipalps and a proboscis. The proboscis is formed of two dorsally serrate chelicerae (for piercing the skin of the bird) enclosed in a sheath and a ventral hypostome, between them a channel is formed for the sucked blood.
- Ventrally, there are 4 pairs of walking legs. The single genital opening lies between the 1^{st} and 2^{nd} pair (it is semicircular in male and transverse in female).
- Two stigmata found between the 3^{rd} and 4^{th} pairs of legs. The anus is placed in the center.

The importance of Arthropods

- Many of species are considered food for human like: the prawn, crabs, lobsters, etc.……
- Some species produce useful products such as: silk, honey and wax.
- Considered the main source of fish food.
- There are some dangerous species such as scorpion, Scolopendra and some spiders
- Some substances extracted from some species used in medicine industry.
- Many types of insects are essential in plant pollination.
- Some species transmit many types of diseases to man such as flies and mosquitoes and some are ectoparasites on mammals such as: ticks, fleas,…….

Phylum: Mollusca

1. Lives in water (freshwater or marine) and some forms are terrestrial. Molluscs come in the second rank after arthropods according to the number of species.
2. They are triploblastic, mostly bilaterally symmetrical except class: Gastropoda.
3. The body is soft, unsegmented without any appendages and divided into: head, a ventral foot and a dorsal visceral hump (no head in class: Bivalvia.(
4. The visceral hump is covered by a thin, fleshy fold called mantle. Mantle secretes a calcarious shell, which may be external or internal or not present at all.
5. Mantle also encloses an opened mantle cavity, within lie a pair of gills, the anus and renal openings.
6. Coelom is reduced represented by the pericardial cavity, cavities of gonads and kidneys.
7. Respiration by gills in aquatic forms and by lungs in terrestrial forms.
8. The circulatory system is open (except class: Cephalopoda) consists of a heart enclosed in a pericardial cavity and extends into a haemocoel.
9. The nervous system contains 3 doubled ganglia: the cerebral, pedal and lateral ganglia and maybe visceral ganglion in some forms. Sense organs are eyes, tentacles and statocyst.

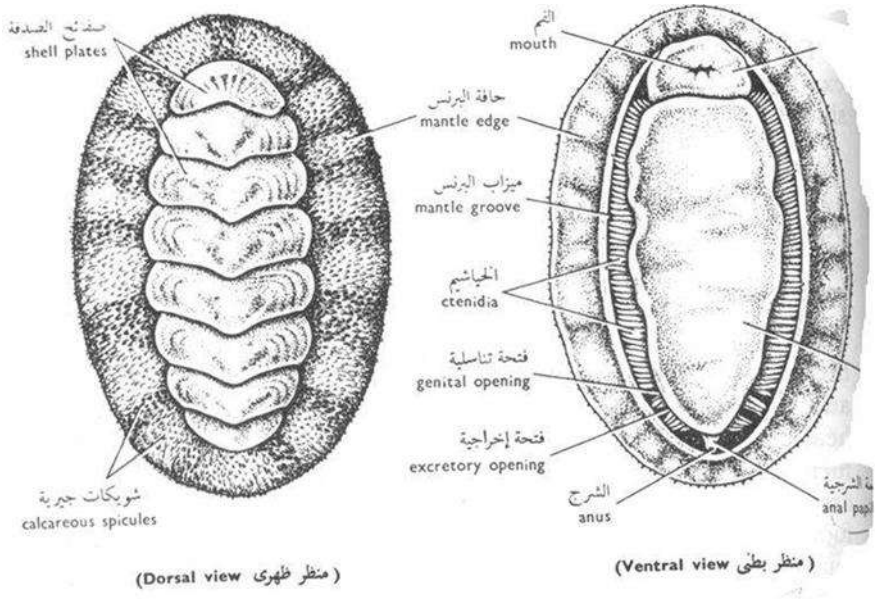
10. Locomotion takes place by ventral muscular foot.
11. The digestive system with salivary and digestive glands. The mouth with a hard chitinous structure, called radula or odontophore (absent in class: Bivalvia()
12. Sexes are usually separate and some are hermaphrodite. Development may be direct or indirect forming larvae.

Class : Placophora (Amphineura)

1. All are marine, present in all depths and contains all chitons.
2. Head is poorly developed without eyes or tentacles.
3. Mantle covers all dorsal surface and secrets calcareous spicules and usually also a shell.
4. Foot is flattened and large like a sucker.
5. Feeds on aquatic plants and algae.
6. Development includes a larvae called: trochophore

Class: Amphineura (Placophora)

e.g.: Acanthochiton spinigera



General characters of Acanthochiton

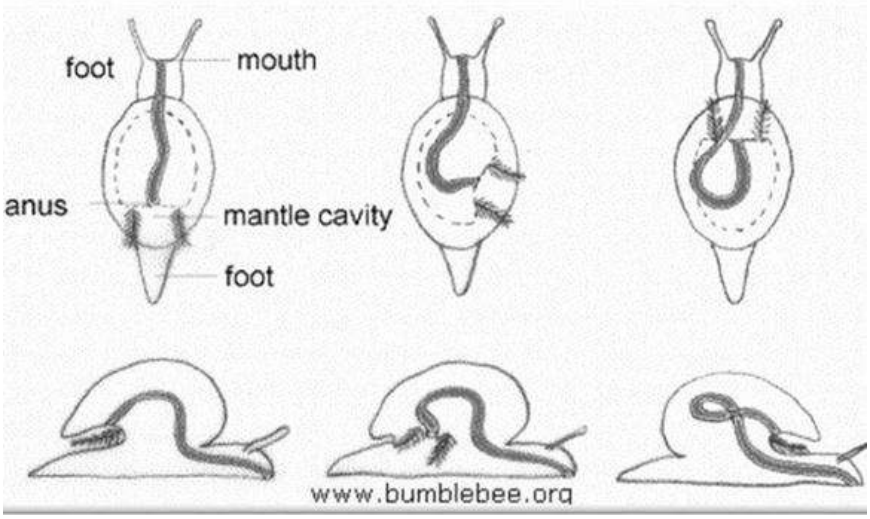
- It is common on our sea coasts, adhering to rocks, but when separated strongly from the rock, it rolls itself up to more or less spherical form like a ball.
- The body is elongated and oval in shape. The mantle secrets in the dorsal side a calcareous shell formed of 8 overlapped plates, enabling the animal to roll into a ball. The mantle edge with calcareous spicules.
- In the ventral side, the head is small with only a mouth. The foot is large acts as a creeping organ and as a sucker.
- The mantle cavity is a groove between head-foot and the mantle edge, within found the gills on each side. The anus opens on a papilla projecting behind the foot. In front of anus on each side, an excretory pore and a genital opening.

Class: Gastropoda

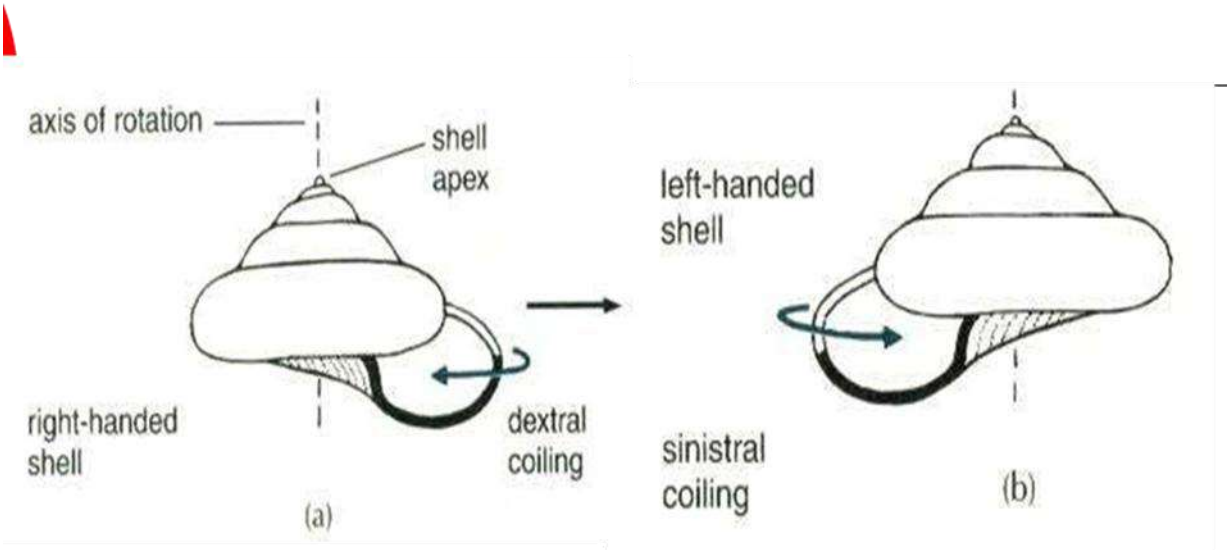
- Gastropoda is the large class of molluscs, lives in marinewater, freshwater and on land.
- The head and foot are fused in one structure (the head- foot), this part is bilaterally symmetrical, but the visceral hump is asymmetrical, due to two processes happened in the embryonic stages called: the torsion and the spiral coiling.
- The mantle form a coiled shell with different colours but sometimes disappear from some forms like slugs.
- Development is direct.
- It is herbivorous, and some species are predators or parasitic.
- Some species acts as intermediate hosts for some parasites like Fasciola and Schistosoma

Torsion and spiral coiling in gastropods

Torsion occurs in gastropods during the larval development, where the body is symmetrical (mouth in front and anus in behind). Torsion is the rotation of the visceral mass and the mantle cavity 180˚ anticlockwise. Torsion brings anus and all other openings just behind the head.

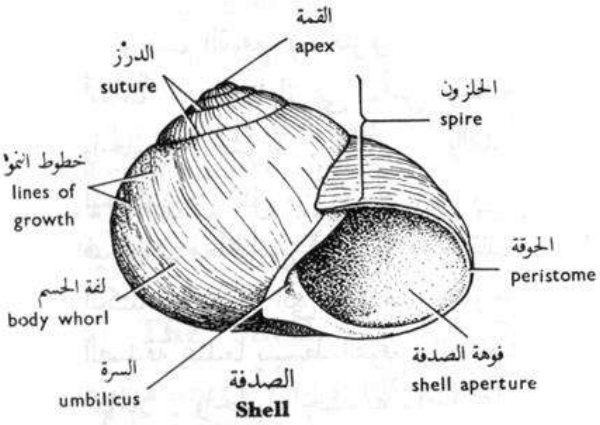


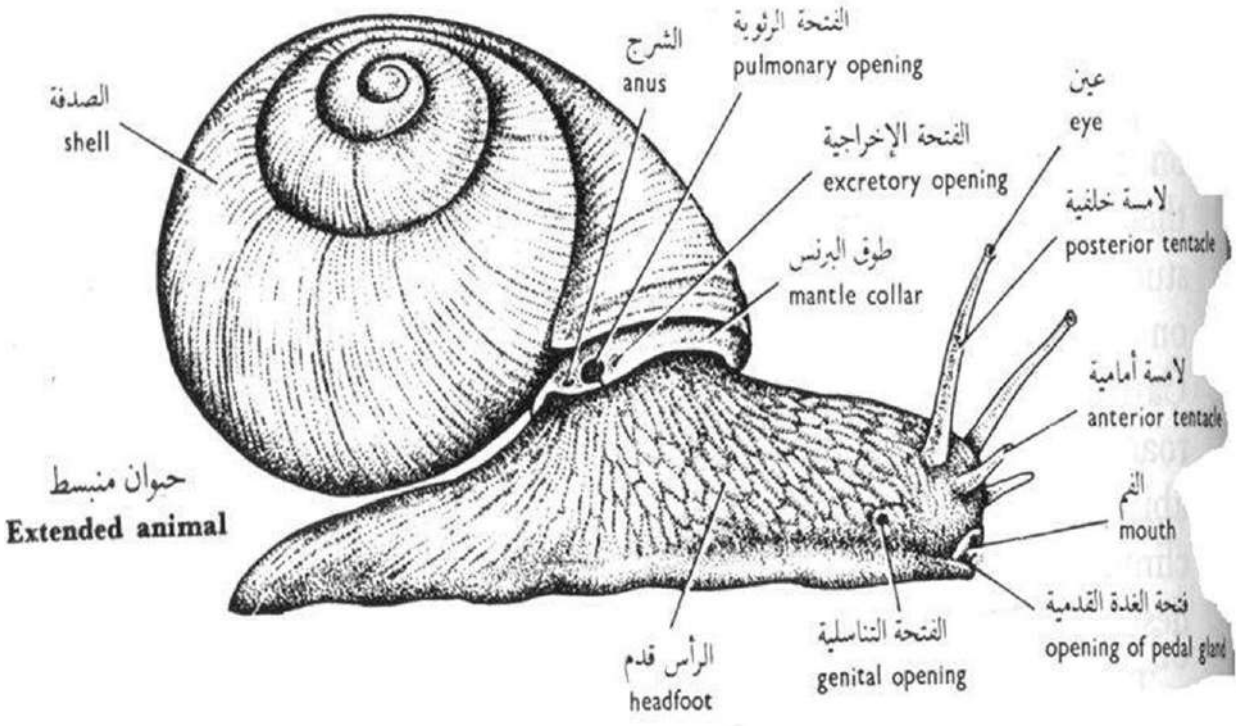
Spiral coiling: due to torsion process, the development of the visceral mass is a problem, so it coiles with its shell: clockwise causes dextral (right handed) coiling of the shell, or anticlockwise which causes sinistral (left handed) coiling of the shell.



Class: Gastropoda

e.g.: *Eremina desertorum*





General characters of *Eremina*

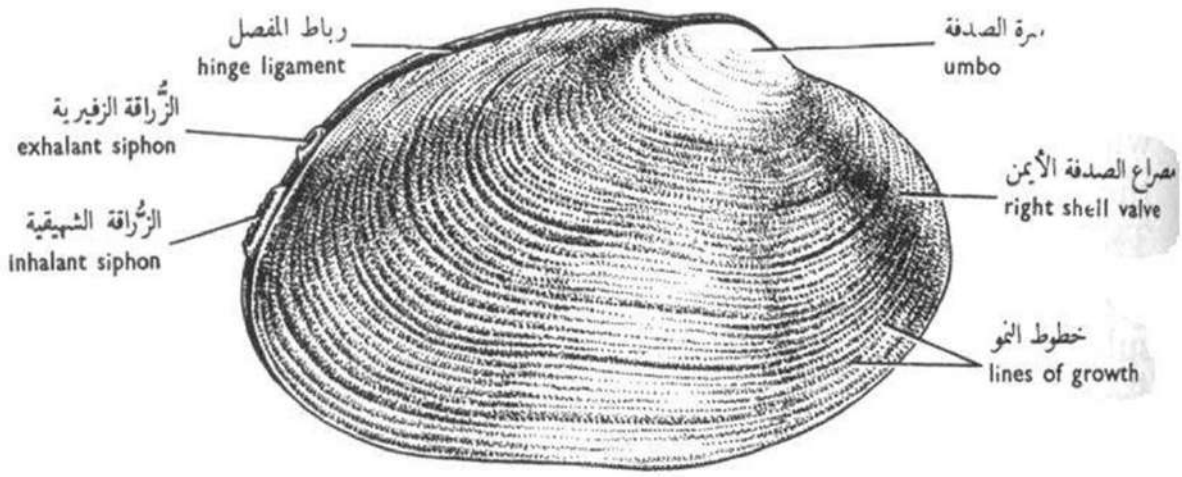
- Common in the Egyptian desert, feeds on leaves and stems of desert plants. It is nocturnal hides in its shell during the day. It is active in winter.
- The shell with 4 whorls, and it is dextral.
- The headfoot mass bears anteriorly: the mouth, below it an opening of a gland (the pedal gland) produce a slimy secretion. There are 2 pairs of tentacles: the anterior pair is short, but the posterior one is long with two black eyes. A single genital opening found on the right side of head.
- The visceral hump is spirally coiled and occupies the shell whrols. The mantle form a thick ring called the mantle collar, bears on the right side: the pulmonary opening which leads internally to a cavity rich with blood vessels and acts as a lung. Note also the anus and the execretory opening on the mantle collar.

Class: Pelecypoda (Bivalvia) or Lamellibranchiata

- Most are marine and some are freshwater.
- The mantle consists of two lobes (right and left), so the shell is bivalved, the two valves hinged dorsally and jointed by a ligament.
- The head is reduced, only labial palps around the mouth. No
- radula because they are ciliary feeders.
- Moves very slowly by the foot, but mostly buried in the sand with its front.

- Sexes usually separated, but some are hermaphrodite. Development includes a larva called: veliger larva in marine forms.

e.g.: ***Anodonta rubens*** **(freshwater mussel or clam)**



General features of *Anodonta*

- Lives on the bottom of the river.
- The shell with 2 lateral valves, hinged dorsally. The umbo is a swollen apex found near the anterior part. Note the parallel lines of growth on the outer surface.
- Internally, the mantle consists of 2 lobes, which united together posteriorly to form two tubes: the exhalent siphon (small and smooth-walled) and the inhalent siphon (wider and papillated edges for testing water.(
- The visceral hump is the compressed mid-dorsal portion of the body.
- The foot is a large mass, which drags the animal very slowly in the bottom mud.

- The labial palps are 2 pairs around the mouth carry cilia which drive food particles towards the mouth.
- The gills are 2 in number, very large and each one is formed of two plate-like folds.
- The muscles showing on the mantle surface are: the anterior and posterior adductor muscles which controlling the shell valves. The anterior and posterior retractor muscles which withdraw the foot inside the shell. The protractor muscle which forcing the foot outside the shell. Note the insertions of these muscles on the smooth inner surface of each valve.

Class :Cephalopoda

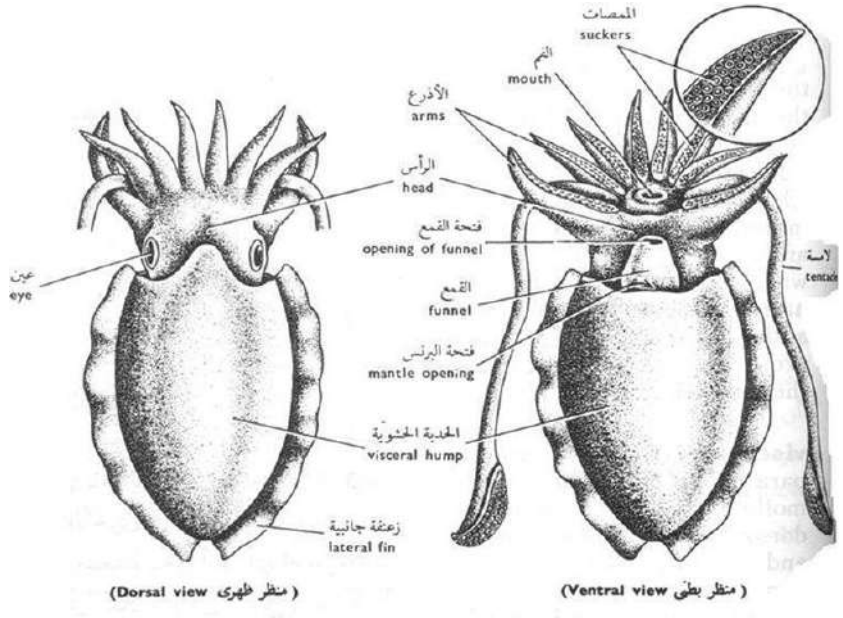
- All are marine, it is the highest molluscs in development.
- The shell present internally or absent.
- The head is well-developed, with large eyes (as vertebrates eyes). The head bears a number of tentacles and arms (8-10) with strong suckers to capture the prey. These arms maybe are the modified anterior part of foot, thus called: Cephalopoda (head-foot.(
- They are predators, so the mouth contains the radula and two sharp horny claws.
- The mantle cavity present in the ventral side contains the gills, anus, execratory and genital openings, also a muscular funnel opens in the cavity (it is the posterior part of foot).
- The circulatory system is closed.

- The nervous system is the highest system in all invertebrates, the ganglia are concentrated and fused together to form a brain eclosed in a cartilaginous capsule which contains statocysts.
- The sexes are separated and the development is direct.
- Cephalopods have several modes of defense. Some species can release light (Bioluminescence). Some species contains Chromatophores in their cells allow them to change colour. Lastly, most species have a sac which contains a black ink- like substance that can envelop and temporarily cloud the enemies' vision.

Order: Dibranchiata

Suborder: Decapoda

e.g.: *Sepia savignyi*



General features of *Sepia*

- The body is divided into a head and a visceral hump.
- The head with 2 large eyes similar to those of vertebrates. Also bears the mouth which surrounded by 8 arms (each arm is provided with 4 rows of suckers) and two long tentacles. The tentacles are used in catching the prey and the arms for holding it during eating.
- A muscular funnel found in the ventral side of the head, it opens in the mantle cavity. The water from the mantle cavity is forced out through the funnel opening causing the animal jerk backwards and emits a cloud of ink to escape from enemies.
- The visceral hump with 2 lateral fins, by which the animal swim. An internal shell present in the dorsal side of the visceral hump

beneath the integument. Ventrally, occures the mantle cavity with a wide anterior mantle opening.

The importance of molluscs

1. Some species of Gastropods consider as food for a lot of vertebrates and some people eat certain types of snails.
2. Some snails acts as intermediate hosts for some parasites like *Fasciola* and *Schistosoma*
3. People feeds on most species of bivalves like clams.
4. The shells of some bivalves are important in the button industry. Also some companies grind the shells and offer them as food rich in calcium for birds.
5. Some countries use broken shells in pavements.
6. Pearl production (from some bivalves) is an important industry, especially in Japan, China, Australia.
7. Some bivalves can dig into untreated wood or rocks and damage marine constructions, such as piers and boats.
8. The squid shell grind and offer them as food for birds and some companies use this shell in toothpaste industry.

Phylum: Echinoermata

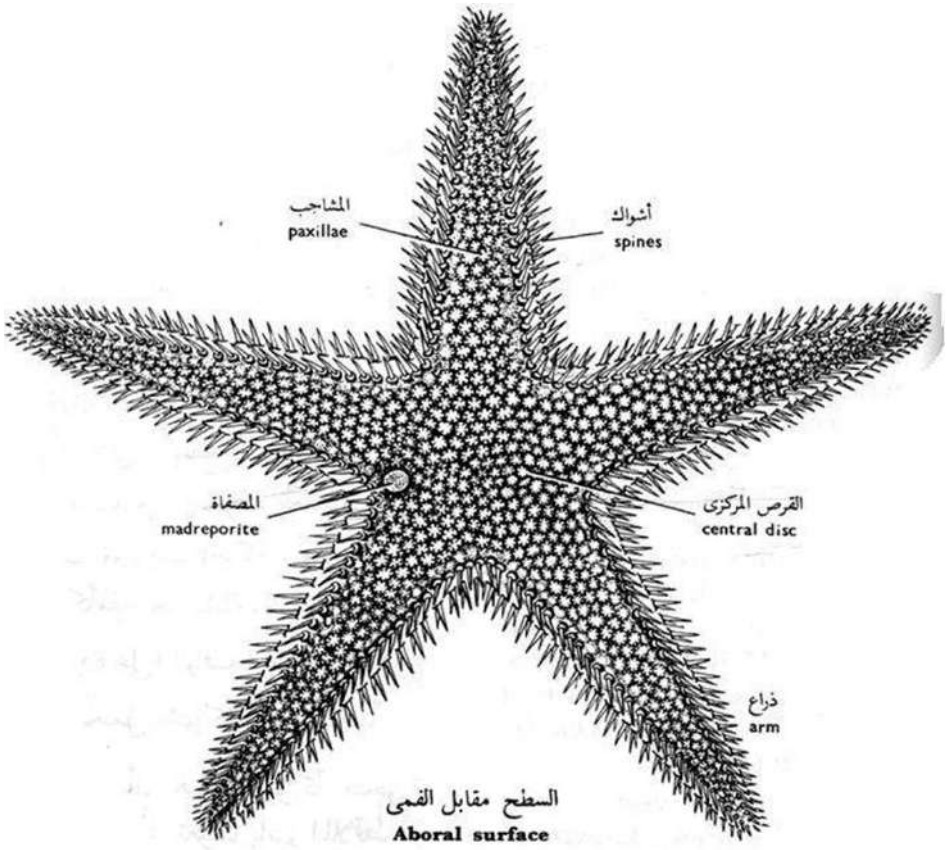
- All are marine, found in the shores to the great depths. Includes forms quite different from the preceding invertebrates.
- Some are free living and some are sessile.
- Adults are radially symmetrical while larvae are bilaterally symmetrical.
- The body is not divided, with different shapes (star, rounded or cylindrical.(
- They possess a dermal skeleton consists of calcareous ossicles which may develop into short or long spines pushes out on the surface, thus the name: Echinodermata.
- The coelom divided into several divisions (perivisceral coelom, perihaemal cavity and a water vascular system characterize this phylum.(
- The water vascular system is connected to tube feet present on the outer body surface, these feet are the main locomotion organs but can also assist in sensation, respiration and food collecting.
- Respiration by dermal gills, tube feet or respiratory tree in class: Holothuroidea.
- The nervous system with circumoral nerve ring and radial nerves in all body.
- The digestive system is usually complete but in some forms
- there is no anus.
- The circulatory system is very reduced.

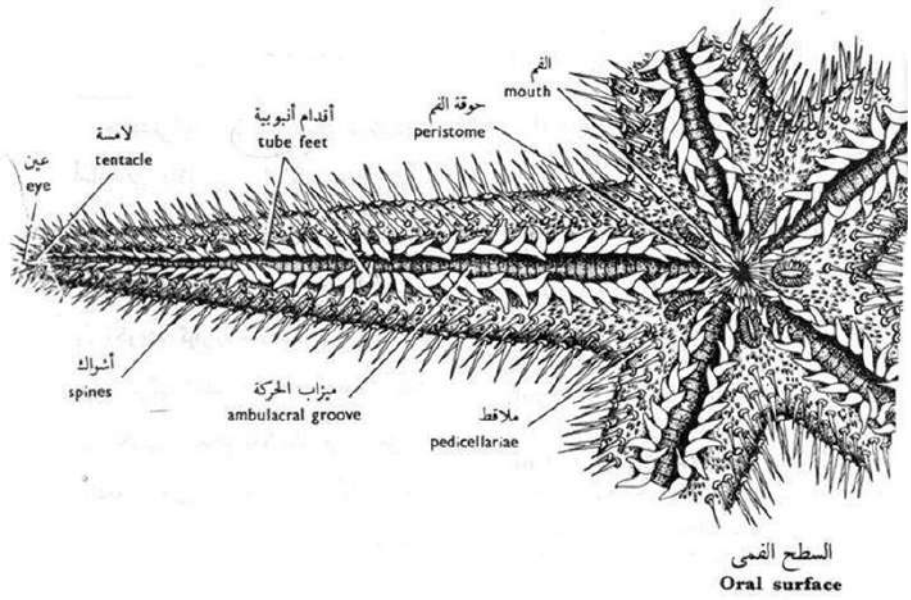
- No special execratory organs.
- The sexes is usually separated and the development maybe direct or including larva formation.
- Show high power of regeneration.

Subphylum: Eleutherozoa

Class : Asteroidea

e.g.: *Astropecten relitaris*





General characters of *Astropecten*

Common in our seas, creeps slowly on the bottom but in rest it lies buried in the sand except the central part.

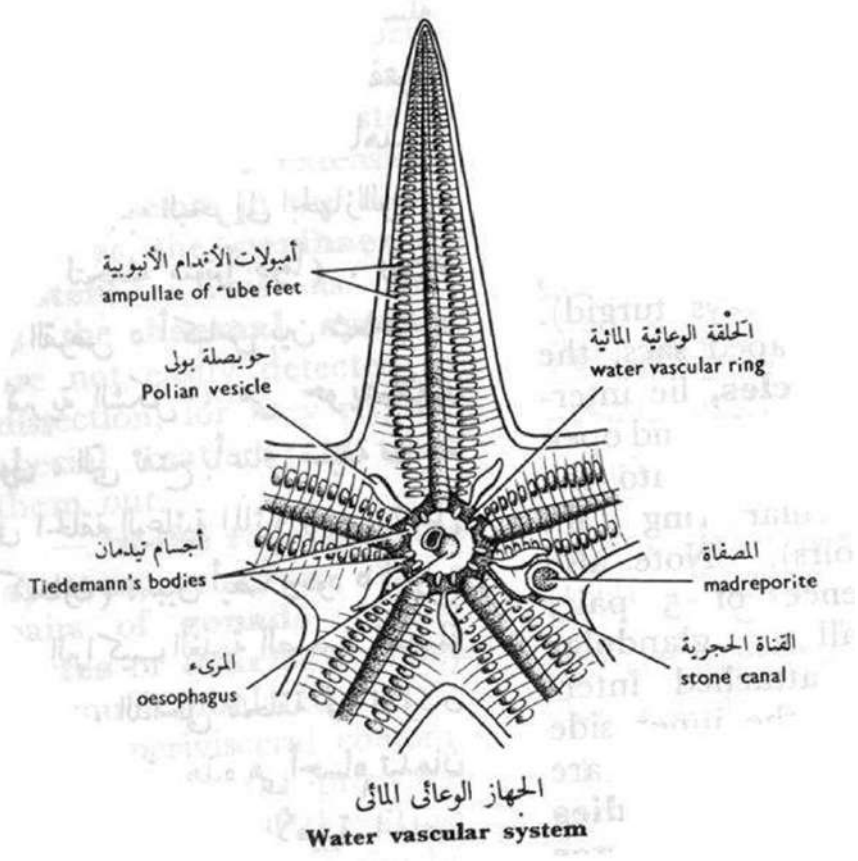
The body is star-shaped, consisting of a central disc prolonged into 5 arms. The with two surfaces: a lower oral surface and an upper aboral surface.

On the aboral surface, note the pointed spines on the edges of each arm and a blunt spines found in bundles called: the paxillae. Very minute dermal gills arise between the paxillae. Note also a plate with pores in the central disc, opposite to the angle between any two arms. This plate (the madreporite) lead into the water vascular system.

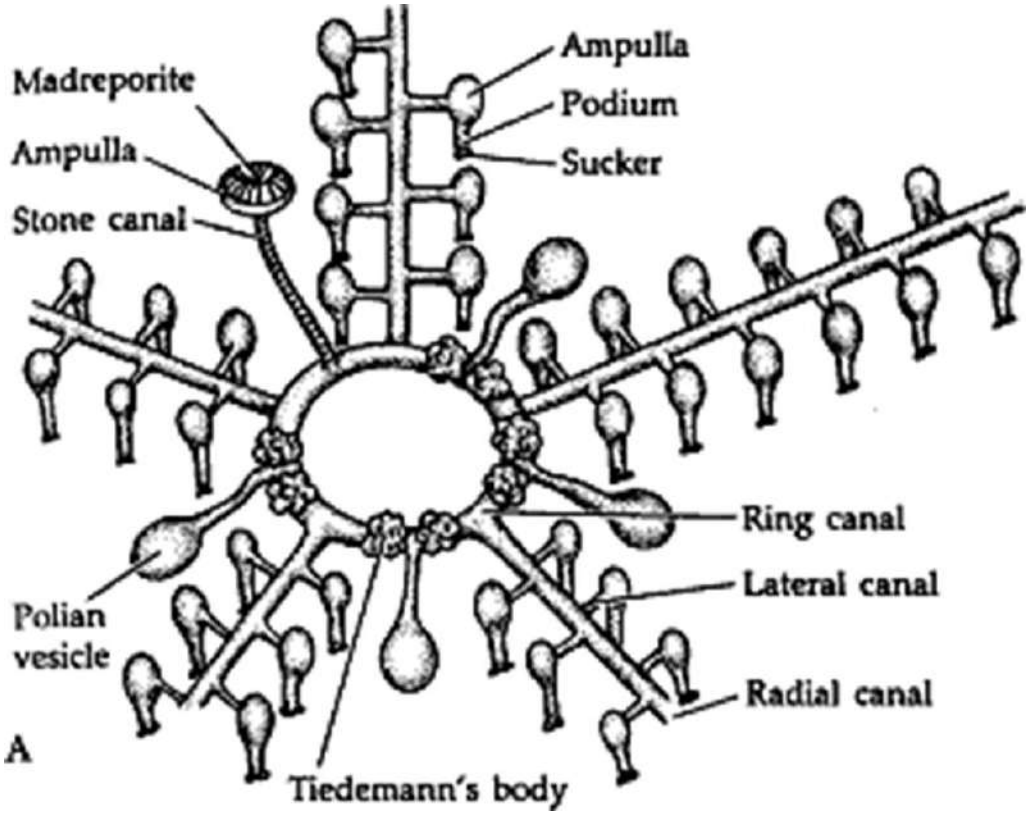
On the oral surface, note the mouth in the centre, surrounded by a soft area (the peristome). Five ambulacral grooves extended out from the mouth along the entire length of each arm. Note, conical structures (the

tube feet) project in 2 rows along each ambulacral groove. The terminal tube foot (called: the tentacle) has a pigmented spot (the eye) on its base. Note the different types of spines and the very small modified spines which known as pedicellariae, these small spines clean the body surface and the ambulacral grooves.

The water vascular system



الجهاز الوعائى المائى
Water vascular system

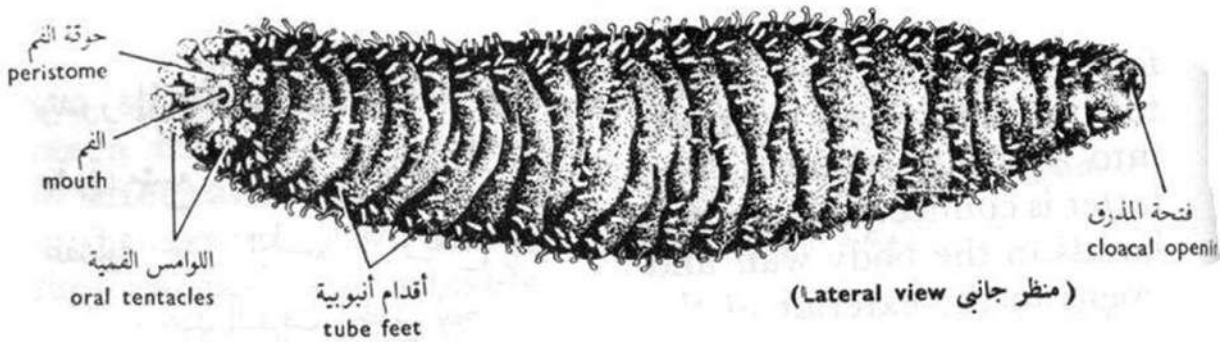


- The water vascular system or Ambulacral system is filled with sea water, It consists of madreporite, stone canal, ring canal, 5 radial canals, Tiedemann's bodies, Polian vesicles, lateral canals and tube feet.
- The madreporite present on the aboral surface of the central disc, and contains a number of pores led into small canal which open into a stone canal.
- The walls of the stone canal are strengthened by calcarious rings keep it open and the inner surface is lined with ciliated cells. The movement of cilia will draw water currents into the stone canal.
- The ring canal: is present around the mouth and contains Polian vesicles and Tiedemann's bodies.

- The radial canals: arise from the ring canal and run throughout the entire length of the arm. Each radial canal lies below the ambulacral groove.
- From the radial canal of each arm, pairs of lateral canals will arise and they end with tube feet. The basal part of the tube feet is bulged and called ampulla and ends with a sucker. The ampulla contains circular and longitudinal muscles. Lateral canal will open into ampulla and is guarded by a valve.
- Polian vesicles: store water so they are considered as reservoirs.
- Tiedmann's bodies: They are produce amoebocytes (the execratory organs).

Class: Holothuroidea

e.g.: *Holothuria curiosa*



General characters of Holothuria

- It is frequently seen near our sea coasts.
- It moves very slowly on the sea bottom by the muscular contractions of its body wall and with the help of its tube feet.
- The body is much elongated, cylindrical and soft. The mouth and anus (cloacal opening) are located at opposite ends of the body
- There are retractile locomotory tube feet, densely scattered all over the body surface.
- At the oral end, there is a large mouth opening, surrounded by a thin peristome. Around the edge of the peristome arises a circle of oral tentacles for food collecting purposes, and are considered as enlarged and greatly modified tube feet.

The importance of echinoderms

- Echinoderms play many environmental roles as some species such as sea cucumbers burrow into the sand, providing more oxygen in the depths of the sea floor, and this allows more organisms to live there.
- They are considered a source of food. In some countries, large quantities of sea urchins and sea cucumbers are caught as they are considered a delicacy.
- They are used as a treatment and in scientific research, and for example, some toxins of sea cucumber slow the rate of growth of cancer cells, so there is interest in using them in cancer research.
- They are used in agriculture where the solid skeleton of echinoderms is used as a source of lime by farmers in some areas where limestone is not available.
- Some species of sea cucumbers have a thick soft skin that is
- used to make slippers.

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