THE ARTHROPODS:

- Metamerism and Tagmatization
- The Exoskeleton Metamorphosis
- Subphylum Chelicerata
  - Class Arachnida (general characteristics)
- Subphylum Crustacea
  - Class Malacostraca
  - Class Branchiopoda
  - Class Copepoda
  - Class Cirripedia
  - Class diplopoda
  - Class chilopoda

SUBPHYLUM CRUSTACEA

- Some members include crayfish, shrimp, lobsters, and crabs.
- Many others are lesser known include copepods, cladocerans, fairy shrimp, isopods, amphipods, and barnacles.

❖ Crustaceans differ from other living arthropods in two ways:

i. They have two pairs of antennae, whereas all other arthropods have one pair or none.

ii. Crustaceans possess biramous appendages.

- Each of which consists of a basal segment, called the protopodite, with two rami attached.
- The medial ramus is the endopodite.
- the lateral ramus is the exopodite.

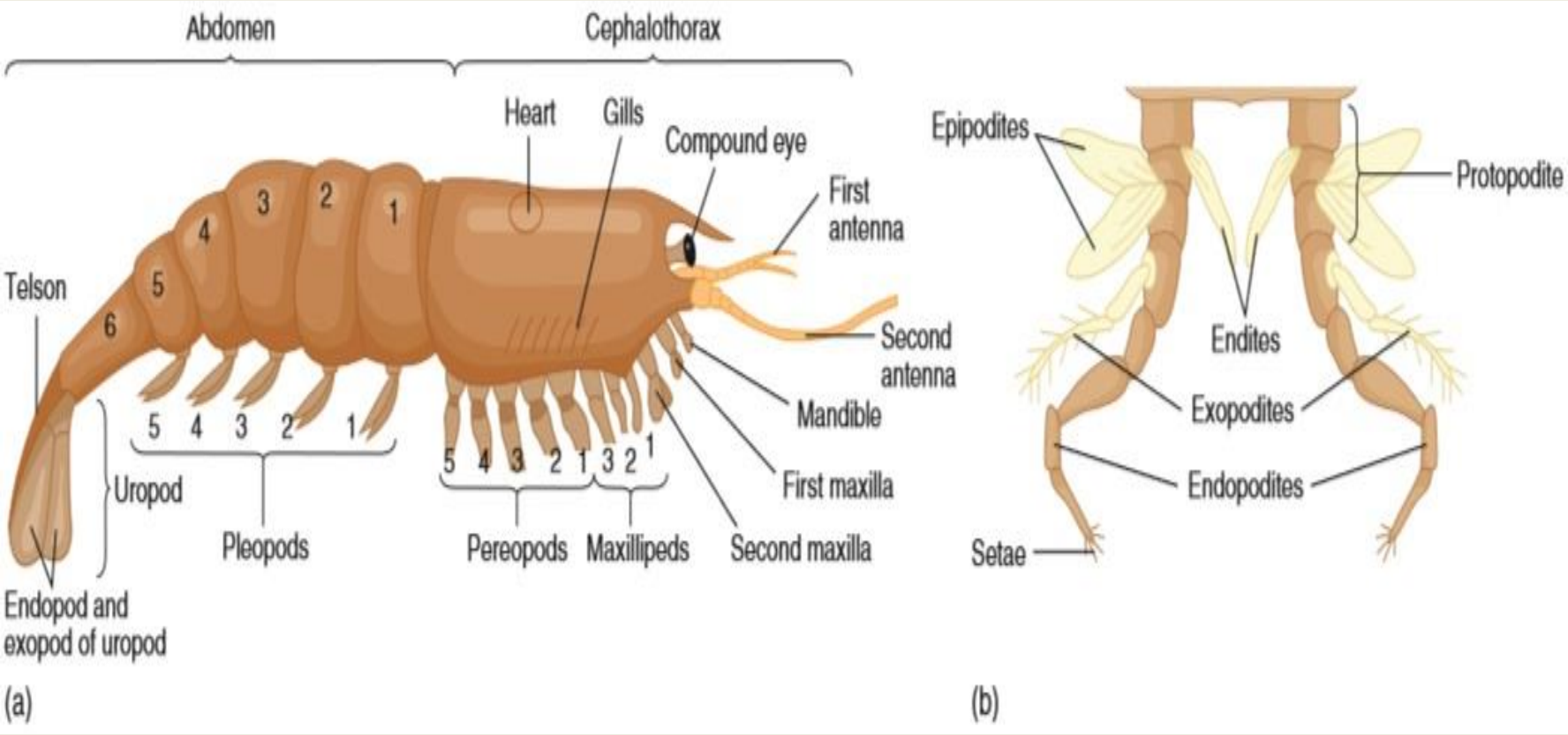
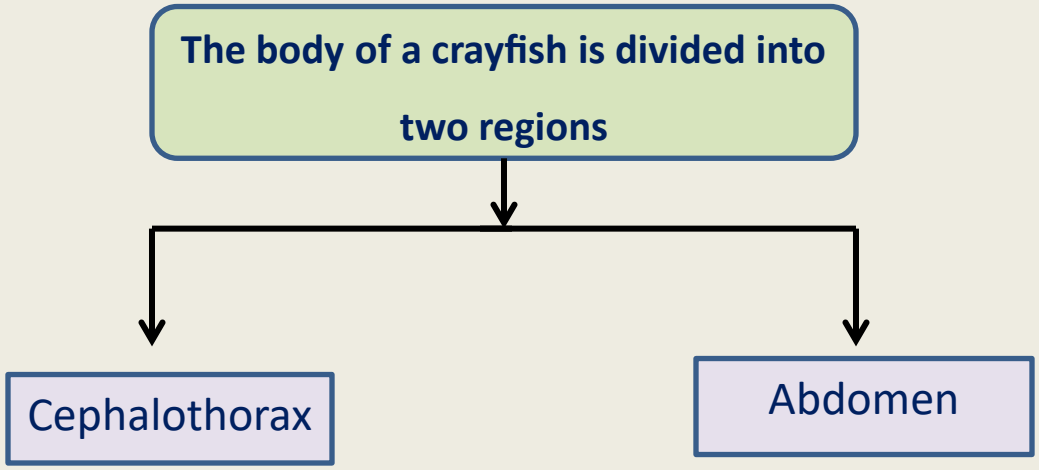


Fig: Crustacean Body Form. (a) External anatomy of a crustacean. (b) Pair of appendages, showing the generalized biramous structure. A protopodite attaches to the body wall. An exopodite (a lateral ramus) and an endopodite (a medial ramus) attach at the end of the protopodite. In modern crustaceans, both the distribution of appendages along the length of the body and the structure of appendages are modified for specialized functions.

CLASS MALACOSTRACA

- **Malacostraca is the largest class of crustaceans.**
- **It includes crabs, lobsters, crayfish, shrimp, mysids, shrimplike krill, isopods, and amphipods.**
- **The order Decapoda is the largest order of crustaceans and includes shrimp, crayfish, lobsters, and crabs.**

Example: crayfish



- The first two pairs of cephalothoracic appendages are the first and second antennae.
- The third through fifth pairs of appendages are associated with the mouth.
- The sixth through the eighth cephalothoracic appendages are called maxillipeds.
- The last two pairs of maxillipeds also bear gills.
- Appendages 9 to 13 are thoracic appendages called periopods (walking legs).
  - The first periopod, known as the cheliped, used in defense and capturing food.
  - All but the last pair of appendages of the abdomen are called pleopods.
  - The abdomen ends in a median extension called the telson.

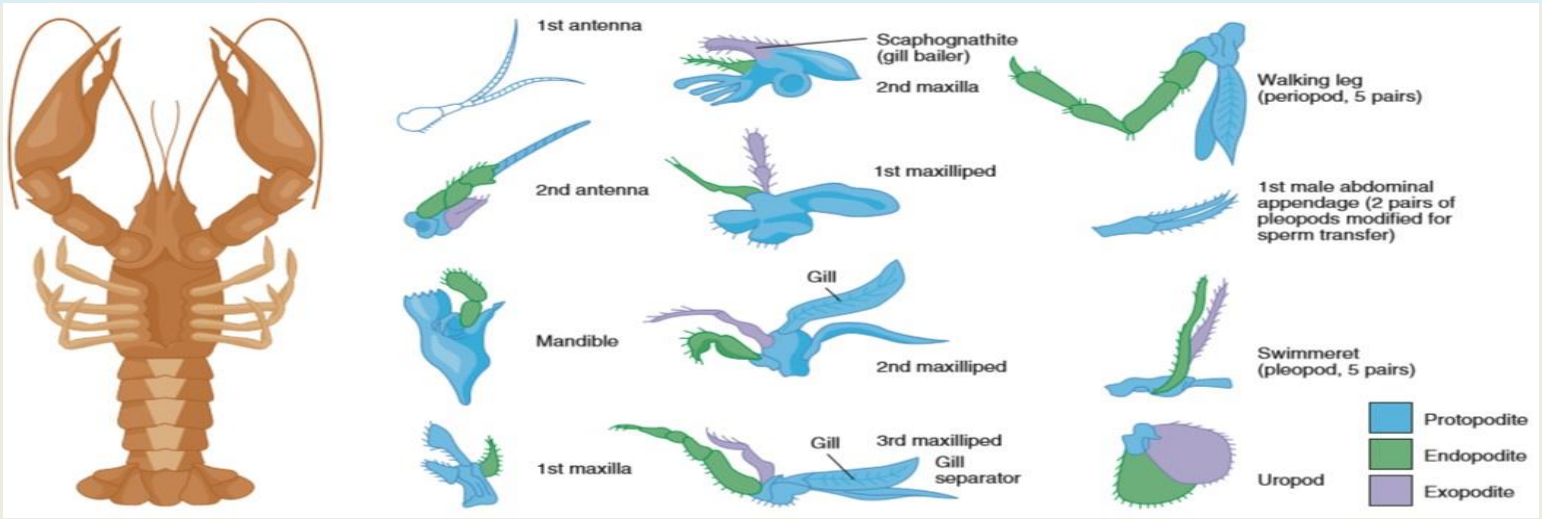
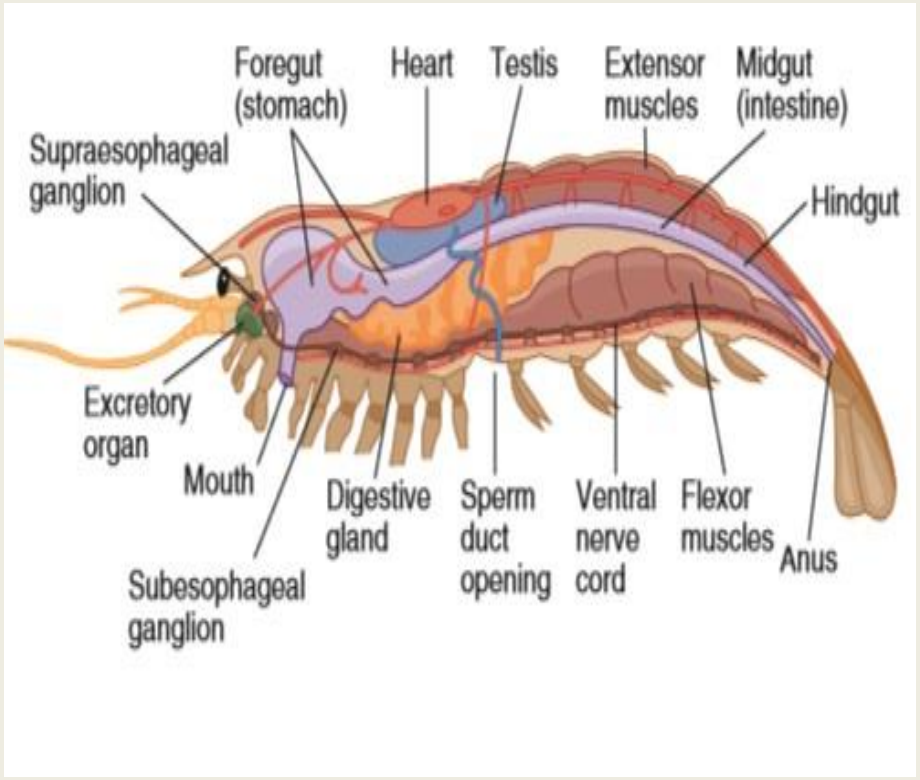


Fig: Crayfish Appendages. Ventral view of a crayfish, with appendages removed and arranged in sequence. Homologies regarding the structure of appendages are color coded. The origin and homology of the first antennae are uncertain



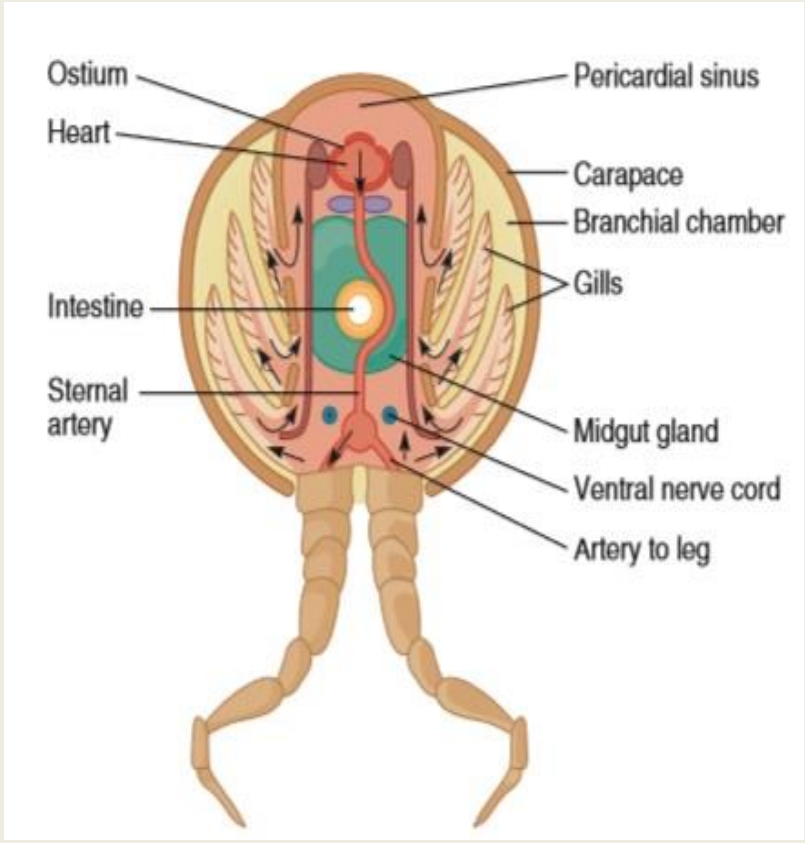
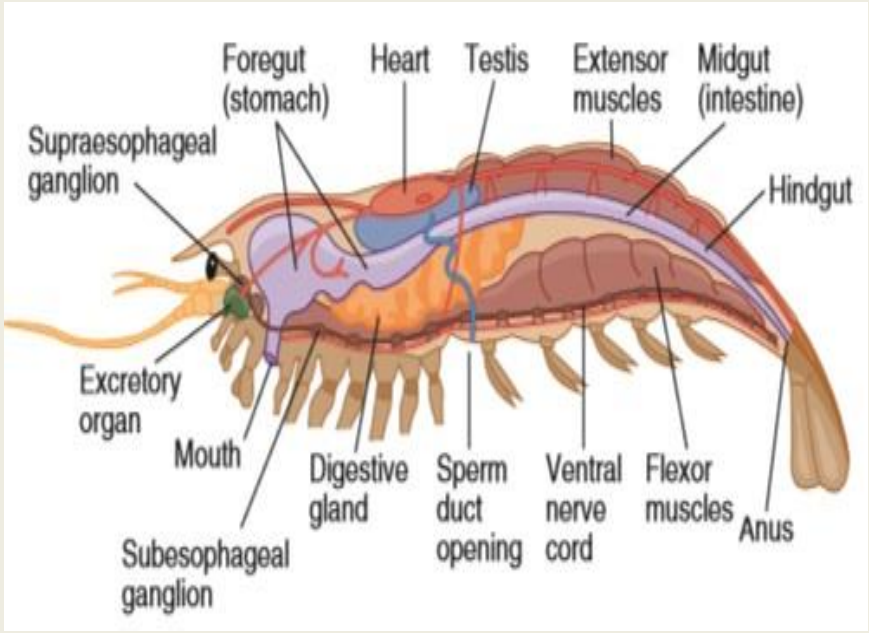


Fig: Internal Structure of a Crayfish. (a) Lateral view of a male. In the female, the ovary is in the same place as the testis of the male, but the gonoducts open at the base of the third periopods. (b) Cross section of the thorax in the region of the heart. In this diagram, gills are shown attached higher on the body wall than they actually occur to show the path of blood flow (arrows) through them.

FEEDING AND THE DIGESTIVE SYSTEM IN CRAYFISH

- Crayfish prey upon other invertebrates, eat plant matter, and scavenge dead and dying animals.
- The foregut includes an enlarged stomach, part of which is specialized for grinding.
- A digestive gland secretes digestive enzymes and absorbs products of digestion.
- The midgut extends from the stomach and is often called the intestine.
- A short hindgut ends in an anus and is important in water and salt regulation.



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GAS EXCHANGE AND CIRCULATION

- Gills of a crayfish attach to the bases of some cephalothoracic appendages.
- The beating of the scaphognathite of the second maxilla drives water anteriorly through the branchial chamber.
- A respiratory pigment, hemocyanin, carries oxygen in blood plasma.
- Dorsal, anterior, and posterior arteries lead away from a muscular heart.
- Blood returning to the heart collects in a ventral sinus and enters the gills before returning to the pericardial sinus, which surrounds the heart.

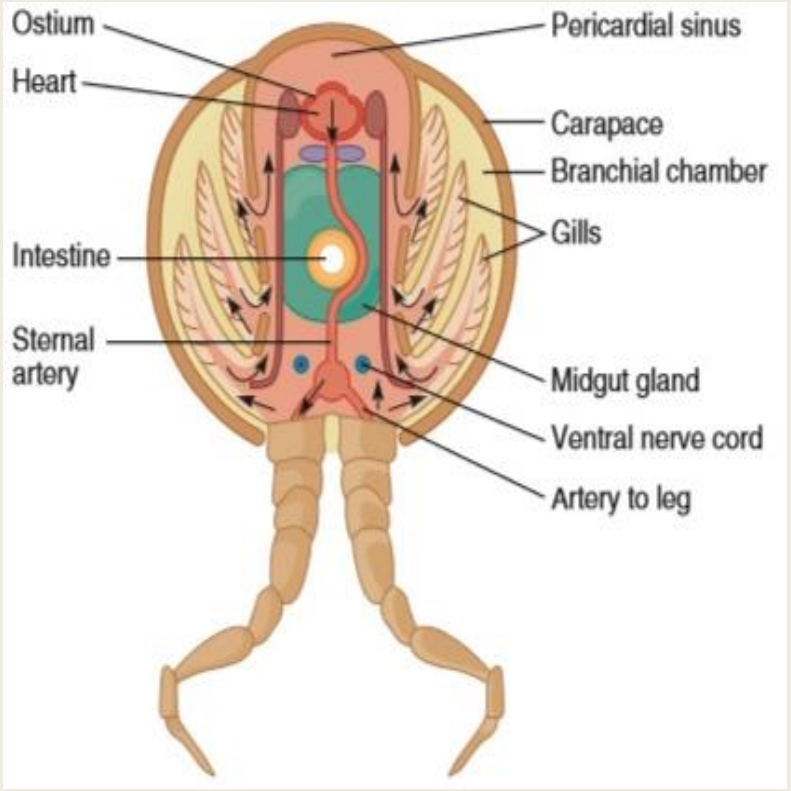
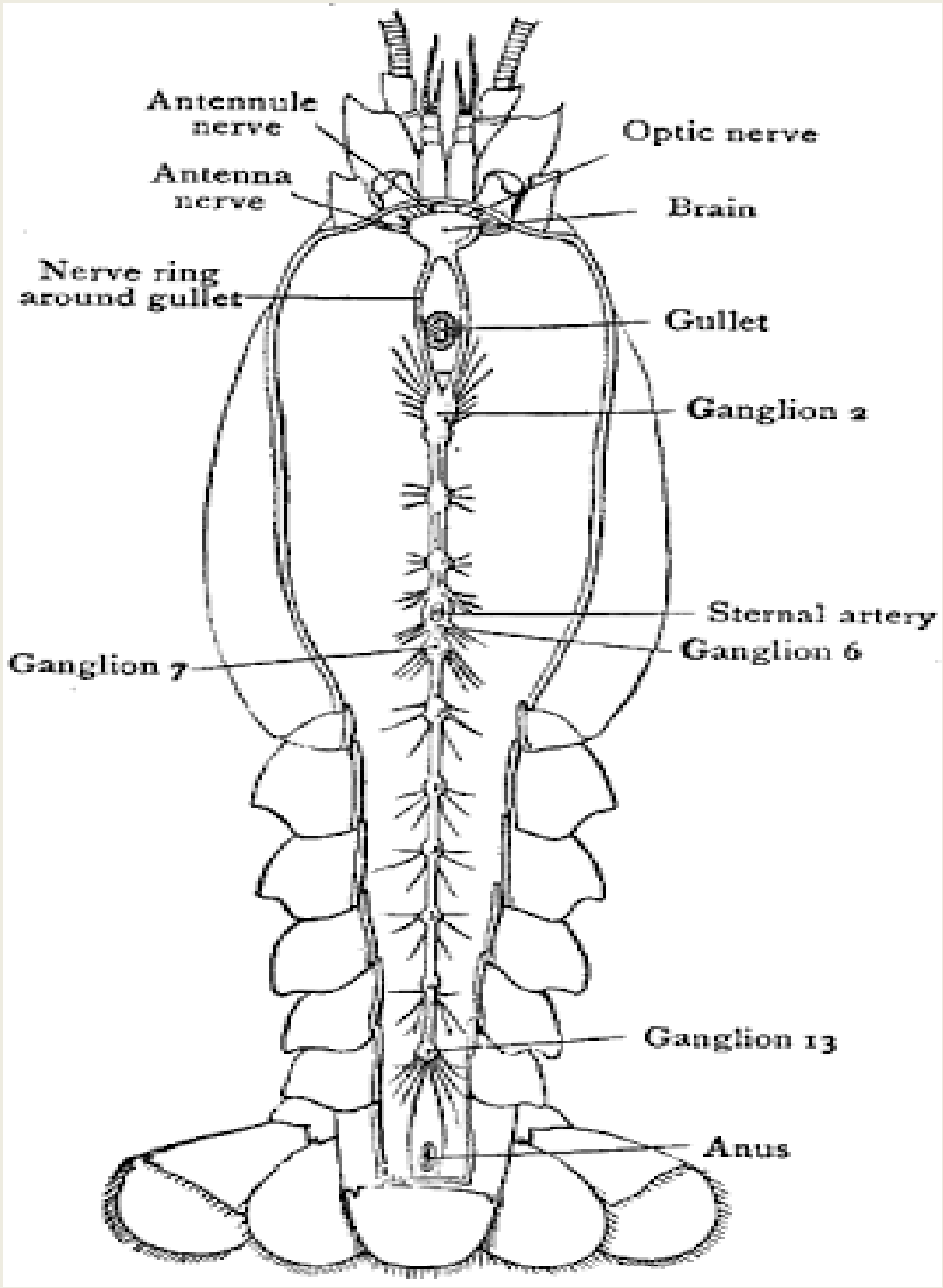


Fig: Internal Structure of a Crayfish. Cross section of the thorax in the region of the heart. In this diagram, gills are shown attached higher on the body wall than they actually occur to show the path of blood flow (arrows) through them.

NERVOUS AND SENSORY FUNCTIONS

- Crustacean nervous systems show trends similar to those in annelids and arachnids.
- Primitively, the ventral nervous system is ladderlike.
- Higher crustaceans show a tendency toward centralization and cephalization.
- Crayfish have supraesophageal and subesophageal ganglia that receive sensory input from receptors in the head and control the head appendages.
- The ventral nerves and segmental ganglia fuse, and giant neurons in the ventral nerve cord function in escape responses


Antennule nerve
Antenna nerve
Optic nerve
Brain
Nerve ring around gullet
Gullet
Ganglion 2
Sternal artery
Ganglion 7
Ganglion 6
Ganglion 13
Anus

NERVOUS AND SENSORY FUNCTIONS

In addition to antennae, the sensory structures of crayfish include:

- ✓ **Compound eyes**
- ✓ **Simple eyes**
- ✓ **Statocysts**
- ✓ **Chemoreceptors**
- ✓ **Proprioceptors**
- ✓ **Tactile setae.**

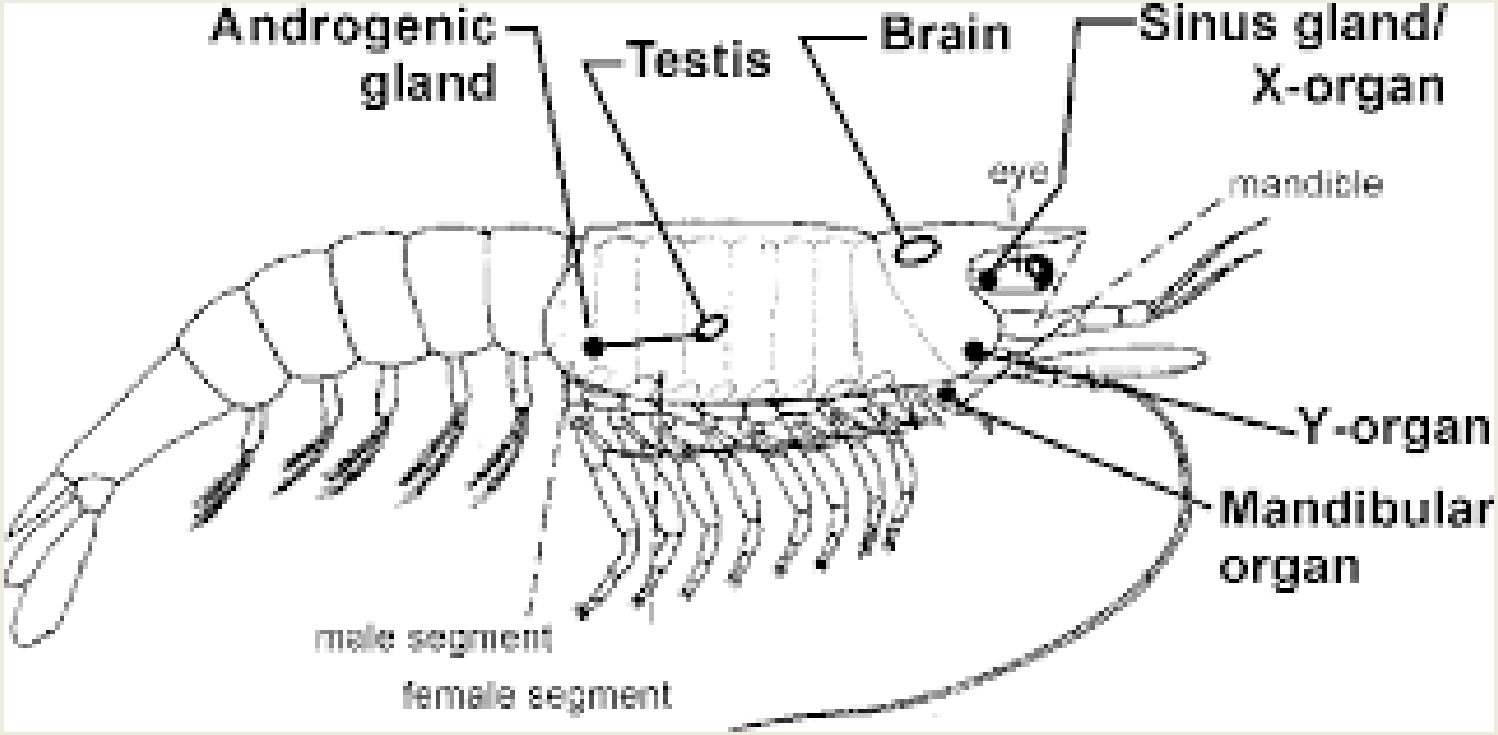
- ➢ A single pair of **statocysts** is at the bases of the first antennae.
- ➢ A statocyst is a pitlike invagination of the exoskeleton that contains setae and a group of cemented sand grains called a **statolith**.
- ➢ Statocysts provide information regarding movement, orientation with respect to the pull of gravity, and vibrations of the substrate.
- ➢ The statocyst is **cuticular**, it is replaced with each **molt**.
- ➢ The lens system consists of **25 to 14,000** individual receptors called **ommatidia**

ENDOCRINE FUNCTIONS

- In crustaceans, endocrine functions are closely tied to nervous functions.
- Nervous tissues that produce and release hormones are called neurosecretory tissues.
- X-organs are neurosecretory tissues in the eyestalks of crayfish.
- Other glands, called Y-organs, are not directly associated with nervous tissues.
- Both the X-organ and the Y-organ control ecdysis.

EXCRETION

- The excretory organs of crayfish are called antennal glands (green glands).
- In other crustaceans, they are called maxillary glands because they are at the bases of the second maxillae.
- They are structurally similar to the coxal glands of arachnids.
- Ions, sugars, and amino acids are reabsorbed in the tubule before the diluted urine is excreted.


Androgenic gland
Testis
Brain
Sinus gland/ X-organ
eye
mandible
Y-organ
Mandibular organ
male segment
female segment

REPRODUCTION AND DEVELOPMENT

- Crayfish, and all other crustaceans except the barnacles, are dioecious.
- Gonads are in the dorsal portion of the thorax.
- Mating occurs just after a female has molted.
- The development of crayfish embryos is direct, with young hatching as miniature adults.
- Many other crustaceans have a planktonic, free-swimming larva called a nauplius.
- Crabs and their relatives have a second larval stage called a zoea
- When all adult features are present, except sexual maturity, the immature is called the postlarva.

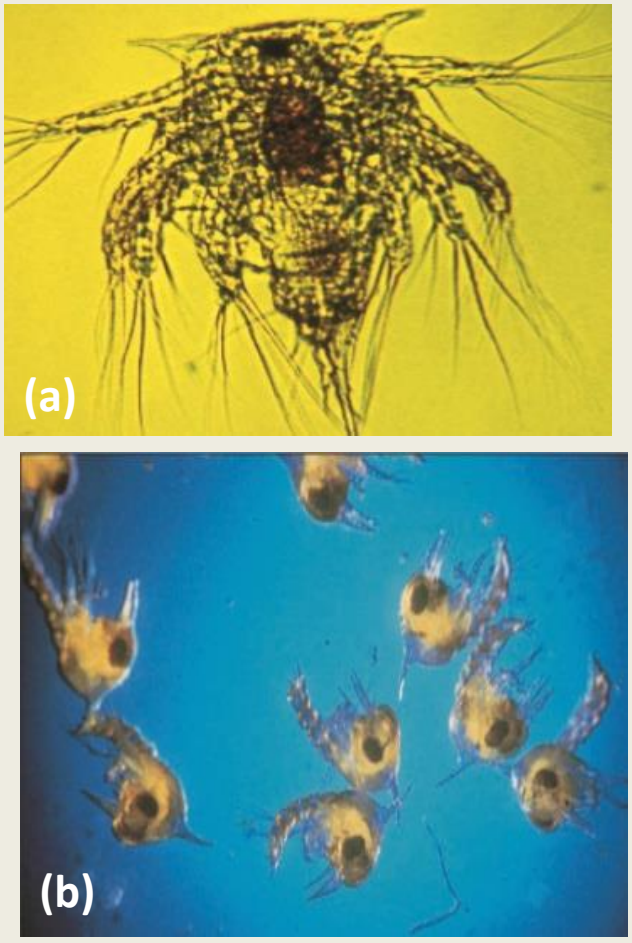


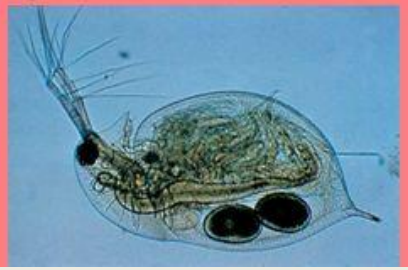
Fig: Crustacean Larvae. (a) Nauplius larva of a barnacle (0.5 mm). (b) Zoea larvae (1 mm) of a crab (Pachygrapsus crassipes).

CLASS BRANCHIOPODA

- Members of the class Branchiopoda primarily live in freshwater.
- All branchiopods possess flattened, leaflike appendages used in respiration, filter feeding, and locomotion.
- Eggs are brooded, and when the female dies, and the temporary pond begins to dry, the embryos become dormant in a resistant capsule.
- Embryos lay on the forest floor until the pond fills again the following spring, at which time they hatch into nauplius larvae.
- Animals, wind, or water currents may carry the embryos to other locations.
- Brine shrimp also form resistant embryos.
- They live in salt lakes and ponds (e.g., the Great Salt Lake in Utah).

Class Branchiopoda

- Fairy shrimp & brine shrimp
  - Mostly freshwater
  - During droughts, embryos become dormant in capsules
- Water fleas (Daphnia!)
  - Look like fleas with large carapace
  - In spring, females reproduce parthenogenetically (without fertilization)
  - In winter, sexual reproduction produces winter eggs that hatch in spring



CLASS COPEPODA

- Members of the class Copepoda include some of the most abundant crustaceans.
- There are both marine and freshwater species.
- Copepods have a cylindrical body and a median ocellus.
- The first antennae (and the thoracic appendages in some) are modified for swimming, and the abdomen is free of appendages.
- Most copepods are planktonic and use their second maxillae for filter feeding.
- A few copepods live on the substrate, a few are predatory, and others are commensals or parasites of marine invertebrates, fishes, or marine mammals.

CLASS CIRRIPEDIA

- Members of the class Cirripedia the barnacles, are sessile and highly modified as adults.
- They are exclusively marine and include about one thousand species.
- Most barnacles are monoecious.
- The planktonic nauplius of barnacles is followed by a planktonic larval stage, called a cypris larva, which has a bivalved carapace.
- Cypris larvae attach to the substrate by their first antennae and metamorphose to adults.

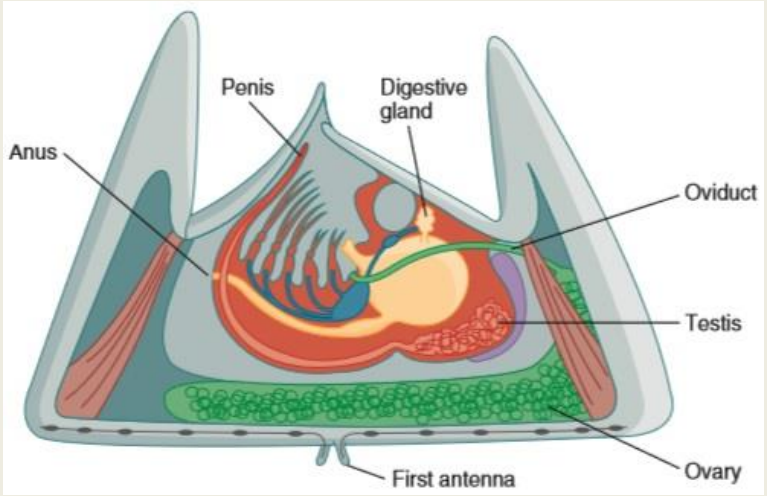


Fig: Class Cirripedia. Internal structure of a stalkless (acorn) barnacle.

CLASS CIRRIPEDIA

- In the process of metamorphosis, the abdomen is reduced, and the gut tract becomes U-shaped.
- Thoracic appendages are modified for filtering and moving food into the mouth.
- Calcareous plates cover the larval carapace in the adult stage.
- Barnacles attach to a variety of substrates, including rock outcroppings, ship bottoms, whales, and other animals.
- Some barnacles attach to their substrate by a stalk. Nonstalked are called acorn barnacle.
- Some barnacles have become highly modified parasites.
- The evolution of parasitism in barnacles is probably a logical consequence of living attached to other animals.

Fig: Class Cirripedia. Stalked (gooseneck) barnacles (*Lepas*)

Class Diplopoda

- The class Diplopoda contains the millipedes.
- Ancestors of this group appeared on land during the Devonian period and were among the first terrestrial animals.
- Millipedes have 11 to 100 trunk segments.
- two pairs of appendages on each apparent trunk segment.
- Each segment is actually the fusion of two segments.
- Fusion is also reflected internally by two ganglia, two pairs of ostia, and two pairs of tracheal trunks per apparent segment.
- Most millipedes are round in cross section, although some are more flattened

Fig: Myriapods. (a) A woodland millipede (*Ophyiulus pilosus*).

GENERAL CHARACTERISTICS:

- Millipedes are worldwide in distribution.
- Nearly always found in or under leaf litter, humus, or decaying logs.
- Their epicuticle does not contain much wax; therefore, their choice of habitat is important to prevent desiccation.
- Their many legs, simultaneously pushing against the substrate, help millipedes bulldoze through the habitat.
- A few millipedes have mouthparts modified for sucking plant juices.
- Millipedes roll into a ball when faced with desiccation or when disturbed.
- Many also possess repugnatorial glands that produce hydrogen cyanide, which repels other animals.
- Hydrogen cyanide is not synthesized and stored as hydrogen cyanide because it is caustic and would destroy millipede tissues. Instead, a precursor compound and an enzyme mix as they are released from separate glandular compartments.

CLASS CHILOPODA

- Members of the class Chilopoda are the centipedes.
- Most centipedes are nocturnal and scurry about the surfaces of logs, rocks, or other forest-floor debris.
- Like millipedes, most centipedes lack a waxy epicuticle and therefore require moist habitats.
- Their bodies are flattened in cross section, and they have a single pair of long legs on each of their 15 or more trunk segments.
- The last pair of legs is usually modified into long sensory appendages.
- Centipedes are fast-moving predators.

Fig: Myriapods. A centipede (*Scolopendra heros*).

GENERAL CHARACTERISTICS:

- Food usually consists of small arthropods, earthworms, and snails.
- Some centipedes feed on frogs and rodents.
- Poison claws (modified first-trunk appendages called maxillipeds) kill or immobilize prey.
- Male lays down a silk web using glands at the posterior tip of the body.
- places a spermatophore in the web, which the female picks up and introduces into her genital opening.
- Eggs are fertilized as they are laid.
- A female may brood and guard eggs by wrapping her body around the eggs, or they may be deposited in the soil.
- Young are similar to adults except that they have fewer legs and segments.
- Legs and segments are added with each molt.