Crayfish – *Procambrus clarkii* (red swamp crayfish)

Crayfish Classification

Kingdom:	Animalia
Phylum:	Arthropoda (jointed exoskeleton)
Subphylum:	Crustacea (aquatic arthropods with 2 pairs of antennae)
Class:	Malacostraca (crustaceans with modified appendages)
Order:	Decapoda (shrimp, crayfish, lobsters, & crabs)

Natural History

Crayfish, commonly known as **crawfish** or **crawdads**, are freshwater crustaceans that resemble small lobsters. Crayfish live in any freshwater body that is low in pollution, does not freeze to the bottom, and provides hiding places (mud, rocks, logs, etc.) from predators. They breathe through feather-like **gills**. Crayfish are considered an **indicator species** because very few of them can survive polluted waters. Crayfish have 8 jointed walking legs, a segmented body, 2 pairs of sensory antennae, and compound eyes. The 2 large pincers or claws are the **chelipeds**. If a crayfish loses a leg, the leg will regenerate.

Crayfish are **omnivores** that feed upon living and dead animals and plants. Larval crayfish are very tiny. They are often active during the day, feeding upon plankton. Adult crayfish are **nocturnal**, actively feeding upon snails, algae, shrimp, insect larvae, worms, tadpoles, and aquatic plants from dusk until daybreak. Body color varies depending on diet. Usually, crayfish move about at a slow walk but can, if startled, use rapid flips of their tail to swim backwards quickly. Most crayfish live short lives, usually less than two years. They rely upon rapid, high-volume reproductive strategies to continue the species.

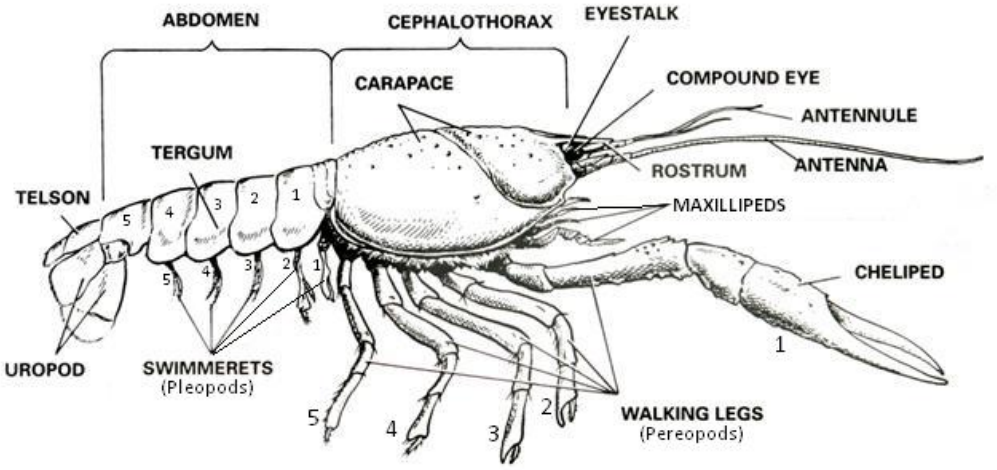
Many crayfish become sexually mature and mate in October or November after they're born, but fertilization and egg laying usually occur the following spring. The fertilized eggs are attached to the female's swimmerets on the underside of her jointed abdomen. There the 10 to 800 eggs change from dark to translucent as they develop. The egg-carrying female is said to be "**in berry**," because the egg mass looks something like a berry. The eggs hatch in 2 to 20 weeks, depending on water temperature. The newly-hatched crayfish stay attached to their mother until shortly after their second molt.

The exoskeleton could be considered a blessing and a curse. The hard exoskeleton is highly protective with joints that allow for movement. However, because their exoskeleton does not grow as their body grows, crayfish must molt (shed) their old exoskeletons as they grow through a process called **ecdysis**. When they first molt they are soft, and very vulnerable to attack by other crayfish or predator fish. It can take a couple days for the new shell to fully harden. Juveniles can molt every week or so. Adults may only molt a couple times a year, and only under the right conditions. Molting occurs 6 to 10 times during the first year of rapid growth, but less frequently during the second year. The empty shell will be consumed to recover the lost minerals.

The natural predators of the crayfish include alligators, burbots (a type of cod), chicken turtles (*Deirochelys reticularia*), painted turtles, desman (a type of otter), and grackles (a type of a bird).

Basic Body Plan

Crayfish have the typical body plan of a decapod crustacean. The body is composed of 19 body segments divided into two main body parts; the cephalothorax and the abdomen. Each body segment possesses a pair of appendages (although they may be reduced or missing in some species). Crustaceans have **biramous appendages** that fork from the basal **protopodite** to form two branches (giving the appendage a Y shape), the inner **endopodite** and the outer **exopodite**. The cephalothorax has sensory, feeding, and locomotion functions while the abdomen has locomotion and visceral functions. Crayfish are typically small, about 7.5 cm (3 inches) in length, but this varies by species.



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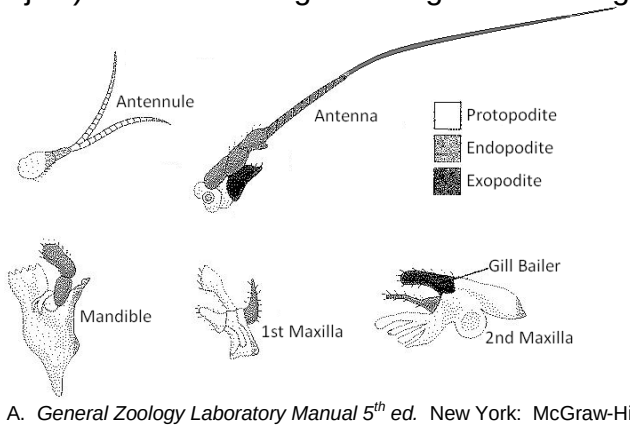
The anterior section of arachnids and most crustaceans is the **cephalothorax** which consists of a fused head and thorax (chest). The **carapace** is a saddle-like covering over the cephalothorax. A transverse groove separates the fused head from the thoracic region. The **rostrum** is an anterior, pointed extension of the head. A pair of **stalked eyes** is located on the lateral side of the rostrum. The **head** has two pairs of sensory antennae. The appendages (and their functions) of the head include:

- Antennule – touch, taste, equilibrium
- Antenna – touch, taste
- Mandible (lower jaw) – crushing food
- 1st maxilla (upper jaw) – food handling
- 2nd maxilla (upper jaw) – food handling & bailing water from gill chamber



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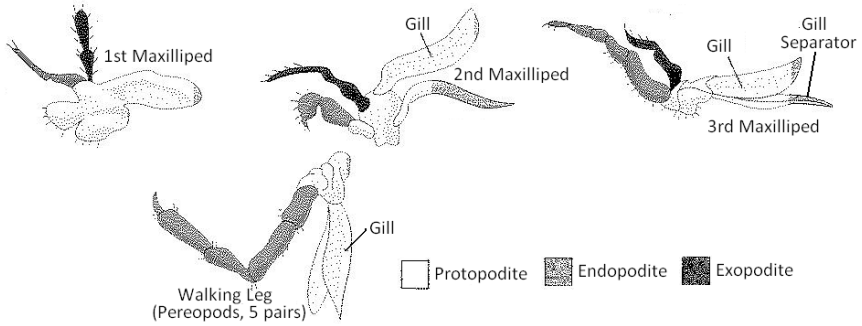
The **thorax** has 4 pairs of walking legs and one pair of claw-bearing **chelipeds** (collectively referred to as **pereopods**). The chelipeds are specialized for cutting, capturing food, attack, and defense. The four pairs of walking legs are also used to probe cracks and crevices between rocks looking for food. The appendages (and their functions) of the thorax include:

- 1st maxilleped – touch, taste, food handling
- 2nd maxilleped – touch, taste, food handling
- 3rd maxilleped – touch, taste, food handling
- Cheliped (claw, 1st walking leg) – grasping food, offense, defense
- 2nd – 5th walking legs – walking



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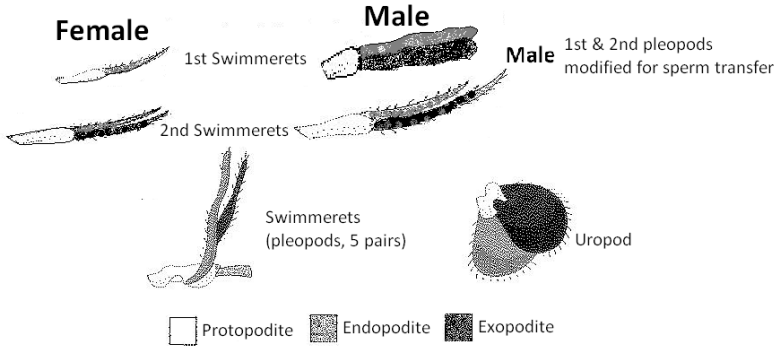
The **abdomen** consists of several segments and is terminated by the **telson.** The abdomen has 5 pairs of swimmerets (collectively referred to as **pleopods**). In males, the 1st swimmerets transfer sperm to the female with assistance from the 2nd swimmerets. In females, swimmerets 2 to 5 carry eggs and young, circulating water around them. The final appendage, at the tail, is the **uropod** used for swimming and egg protection.



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The Circulatory System

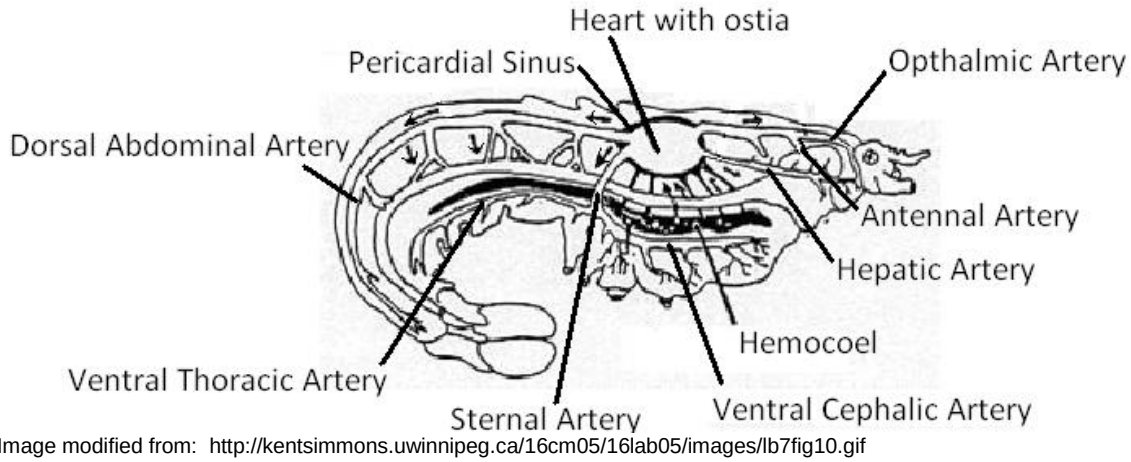
The circulatory system of the crayfish consists of a muscular **heart** located just posterior to the stomach. Surrounding the heart is a sac, the **pericardium.** The heart pumps blood into five arteries:

1. A median **ophthalmic artery** (extending towards the head) – supplies the cardiac stomach, esophagus, & head
2. A pair of **antennal arteries** (one each side of the ophthalmic artery) – supplies stomach, antennae, & parts of head
3. A pair of **hepatic arteries** (from the ventral surface of the heart) – supplies the hepatopancreas

4. The **dorsal abdominal artery** (from the posterior end of the heart) – supplies the abdominal organs
5. The **sternal artery** (runs straight down) – supplies the appendages & other ventral structures

Branches of these arteries empty into the sinuses of the **hemocoel** (i.e. the large tissue spaces containing blood), distributing respiratory gases and nutrients to the tissues of the body. Crustaceans have an **open circulatory system** because the blood returns to the heart via open sinuses rather than veins.

The **ventral sinus** collects the blood. The blood then flows to the gills, where it is oxygenated. Blood from the gills is released into the **pericardial sinus** (a space around the heart, contained by the pericardium). Blood reenters the heart via three pairs of slit-like openings, the **ostia**, where it is again pumped to the body.



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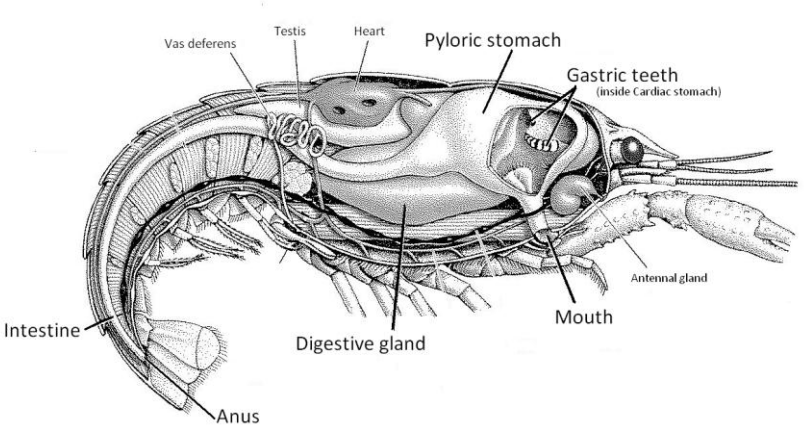
The Digestive System

The digestive system of a crayfish is simple compared to vertebrates, but far more complex than other invertebrates. The digestive tract is composed a **foregut** (enlarged stomach that is specialized for grinding), the **midgut** which extends from the foregut, and the **hindgut** which leads to the anus and functions in salt and water regulation.

From ingestion through the mouth, food passes through a short **esophagus** to the large **stomach** which occupies most of the anterior region of the cephalothorax. The stomach consists of two parts; anteriorly a large firm **cardiac chamber** and posteriorly a smaller soft **pyloric chamber**. Within the stomach are chitinous teeth that form the **gastric mill** used in grinding food. After passing through the stomach, food enters the **intestine** which runs through the abdomen to the **anus**.

The large **hepatopancreas,** also known as **liver** or **digestive gland,** secretes enzymes that are poured through hepatic ducts into the pyloric chamber of the stomach. The hepatopancreas is the chief site of nutrient absorption and serves to store food reserves.



INTERNAL ANATOMY OF A MALE CRAYFISH: Image modified from: Hickman, Cleveland P. Jr. and Lee B. Kats. *Laboratory Studies in Animal Diversity, 4th ed.* Boston: McGraw Hill Higher Education, 2007.

The Excretory System

The excretory organs of crayfish are the **antennal glands** (a.k.a. green glands) which are round and pink and are located at the base of the second antenna. They excrete the waste products (primarily ammonia) of blood filtration. Fluid is filtered through the antennal glands by hydrostatic pressure in the hemocoel. Salts and water are reabsorbed from the filtrate, and the resulting urine is then excreted. Ammonia is also excreted across the gill surfaces and by diffusion across thin parts of the exoskeleton.

The Integumentary System

The crayfish has a jointed **exoskeleton** which they shed to allow growth. The exoskeleton is a **cuticle** secreted by the epidermis and hardened by **chitin**.

Muscular System

A major portion of the crustacean body is made of striated muscles. Most muscles are arranged in **antagonistic pairs. Flexors** draw a limb toward the body while **extensors** straighten the limb out. For example, the large **abdominal flexor muscle (**making up the majority of the bulk of the abdomen) curls the tail up and allows the crayfish to swim backward. The antagonistic **abdominal extensor muscles (**originating in the cephalothorax and extending to the tail) straighten the tail when contracted.

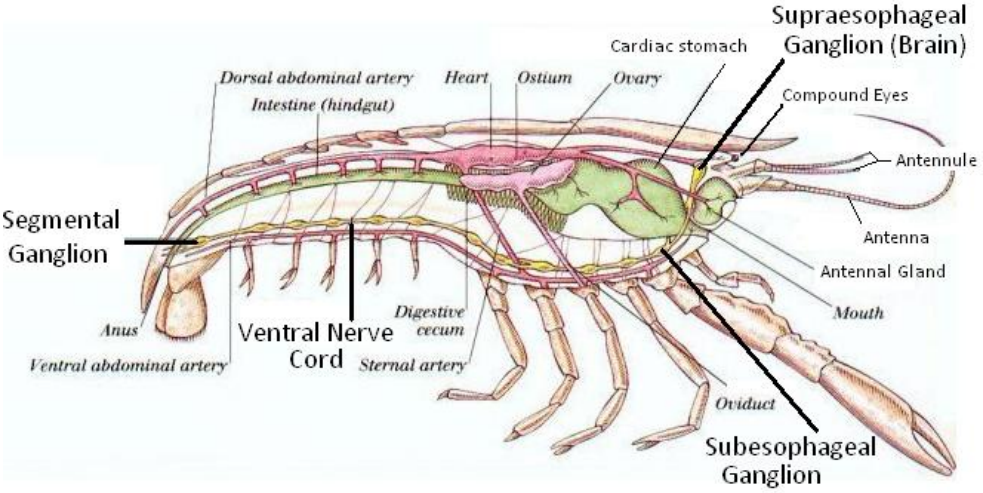
On either side of the stomach are the large **mandibular muscles,** which originate (the fixed end of the muscle) on the carapace and insert (the moving end of the muscle) on the mandibles. Contraction of these powerful muscles causes the crushing and grinding action of the jaw-like mandibles.

The prominent stomach is attached to the inner wall of the carapace by **anterior and posterior gastric muscles**.

The Nervous System and Sensory Organs

A crayfish's nervous system is composed of a **ventral nerve cord** (fused with **segmental ganglia)**, the supresophageal ganglia, and subesophageal ganglia. Giant neurons in the ventral nerve cord function in escape responses. The **supraesophageal and subesophageal ganglia** control the head appendages in response to sensory input received from receptors.

Crayfish have many sensory organs. The **tactile hairs** are dispersed across the exoskeleton and help sense touch, detect water currents, and to orient the body. The antennules have **statocysts** that detect the pressure of sand grains, giving the crayfish a sense of equilibrium. The **compound eyes** consist of many individual lenses (ommatidia) that form a myopic, mosaic image, but are especially attuned to detecting movement.



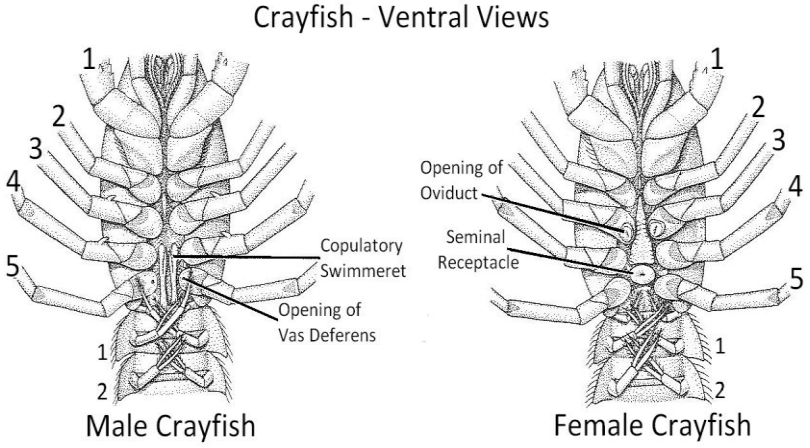
INTERNAL ANATOMY OF A FEMALE CRAYFISH: Image modified from: http://universe-review.ca/I10-82-crayfish.jpg

The Reproductive System

Crayfish have separate male and female sexes (they are **dioecious**) and the **gonads** (testes or ovaries) are located in the dorsal portion of the thorax, lateral to the anterior portion of the intestine. Mating usually takes place in the spring, just after the female has molted.

The **testes** are generally white and are difficult to distinguish from the digestive gland. Sperm from the testes exit the body through a pore at the base of the 5th pair of walking legs. The male deposits sperm near the openings of the female gonoducts (at the base of the 3rd periopods(walking legs) and uses the two modified pleopods (swimmerets) to guide the sperm into the female sperm receptacle.

The **ovaries** are usually orange and are coarser in texture and darker than the digestive gland. Fertilization is internal. Eggs are released at the base of the 3rd pair of walking legs. The eggs are "glued" to the female swimmerets while the young undergo 3 molts and develop their appendages before leaving their mother.



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Respiratory System

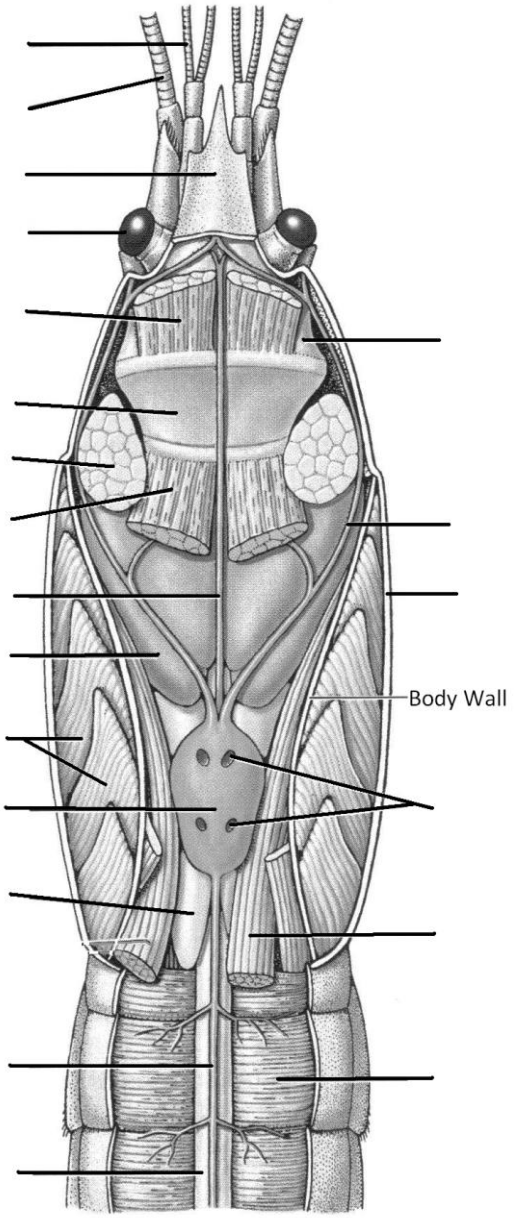
Aquatic arthropods generally have **gills** for respiration. The only exceptions are a few extremely small species which exchange respiratory gases across their epidermis. In crayfish, the carapace covers the gills except at the anterior and posterior ends of the gill chamber. Crayfish drive oxygen-containing water over their gills with their 2nd pair of maxillae, the **gill bailers**. There are also gills attached to certain appendages, called the **foot gills**. Another row of gills (the **joint gills)** found on the underside of the body is attached to membranes that hold the appendages to the body. The gills on your dissected specimen will look "feathery." The gills are well vascularised (having an abundant supply of blood vessels).

Dissection Instructions

1. Turn your crayfish onto it dorsum (ventral or belly-side up) to determine if it is male or female – so that you will know whether to look for testes or ovaries during the dissection.
2. Turn your crayfish over, dorsal side up. Carefully remove the carapace from the dorsum of the crayfish.
    a. Beginning under the posterior edge of the lateral carapace, use your fingers or a probe to gently pry the exoskeleton off the animal's body.
    b. **Be careful not to pull the carapace away too quickly.** Carefully remove the carapace, a little at a time, trying to avoid pulling the underlying epidermis, muscles, and organs off of the crayfish's body.
        i. The underlying structures will cling to the carapace, especially in the head.
3. Locate the pinkish **heart** lying on the dorsal surface of the thorax of the crayfish.
    a. Find the **ostia** (small holes in the heart) through which blood re-enters the heart from the hemocoel.
    b. Note the location and extent of the **hemocoel** - the circulatory system has been injected with dyed latex. The latex that is not associated with arteries is filling the hemocoel.
    c. Locate the large arteries leading from the heart.
4. Begin dissection of the digestive system.
    a. Locate the large yellowish **digestive gland,** which occupies much of the posterior part of the cephalothorax.
    b. The large **stomach** occupies most of the anterior region of the cephalothorax.
        i. Open the stomach and locate the chitinous teeth that form the **gastric mill** which is used to grind food.
5. Locate and identify other organs discussed in this dissection guide.
6. Label the diagram of the male crayfish on the next page.
7. Clean up your work station

On the next page is a diagram representing a dorsal view of the internal structures of a male crayfish. Use the terms above the diagram to identify the indicated structures.

Organ System	Structures to Identify
Circulatory	Antennal artery, Dorsal abdominal artery, Heart, Ophthalmic artery, & Ostia of heart
Digestive	Cardiac stomach, Digestive gland (hepatopancreas), Intestine, & Pyloric stomach
Integumentary	Antenna, Antennule, Carapace, Compound eye, & Rostrum
Muscular	Abdominal extensor muscle, Abdominal flexor muscle, Anterior gastric muscle, Mandibular muscle, & Posterior gastric muscle
Reproductive	Testis
Respiratory	Gills



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