Anatomy of a Shrimp/Crawfish

Grade Level:
5-12

Subject Area:
Biology, Anatomy

Time:
Preparation: 10 minutes
Activity: 3-45 minutes
Clean-up: 10 minutes

Student Performance Standards (Sunshine State Standards):
02.02 Demonstrate proper safety precautions and use of personal protective equipment. (SC.912.L.14.6, SC.912.L.16.10; SC.912.L.17.12, 14, 15, 16; MA.012.A.2.1, 2)
03.02 Demonstrate safe and effective use of common laboratory equipment (LA.910.1.6.1, 2, 3, 4, 5; SC.912.L.14.6SC.912.L.16.10; SC.912.L.17.12, 14, 15, 16; MA.912.A.2.1, 2)
06.04 Compare basic internal and external anatomy of animals (LA.910.1.6.1, 2, 3, 4, 5; SC.912.L.14.11, 12, 13, 14, 15, 16, 17, 18, 19, 21, 22, 28, 29, 31, 32, 33, 34, 36, 40, 41, 42, 43, 45, 46, 47,48, 51; SC.912.L.15.6, 7)
11.01 List and explain the meaning of morphology, anatomy, and physiology (LA.910.1.6.1, 2, 3, 4, 5; SC.912.L.14.7).
11.02 List and describe the physiology of aquatic animals (LA.910.1.6.1, 2, 3, 4, 5; LA.910.2.2.2; SC.912.L.14.11, 12, 13, 14, 15, 16, 17, 18, 19, 21, 22, 28, 29, 31, 32, 33, 34, 36, 40, 41, 42, 43, 45, 46, 47,48, 51SC.912.L. 18. 7, 8, 9).
11.03 Identify and describe the basic structures and external anatomy of crustaceans (LA.910.1.6.1, 2, 3, 4, 5; LA.910.2.2.2)
11.09 Develop an information file in aquaculture species (LA.910.1.6.1, 2, 3, 4, 5)
12.01 Recognize and observe safety practices necessary in carrying out aquaculture activities (LA.910.1.6.1, 2, 3, 4, 5)

Objectives:
1. Students will be able to identify types of crustaceans and provide examples.
2. Students will be able to describe the basic biology of aquacultured crustaceans.
3. Students will be able to identify key anatomical features of common crustacean species.
4. Students will be able to describe primary functions of anatomical features of

common crustacean species.

Abstract:

Crustacean aquaculture is one of the oldest and economically important aquaculture industries in the world. It involves commercial and experimental culture of several species of oysters, crabs, and freshwater crustaceans (prawns and crawfish), but the culture of penaeid shrimp dominates the worldwide market in shellfish aquaculture. In this lesson, students will learn about crustacean biology and complete a live or a virtual dissection of a penaeid. Students will identify the external anatomy of lobsters, blue crabs, and shrimp and describe the function of important external features. They will be able to identify the major internal organs of these species and their functions related to swimming, digestion, and respiration. Additionally, students will demonstrate dissection skills (for live dissections). Using a dissection guide or a virtual dissection on the computer, the students will participate in a dissection of a penaeid shrimp (preserved or fresh).

Interest Approach:

Have the students list some of the different types of crustacean they have consumed or caught and ask them if they think they are an aquacultured species. For example, have they ever eaten whole steamed crabs or participated in an old-fashioned shrimp boil (a southern tradition)? Ask them to identify how shrimp or crawfish are cultured and where in the United States or throughout the world they are most likely to occur (hint: environmental conditions suitable for culture).

Student Materials:

1. *Introduction to the Biology of Crustaceans* handout
2. Dissection equipment (or computer access for virtual dissection)
3. *External* and *Internal Anatomy* worksheets

Teacher Materials:

Material	*Store*	*Estimated Cost*
LIVE DISSECTION		
Dissection kits	Carolina Biological	$16 and up
Crawfish dissection guide	www.tobinslab.com	$1.99 and up
Dissection pan	Carolina Biological	$15.50 and up
Penaeid shrimp or crawfish	Carolina Biological-preserved (or fresh specimen from a local market)	$2.35 and up
Paper towels	Local grocery store	$3 and up

Hand sanitizer	Local grocery store	$3 and up
External and *Internal Anatomy* handouts	NA	NA
VIRTUAL DISSECTION		
Carolina BioLab software	Carolina Biological	$80 and up
Shrimp	http://www.shrimpcrabsandcrayfish.co.uk/Shrimp.htm?Anatomy.htm~mainFrame	
Dissection worksheets	http://www.saalt.com.au/sciweb/activity/AC/anatomys7.html	
Diagram of internal anatomy	http://community.webshots.com/photo/fullsize/2542866070089554796gtfSGY	
Crayfish dissection part I	http://www.youtube.com/watch?v=6GQKy3nL7es	
Crayfish dissection part II	http://www.youtube.com/watch?v=gKhgxtSX1cw	
Crayfish dissection part III	http://www.youtube.com/watch?v=dx54WY4tEHg	
Crayfish dissection part IV	http://www.youtube.com/watch?v=p_fgKxRwwXM	
Crayfish dissection part V	http://www.youtube.com/watch?v=f0-CIIuNIBk	
Crayfish dissection guide	http://www.middleschoolscience.com/crayfish.htm	

Student Instructions:

1. Read the handout *Introduction to the Biology of Crustaceans* for homework in preparation for this laboratory (extracted from the crustacean biology module: Objectives 1-4).
2. Once assigned to a group, prepare your table for a live dissection (or prepare your worksheets for a virtual dissection).
3. Begin to identify and label the external anatomy and their functions on your worksheet or in your lab notebook.
4. Follow the teacher's instructions and your dissection guide for the internal anatomy and the proper way to prepare your dissection.
5. Be sure to identify the internal organs and their functions in response to swimming, digestion, and respiration.

Teacher Instructions:

Preparations:

1. Obtain your shrimp or crawfish specimens (fresh or preserved).
2. Divide your class into small groups (2-4 per group if possible).
3. Prepare one dissection kit, pan, and clean-up materials per group.
4. Copy the dissection guide for each student.
5. Copy the *External* and *Internal Shrimp Anatomy* handouts for each student.
6. Give students a copy of the *Introduction to the Biology of Crustaceans*

handout and have them read this as homework, or touch on the different types of fishes prior to the dissection in classroom lectures.

Activity:

1. Once students are in their groups, ask them to identify the external anatomy (perhaps put a drawing on the board).
2. Follow the dissection guide step by step in order to ensure each group is moving through the anatomy at the same time.
3. Ask the students to label and/or draw (if using lab notebooks) each step of the dissection and identify major organs and their uses (information will be in dissection guide).

Post work/Clean-up:

1. When students are finished with the dissection, have them fold all materials into their paper towels and set aside a separate trashcan for dissection materials.
2. Have each group thoroughly rinse and sanitize dissection equipment (water and mild bleach solution or other sanitizing agent). Have them dry the equipment and return it to the kit. Make sure that they rinse and dry their tray as well.
3. Dispose of dissection material appropriately (e.g., outside dumpster) and immediately.
4. Wipe all dissection stations with a sanitizer (mild bleach solution).

Anticipated Results:

1. Students will identify the external anatomy of a shrimp or crawfish and describe the function of important external features.
2. Students will know the major internal organs of a shrimp and their functions related to swimming, digestion, and respiration.
3. Students will demonstrate dissection skills (for live dissections).

Support Materials:

1. *Introduction to the Biology of Crustaceans* handout
2. *External Anatomy of a Shrimp* handout
3. *Internal Anatomy of a Shrimp* handout
4. *Shrimp Culture Overview* presentation (Powerpoint: Creswell – UF/IFAS)
5. *Biology and Culture of Spiny and Clawed Lobsters* (Powerpoint: HBOI)

Explanation of Concepts:

Anatomy of invertebrates
Dissection skills

Relationship of structure and function

Support Materials

Introduction to the Biology of Crustaceans

Crustaceans are a group of hard-bodied animals that are members of the phylum Arthropoda that they share with such other organisms as spiders, scorpions, centipedes, millipedes, insects, and horseshoe crabs. Arthropods are characterized by having an **exoskeleton** (composed of a carbohydrate polymer called chitin, minerals, mostly $CaCO_3$, and proteins) and segmented appendages. Crustaceans are a sub-group of arthropods that are segmented, primarily aquatic, and use gills to breath. There are many types of crustaceans that are surprisingly dissimilar to the eye – brine shrimp, crabs, copepods (zooplankton), lobsters, and barnacles. The species of crustaceans that are important for aquaculture are all in the class Malacostraca. All adult members of the Malacostraca have 19 segments (1-5 are the head, 6-13 are the thorax, and 14-19 are the abdomen), although some of the segments may be partially fused, such as the cephalothorax, or carapace, of lobsters (head and thorax fused).

In addition to being malacostracans, the major groups of cultured crustaceans — lobsters, crabs, crawfish, shrimp and prawns — are members of the order **Decapoda**, having five (5) pairs of walking legs (**periopods**) on segments 9 – 13. In some species (Maine lobster, crabs, and some prawns) the first pair are clawed, or **chelate**, and may be used for capturing food or defense; penaeid shrimp and the palinurid lobsters (Caribbean spiny lobster) have no chelated appendages. There are also appendages on the abdomen, called **pleopods**, which may be modified for swimming (swimmerets) and/or hold fertilized eggs (females). Most decapod crustaceans (with the exception of crabs) have a fan-shaped tail (called the telson) comprised of several **uropods**. The abdomen, equipped with the paddle-like telson serves for locomotion, and it is often used to rapidly escape from potential predators.

Decapod crustaceans, and all arthropods for that matter, are housed in a hard exoskeleton, called the **carapace**, which is comprised of a carbohydrate polymer, called **chitin**, minerals (mostly $CaCO_3$), and proteins. This structural arrangement poses a unique challenge for growth, similar to a knight who has outgrown his metal armor. In order to grow, the animal must shed the old carapace, secrete a new, larger one that it will eventually fill and shed again (*figure*). This process of shedding the exoskeleton is called **ecdysis** or **molting**. The molt cycle is normally triggered by external stimuli (light and temperature), as well as internal signals, which initiate the secretion of the hormone **ecdysone**, which facilitates the molting events that follow. It requires a series of physiological steps — breaking down the old shell, storing the $CaCO_3$, regenerating missing limbs, building carbohydrate reserves for chitin production, and finally the physical act of extraction from the old, hard carapace and inflating (with water) the new soft carapace to a larger size. For the next day or so, the shell is soft (hence the term soft-shelled crabs), and the animal is immobile and highly vulnerable to predation. Once the shell has hardened the animal will resume its regular activities. Usually a few days before ecdysis, the crustacean will find a secure hiding place and suspend feeding activities.

There are two components to growth by molting that scientists use: 1) the **intermolt period** — the duration, or time between, successive molts, and 2) the **molt increment** the increase in size from a single molt (expressed as the % weight gain after the molt). Both are size and age dependent. Juvenile crustacean molt frequently (short intermolt period) and experience significant weight increases (molt increment). As they grow older (and larger), the intermolt period gets longer and longer, and the weight gain (as a percentage) declines.

The process of molting poses the most physiological stressful and dangerous period during the animal's life. Under culture conditions, particularly during the crustacean's larval period and metamorphosis, but also throughout life, mortality is most likely to occur during ecdysis. Nutrient deficiency is often the culprit, such as "molt death syndrome", first discovered in hatcheries for Maine lobsters (but probably not limited to that species) that were determined to be caused by vitamin C deficiency. There are likely other dietary requirements for successful molting yet to be discovered.

However, the challenge for most crustacean culture (with the exception of penaeid shrimp) is the tendency for aggressive and cannibalistic behavior — non-molting animals attacking the vulnerable, unprotected soft-shelled one (a particular problem in tank systems). Providing habitat to create a complex environment offers some shelter for post-molt animals, but such a strategy compromises water flow, can create stagnant pockets of uneaten feed and feces, and complicates tank cleaning and harvesting. In some cases, Maine lobster culture and blue crab shedding operations, animals are individually housed to prevent cannibalistic predation. Even the Caribbean spiny lobster, a gregarious crustacean under normal conditions, will become cannibalistic when its dietary requirements are not met.

Decapod crustaceans are fairly anatomically similar with regard to reproduction, although spawning behavior and larval development are quite variable. Crustacean gonads are paired, elongate organs located in the thorax and/or abdomen. The oviducts are tubules, usually terminating on the last pair of walking legs for males and the third from the last pair in the females. A **gonad-stimulating hormone**, produced in the thorax stimulates egg production, and once the ovaries are fully developed (and the males are ready to copulate) some crustaceans release chemical signals called **pheromones** into the water to attract potential mates. Copulation often occurs when the females are in the process of molting, at which time the male releases its gametes, often in the form of a sperm mass or packet called the **spermatophore** using specially modified appendages, and the female usually has a receptacle that is used to hold the male gametes until fertilization. Most female crustaceans carry the fertilized eggs beneath the abdomen attached to the periopods.

The larval development of decapod crustaceans that may have potential for aquaculture is highly variable and is one of several critical components to realizing commercial-scale farming. The Maine lobster, *Homarus Americana* for example, has a very short-lived larval period (4 stages, 10 days), although the femal may carry the eggs for almost year before that hatch. In contrast, the Caribbean spiny lobster, *Panulirus argus*, will remain berried for just a few weeks before releasing the larvae, but it has a protracted larval cycle (12 stages lasting as much as 400 days). Clearly, hatchery production of spiny lobsters is not economically viable, and collection of post-larvae from the wild is currently being evaluated for commercial spiny lobster aquaculture. Maine lobsters have been successfully reared in hatcheries for decades, but other obstacles are confronted later on in the production cycle (guess what?).

The male blue crab (*Callinectes* spp.) will mate at any time during its last three intermolts (they live for 2 to 3 years), while the female will mate only once during her molt from juvenile to adult. She will spawn (release her eggs) 1- 10 months after copulation, and will carry up to two million eggs under her abdomen apron (berried) for a week to 10 days. The hatched larvae undergo eight (8) stages that may last from 40 to 70 days, dependent upon temperature and food availability.

Freshwater crawfish (*Procambarus* spp.) may spawn year-round in warm climates, mating occurring in the spring and the eggs fertilized in the fall (six months) while the female remains in a burrow. The eggs are attached to the pleopods and fanned (or oxygen) for two to three weeks. Upon hatching, the juveniles (no planktonic larval period) remain attached to the females for about two molts before assuming their own benthic existence. They will mature in three to five months and live for up to four years.

The adult decapod may be an active predator, a scavenger, or an omnivore, and in almost all crustaceans the mouthparts break up the food that passes food through the esophagus into the cardiac stomach, pyloric stomach, and finally the intestines. Between the two stomachs is the “gastric mill” which helps to grind the food, while the hepatopancreas releases digestive enzymes.

Table 1: Larval development of decapod crustaceans

Common Name	Scientific name	Spawning season	Larval Stages and Duration (days)	Diet
Maine lobster	*Homarus americana*	Summer, eggs released 9-12 months later (next summer)	4 stages lasting 10 days	Phytoplankton and Artemia
Caribbean Spiny lobster	*Panulirus argus*	Summer	At least 12 stages of phyllosma larvae lasting one year +	Unknown; probably zooplankton and perhaps jellyfish (in the wild)
Penaeid shrimp	*Penaeus/Litopenaeus spp.*	Year round maturation in aquaculture facilities		
Blue crab	*Callinectes* spp.	Spring/summer; eggs released 1-10 months later	7 zoea (31-49 days), 1 megalopa(6-20 days)	Phytoplankton and zooplankton
Freshwater crawfish	*Procambarus* spp.	Year-long in warm climates: Usually mate in spring; Sperm may not be used by female for up to 6 months (fall)	Fertilized eggs attached to pleopods for 2-3 weeks	

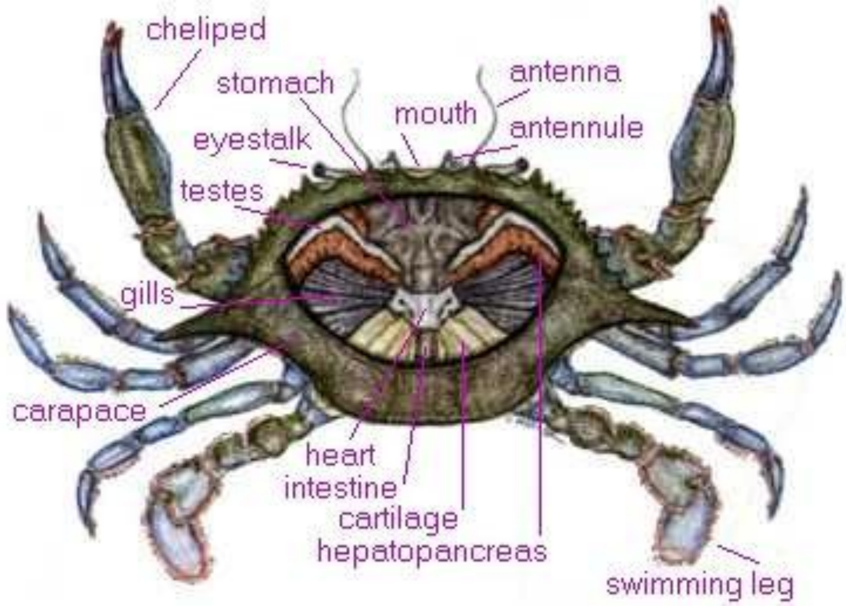


Figure 1: Anatomy of blue crab

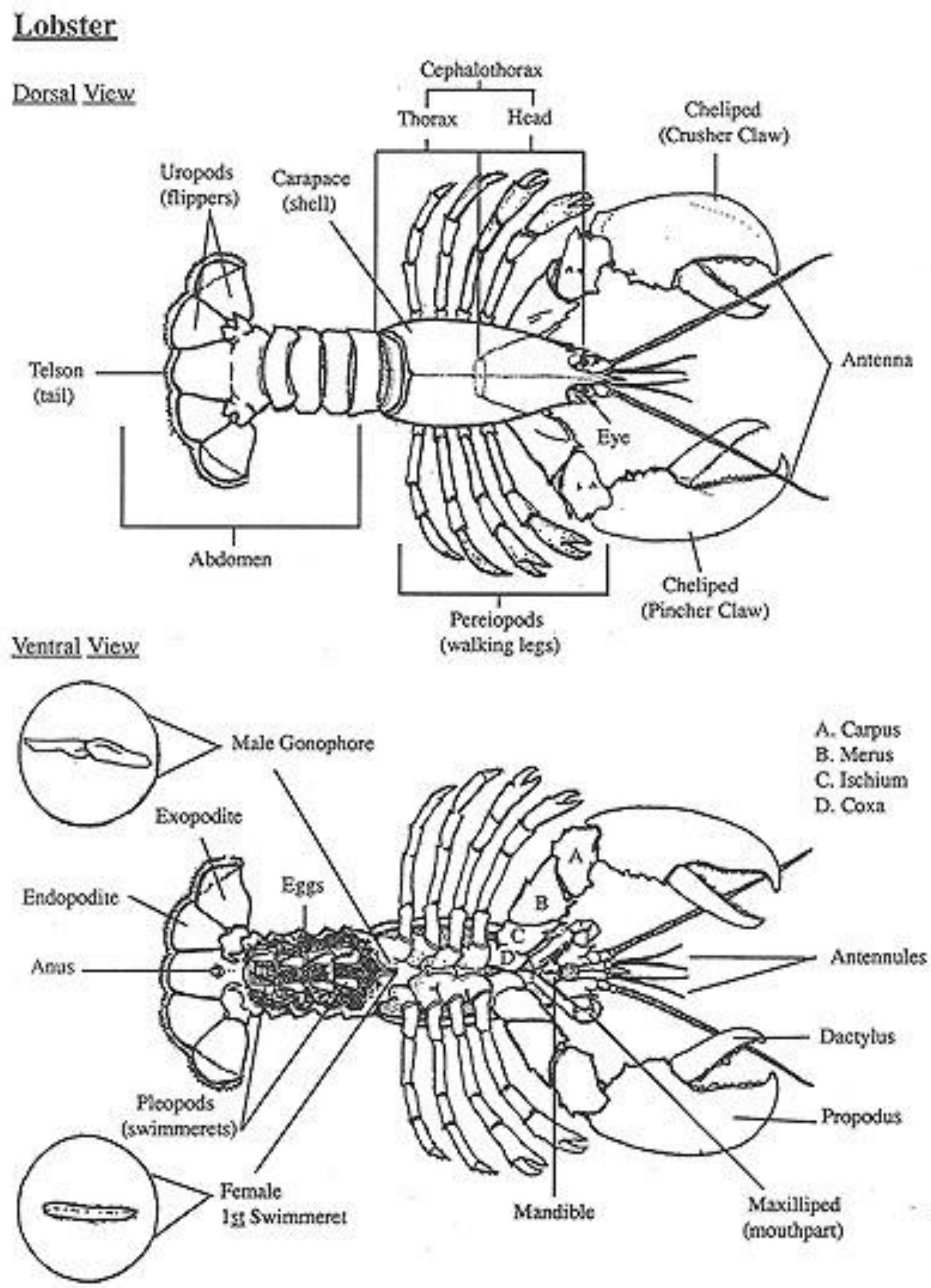
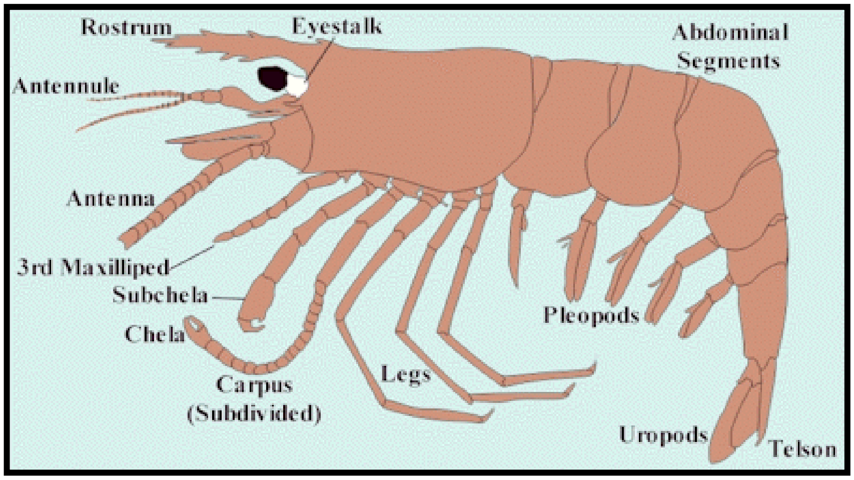


Figure 2: External anatomy of the Maine lobster

Name: ________________________

External Anatomy of Shrimp

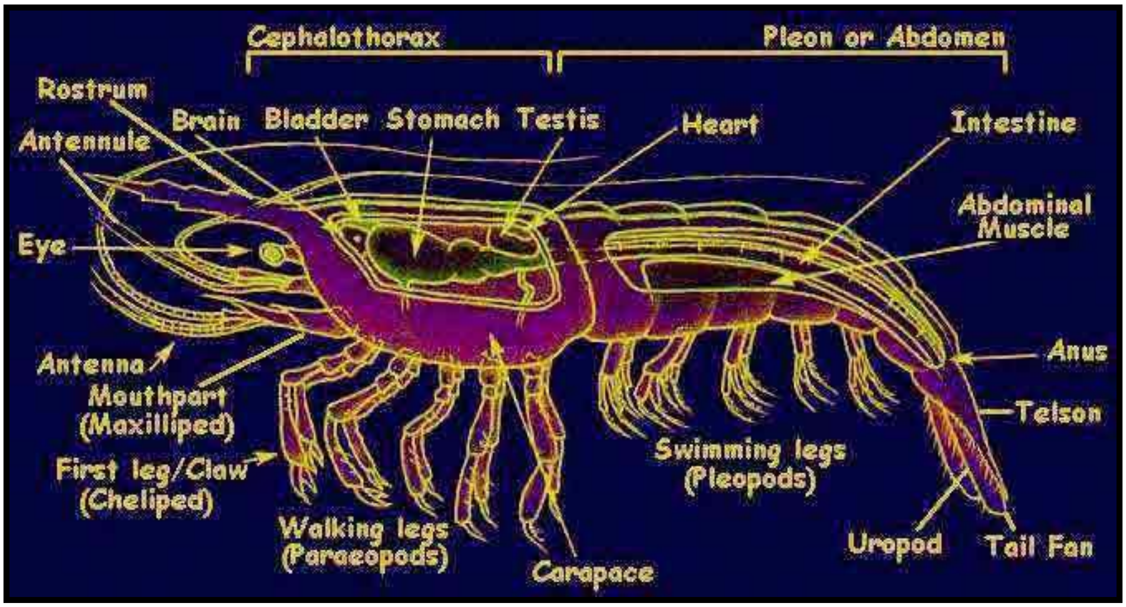


Identify the function of the following structures:

1. Rostrum-
2. Eyestalk-
3. Antenna-
4. Pleopods-
5. Telson-
6. Uropods-
7. Exoskeleton-

Name: ________________________

Internal Anatomy of a Shrimp



Identify the function of the following structures:

1. Bladder-
2. Stomach-
3. Anus-
4. Abdominal muscle-