

Invertebrates II

Objectives

1. Describe the general characteristics of arthropods and the specific features of the six classes of arthropods.
2. Identify and/or locate external and internal structures of the crayfish and grasshopper after dissecting examples of each.
3. Contrast the anatomy of the crayfish and the grasshopper, indicating how each is adapted to its way of life.
4. Describe the general characteristics of echinoderms and the specific features of the five classes of echinoderms.
5. Identify and locate the external and internal structures of a sea star.
6. Trace the path of water in the water vascular system of a sea star.

In this laboratory, you will be working in groups of three on the dissection of the organism assigned to you by the professor. You will be responsible for identifying the external and internal features of your organism using Van Der Graaf and Crawley and other resources as provided by your instructor. After completing the dissection, you will be responsible for explaining these features to other members of the class who dissected one of the other organisms. You are also required to examine the dissections of other groups and learn about their organisms. At the end of the laboratory you are required to turn in labeled drawings of all three organisms plus answers to the six objectives listed above. (**NOTE:** Don't forget to check out the other specimens that are available at the rear of the lab. These will assist you in identifying the key shared features of arthropods and echinoderms, and the classes contained within these phyla.)

Arthropods

The majority of animal species are arthropods and the biomass of insects alone outweighs that of human beings. Arthropods and annelids share a common ancestry, but arthropods have evolved to occupy every possible habitat on land and in the sea. The success of arthropods is due to the evolution of a hard exoskeleton composed of protein and chitin, a polysaccharide. The exoskeleton consists of hardened plates separated by thin, membranous areas that allow movement of body

segments and appendages; the term arthropod means jointed foot. The exoskeleton is versatile and protects the animal's body and prevents it from drying out.

The exoskeleton also poses a problem to arthropods in that it restricts their ability to grow. Because the skeleton can't grow with the animal, periodically the animal has to shed the skeleton during a molt. During this period the animal is particularly vulnerable to attack. Because the skin of the animal is covered by the exoskeleton, it cannot be used for sensing and detecting stimuli; instead, antennae and sensory bristles are used.

Arthropods are coelomates although the coelom is lost during development; the body cavity of the mature arthropod has a different origin, developing from the hemocoel. There are usually some signs of segmentation in the body and there is pronounced cephalization, with the mouth, nervous system, and sense organs concentrated in the region of the head. The ancestral arthropod is thought to have had many segments each with a pair of appendages, somewhat like the fossil trilobites. The paired, jointed appendages may be modified for other purposes than locomotion. The basic arthropod appendage is two-branched although in most arthropods one or other of the branches is lost; both branches are retained in some arthropods, notably in crustaceans. Modified appendages are used for chewing, biting, stinging, transferring sperm, chemoreception, and touch perception.

Sexes are separate, and arthropods copulate and have internal fertilization. Most arthropods care for the eggs in some way, either by laying the eggs with a protective shell in or on a food source or by carrying them around on their bodies until they hatch. Larvae are often very different from adults and undergo metamorphosis, during which they change into the adult form in a short period of time.

All arthropods have a complete digestive system (runs from mouth to anus), a double ventral nerve chord, an open circulatory system consisting of the body cavity (hemocoel) filled with hemolymph pumped by the dorsal heart, and excretory organs called the Malpighian tubes.

Anatomy of Crayfish

Jointed paired appendages are attached to all three body regions of a crayfish. The presence of two pairs of antennae and biramous appendages identifies them as belonging to the subphylum *Crustacea*. Crayfish are known to be scavengers, but they also prey on other invertebrates. The mouth is surrounded by appendages modified for feeding, and there is a well-developed digestive tract. Dorsal, anterior,

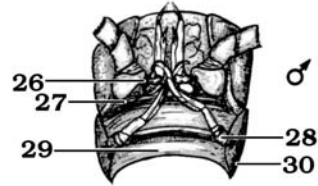
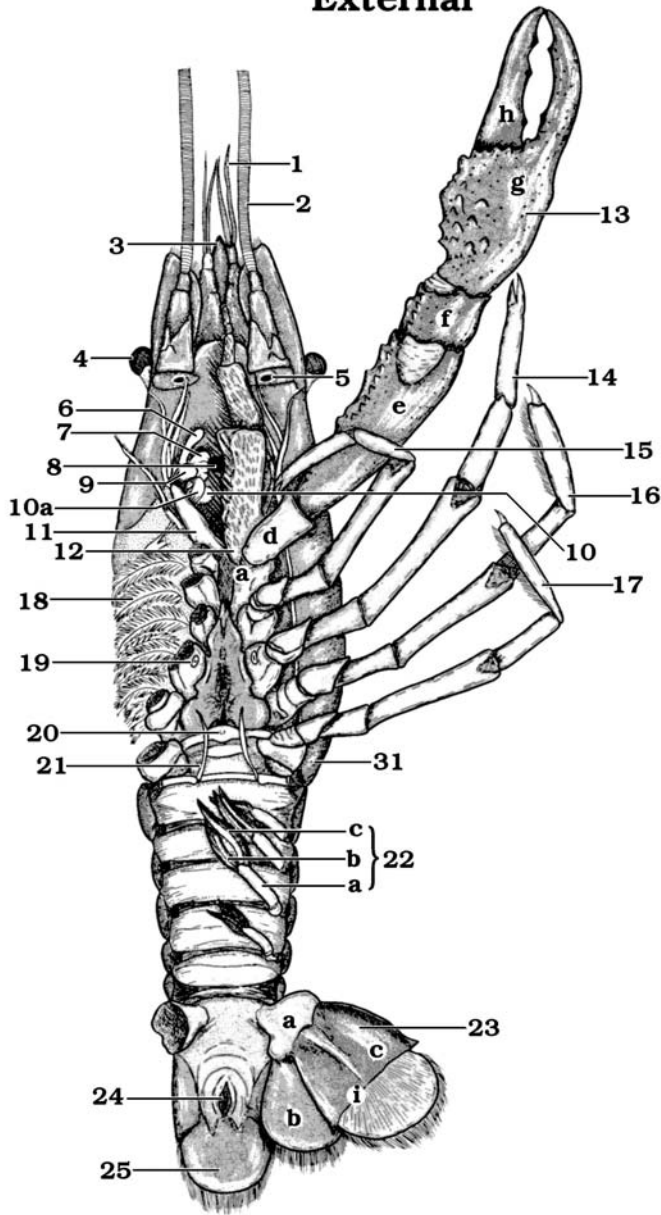
and posterior arteries carry hemolymph (blood plus lymph) to tissue spaces (hemo-coel) and sinuses. In contrast to vertebrates, there is a ventral solid nerve cord. Crayfish are adapted to an aquatic existence.

External Anatomy

1. Obtain a preserved crayfish, and place it in a dissecting pan.
2. Identify the **chitinous exoskeleton**. With the help of Van der Graaf and Crawley, identify the head, thorax, and abdomen. Together, the head and thorax are called the **cephalothorax**; the cephalothorax is covered by a **carapace**. Has specialization of segments occurred? Explain.
3. Find the **antennae**, which project from the head. At the base of each antenna, locate a small, raised nipple containing an opening for the **green glands**, the organs of excretion. Crayfish excrete a liquid nitrogenous waste.
4. Locate the **compound eyes**, which are composed of many individual units for sight. Do crayfish demonstrate cephalization? Explain.
5. Identify the six pairs of appendages around the mouth for handling food.
6. Find the five pairs of appendages (legs) attached to the cephalothorax. The most anterior pair is the pincer-like claws. The other four pairs are walking legs.
7. Locate the five pairs of **swimmerets** on the abdomen. In the male, the anterior two pairs are stiffened and folded forward. They are claspers and aid in the transfer of sperm during mating.
8. In the female, identify the **seminal receptacles**, a swelling located between the bases of the third and fourth pairs of walking legs. Sperm from the male are deposited in the seminal receptacles. In the male, identify the opening of the sperm duct located at the base of the fifth walking leg. What sex is your specimen?
9. Examine the opposite sex also.
10. Find the last abdominal segment, which bears a pair of broad, fan-shaped **uropods**, which, together with a terminal extension of the body, form a tail. Has specialization of appendages occurred? Explain.

CRAYFISH ANATOMY

External



1. Antennule
2. Antenna
3. Rostrum
4. Eye
5. Nephridiopore
6. Mandibular palp
7. Mandible
8. Mouth
9. 1st maxilliped
10. 1st maxilla
- a. 2nd maxilla
11. 2nd maxilliped
12. 3rd maxilliped
13. Cheliped
14. 3rd walking leg
15. 2nd walking leg
16. 4th walking leg
17. 5th walking leg
18. Gills
19. Oviduct opening
20. Seminal receptacle
21. 1st pleopod
22. 4th pleopod
23. Uropod
24. Anus
25. Telson
26. Genital opening (male)
27. 1st pleopod
28. 2nd pleopod
29. Sternum
30. Pleuron
31. Tergum
- a. Protopodite
- b. Endopodite
- c. Exopodite
- d. Ischium
- e. Merus
- f. Carpus
- g. Propus
- h. Dactylus
- i. Transverse hinge

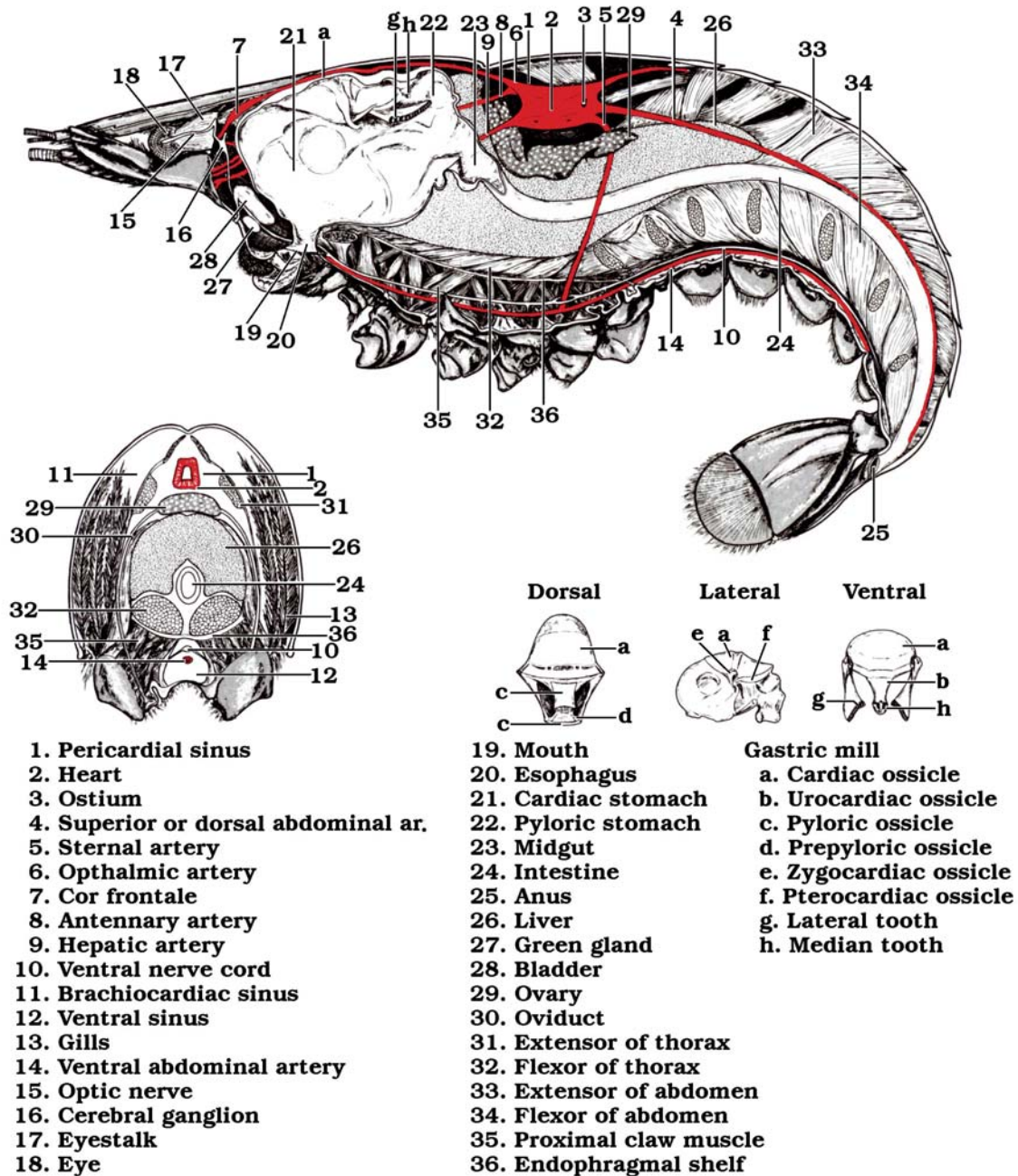
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Internal Anatomy

1. Place the crayfish in the dissecting pan.
2. Cut away the lateral surface of the carapace with scissors to expose the **gills**. Observe that the gills occur in distinct, longitudinal rows. How many rows of gills are there in your specimen? The outer row of gills is attached to the base of certain appendages. Which ones? These outer gills are the **podobranchia** (“foot gills”). How many podobranchia do you find in your specimen?
3. Carefully separate the gills with a probe or dissecting needle, and locate the inner row(s) of gills. These inner gills are the **arthrobranchia** (“joint gills”) and are attached to the chitinous membrane that joins the appendages to the thorax. How many rows of arthrobranchia do you find in the specimen?
4. Remove a gill with your scissors by cutting it free near its point of attachment, and place it in a watch glass filled with water. Observe the numerous gill filaments arranged along a central axis.
5. Carefully cut away the dorsal surface of the carapace with scissors and a scalpel. The epidermis that adheres to the exoskeleton secretes the exoskeleton. Remove any epidermis adhering to the internal organs.
6. Identify the diamond-shaped heart lying in the mid-dorsal region. A crayfish has an open circulatory system. Carefully remove the heart.
7. Locate the **gonads** anterior to the heart in both the male and female. The gonads are tubular structures bilaterally arranged in front of the heart and continuing behind it as a single mass. In the male, the testes are highly coiled, white tubes.
8. Find the **mouth**; the short, tubular **esophagus**; and the two-part **stomach**, with attached **digestive gland**, that precedes the **intestine**.
9. Identify the **green glands**, two excretory structures just anterior to the stomach, on the ventral segment wall.
10. Remove the thoracic contents previously identified.
11. Identify the **brain** in front of the esophagus. The brain is connected to the ventral nerve cord by a pair of nerves that pass around the esophagus.
12. Remove the animal’s entire digestive tract, and float it in water. Observe the various parts, especially the connections of the digestive gland to the stomach.
13. Cut through the stomach, and notice in the anterior region of the stomach wall the heavy, tooth-like projections, called the **gastric mill**, which grind up food. Do you see any grinding stones ingested by the crayfish?

CRAYFISH ANATOMY

Dissection



- 1. Pericardial sinus
- 2. Heart
- 3. Ostium
- 4. Superior or dorsal abdominal ar.
- 5. Sternal artery
- 6. Ophthalmic artery
- 7. Cor frontale
- 8. Antennary artery
- 9. Hepatic artery
- 10. Ventral nerve cord
- 11. Brachiocardiac sinus
- 12. Ventral sinus
- 13. Gills
- 14. Ventral abdominal artery
- 15. Optic nerve
- 16. Cerebral ganglion
- 17. Eystalk
- 18. Eye

- 19. Mouth
- 20. Esophagus
- 21. Cardiac stomach
- 22. Pyloric stomach
- 23. Midgut
- 24. Intestine
- 25. Anus
- 26. Liver
- 27. Green gland
- 28. Bladder
- 29. Ovary
- 30. Oviduct
- 31. Extensor of thorax
- 32. Flexor of thorax
- 33. Extensor of abdomen
- 34. Flexor of abdomen
- 35. Proximal claw muscle
- 36. Endophragmal shelf

- Gastric mill**
- a. Cardiac ossicle
 - b. Urocardiac ossicle
 - c. Pyloric ossicle
 - d. Prepyloric ossicle
 - e. Zygocardiac ossicle
 - f. Pterocardiac ossicle
 - g. Lateral tooth
 - h. Median tooth

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Answer the following questions:

1. Which body region of the crayfish is most obviously segmented?
2. How many legs are chelate (that is, pincer-like with opposing claws)?
3. What is the function of the uropods and telson, and what feature indicates this function?
4. Are the anterior swimmerets different from the posterior pair? Is your crayfish a male or a female?
5. Which set of legs (swimmerets or walking legs) appears best adapted to carry an incubating egg mass delicately and in a protected place on the body?
6. In what two ways do crayfish move?

Anatomy of Grasshopper

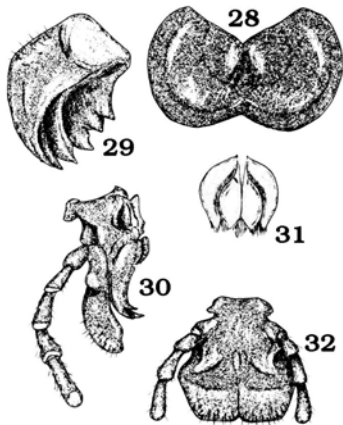
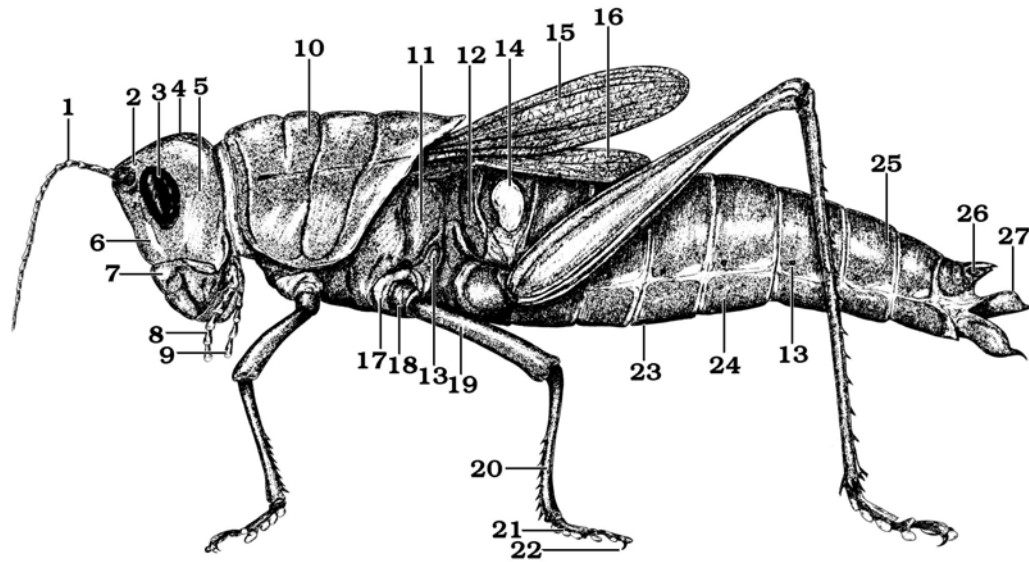
The grasshopper is an insect. The presence of a single pair of antennae and uniramous appendages among other features identifies insects as belonging to the subphylum *Uniramia*. There are no appendages attached to the abdomen. Insects are adapted to life on land. In insects with wings, such as the grasshopper, wings are attached to the thorax. Respiration is by a highly branched internal system of tubes, called tracheae.

External Anatomy

1. Obtain a preserved grasshopper, and study its external anatomy with the help of Van de Graaf and Crawley. Identify the head, thorax, and abdomen.
2. The grasshopper's thorax consists of three fused segments: the large anterior **prothorax**, the middle **mesothorax**, and the hind **metathorax**. Identify the first pair of legs attached to the prothorax. Then find the second pair of legs and the outer pair of straight, leathery **forewings** attached to the mesothorax. Finally, locate the third pair of legs and the inner, membranous **hind wings** attached to the metathorax. Each leg consists of five segments. The hind leg is well developed and used for jumping. How many pairs of legs are there?
3. Is locomotion in the grasshopper adapted to land? Explain.
4. Use a hand lens or dissecting microscope to examine the grasshopper's special sense organs of the head. Identify the antennae (a pair of long, jointed feelers), the compound eyes, and the three, dot-like simple eyes.
5. Remove the **mouthparts** by grasping them with forceps and pulling them out. Arrange them in order on an index card, and compare them to Figure 7.97. These mouthparts are used for chewing and are quite different from those of a piercing and sucking insect.
6. Identify the **tympana** (sing., **tympanum**), one on each side of the first abdominal segment. The grasshopper detects sound vibrations with these membranes.
7. Locate the spiracles, along the sides of the abdominal segments. These openings allow air to enter the tracheae, which constitute the respiratory system.
8. Find the **ovipositors**, four curved and pointed processes projecting from the hind end of the female. These are used to dig a hole in which eggs are laid. The male has **claspers** that are used during copulation.

GRASSHOPPER ANATOMY

External



- | | |
|-------------------|----------------------|
| 1. Antenna | 17. Coxa |
| 2. Ocellus | 18. Trochanter |
| 3. Compound eye | 19. Femur |
| 4. Vertex | 20. Tibia |
| 5. Gena | 21. Tarsus |
| 6. Frons | 22. Claw |
| 7. Clypeus | 23. Abdomen |
| 8. Maxillary palp | 24. Sternum |
| 9. Labial palp | 25. Tergum |
| 10. Prothorax | 26. Cercus |
| 11. Mesothorax | 27. Ovipositor |
| 12. Metathorax | 28. Labrum |
| 13. Spiracle | 29. Mandible (right) |
| 14. Tympanum | 30. Maxilla (right) |
| 15. Fore wing | 31. Hypopharynx |
| 16. Hind wing | 32. Labium |

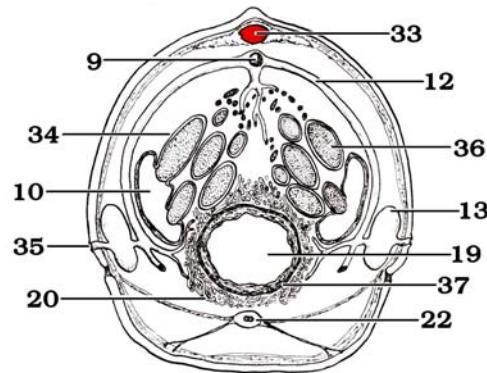
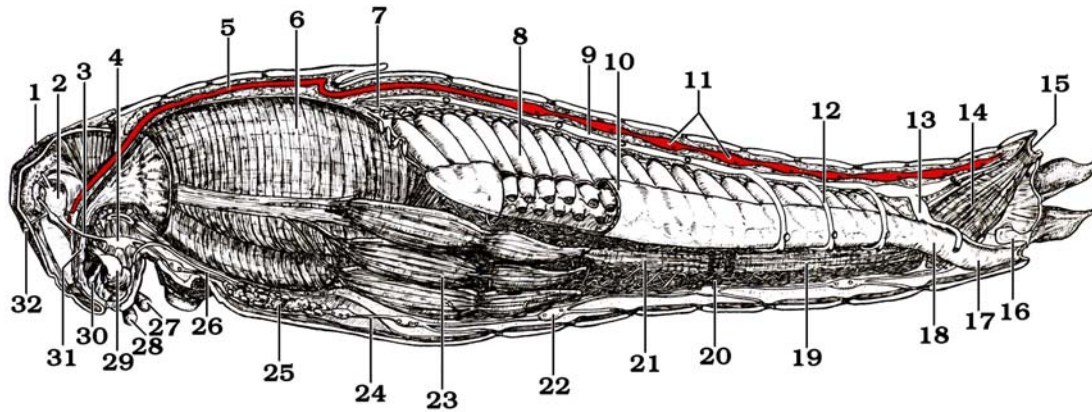
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Internal Anatomy

1. Detach the wings and legs of the grasshopper. Then turn the organism on its side, and use scissors to carefully cut through the exoskeleton (dorsal to the spiracles) along the full length (from the head to the posterior end) of the animal. Repeat this procedure on the other side.
2. Cut crosswise behind the head so that you can remove a strip of the exoskeleton. If necessary, reach in with a probe to loosen the muscle attachments and membranes.
3. Pin the insect to the dissecting pan, dorsal side up. Cover the specimen with water to keep the tissues moist.
4. Identify the heart and aorta just beneath the portion of exoskeleton you removed. A grasshopper has an open circulatory system. Remove the heart and adjacent tissues.
5. Locate the **fat body**, a yellowish fatty tissue that covers the internal organs. Carefully remove it.
6. Find the **tracheae**, the respiratory system of insects. Using the dissecting microscope, look for glistening white tubules, which deliver air to the muscles.
7. Identify the reproductive organs that lie on either side of the digestive tract in the abdomen. If your specimen is a male, look for the testis, a coiled, elongated cord containing many tubules. If your specimen is a female, look for the ovary, essentially a collection of parallel tapering tubules containing cigar-shaped eggs.
8. Locate the digestive tract and, in sequence, the **crop**, a large pouch for storing food (a grasshopper eats grasses); the **gastric caeca**, digestive glands attached to the stomach; the stomach and the intestine, which continues to the anus; and **Malpighian tubules**, excretory organs attached to the intestine. Insects secrete a solid nitrogenous waste. Is this an adaptation to life on land? Explain.
9. Work the digestive tract free, and move it to one side. Now identify the **salivary glands** that extend into the thoracic cavity.
10. Remove the internal organs. Now identify the ventral **nerve cord**, which is thickened at intervals by ganglia.
11. Remove one side of the exoskeleton covering the head. Identify the brain, which is anterior to the esophagus.

GRASSHOPPER ANATOMY

Dissection



- | | | |
|--------------------------------|--------------------------|------------------------------|
| 1. Antenna | 14. Rectum | 26. Salivary duct |
| 2. Supraesophageal ganglion | 15. Anus | 27. Labial palp |
| 3. Circumesophageal connective | 16. Seminal receptacle | 28. Maxillary palp |
| 4. Subesophageal ganglion | 17. Vagina | 29. Hypopharynx |
| 5. Aorta | 18. Oviduct | 30. Mandible |
| 6. Crop | 19. Intestine | 31. Exophagus |
| 7. Ovary | 20. Malpighian tubules | 32. Ocellus |
| 8. Egg in egg tube | 21. Midgut | 33. Dorsal heart |
| 9. Dorsal tracheal trunk | 22. Ventral ganglion (8) | 34. Egg tube |
| 10. Calyx | 23. Gastric caeca | 35. Abdominal spiracle |
| 11. Hearts (9) | 24. Ventral nerve cord | 36. Egg |
| 12. Dorsal tracheal branch | 25. Salivary gland | 37. Longitudinal muscle band |
| 13. Air sac | | |

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Answer the following questions:

1. How many ocelli, or simple eyes, does a grasshopper have?
2. What is the probable function of the maxillary and labial palps?
3. Wing morphology varies among species and orders of insects. Spread the wings. Do they all have the same shape and consistency?
4. Do you suspect that the fore- and hind-wings have different functions? Why or why not?

Comparison of Crayfish and Grasshopper Anatomy

	Crayfish	Grasshopper
Locomotion		
Respiration		
Nervous System		
Reproductive Features		
Sense organs		

Echinoderms

Echinoderms are all marine, and they live on the sea bottom, either attached to it, like sea lilies, or creeping slowly over it. The name echinoderm means spiny skinned and most members of the phylum have defensive spines on the outside of their bodies. The spines develop from the endoskeleton that is composed of calcium carbonate plates. The endoskeleton supports the body wall and is covered with living tissue that can be either soft (as in sea cucumbers) or hard (as in sea urchins).

While adult echinoderms show radial symmetry, with generally five points of symmetry arranged around the axis of the mouth, the larvae are bilaterally symmetrical. The most unique feature of echinoderms is their water vascular system, a network of hydraulic canals that branch out into the body. Those echinoderms that have arms in contact with the substratum have tube feet associated with the water vascular system that are used for locomotion. In other echinoderms the tube feet are used for gas exchange and food gathering.

Sexual reproduction in echinoderms usually involves separate sexes that release their gametes into the water. The radial adults develop by metamorphosis from the bilateral larvae. Sea stars have the ability to regenerate lost parts; new individuals may form from a single arm provided part of the central body is attached. The rapid increase in sea star populations in some mussel beds has been attributed to mussel fisherman attempting to rid the beds of sea stars by hacking them to pieces.

Echinoderms have a rudimentary nervous system with no distinct brain. Movements are loosely coordinated by a system consisting of a nerve ring encircling the esophagus and radial nerves to the rest of the body. In sea stars simple receptors for light and chemicals are concentrated on the tips of the arms and sensory cells are scattered over the skin. Echinoderms lack a circulatory system; fluid movement in their coelom carries out this function. Gas exchange occurs through the tube feet or through “skin gills” projecting through the epidermis.

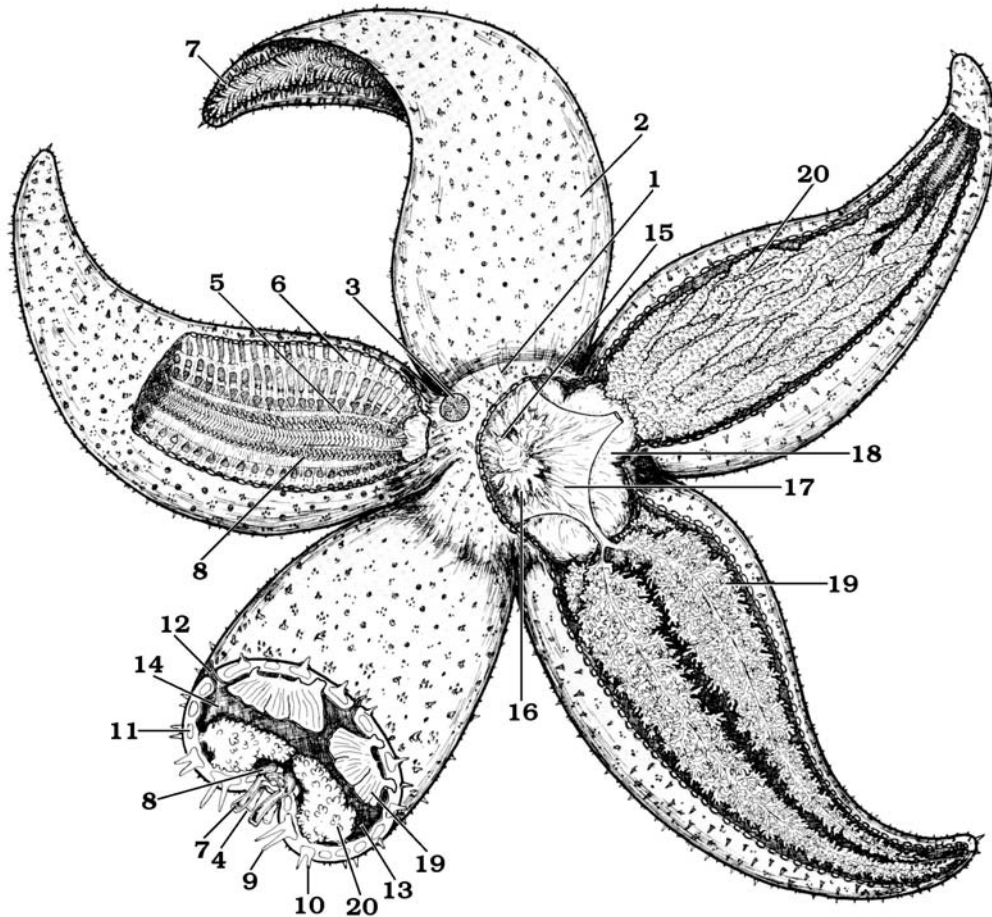
Anatomy of Sea Star

Sea stars usually have five arms that radiate from a central disk, accounting for the class name *Asteroidea*. The mouth is normally oriented downward, and when sea stars feed on clams they use the suction of their tube feet to force the shells open a crack. Then they evert the cardiac portion of the stomach, which releases digestive juices into the mantle cavity. The pyloric portion of the stomach takes up partially digested tissues; digestion continues in this portion of the stomach and in the digestive glands found in the arms.

External Anatomy

1. Place a preserved sea star in a dissecting pan so that the oral side is uppermost.
2. Identify the **central disk** and five arms. What type of symmetry does an adult sea star have?
3. Find the mouth, located in the center and protected by spines. Why is this side of the sea star called the oral side?
4. Locate the **ambulacral groove** that runs along the middle of each arm and the **tube feet** (suction-like disks) in rows on either side of the groove. Pluck away the tube feet from one area, and determine how many rows of feet there are. In the valley of each ambulacral groove, identify the **radial canal** that extends to the tip of each arm.
5. Turn the sea star over to its aboral side.

STARFISH ANATOMY



- | | |
|------------------------------|------------------------|
| 1. Central disk | 11. Ossicle |
| 2. Arm | 12. Papula (skin gill) |
| 3. Madreporite (sieve plate) | 13. Peritoneum |
| 4. Ambulacral groove | 14. Coelomic cavity |
| 5. Ambulacral plates | 15. Anus |
| 6. Skeletal plates | 16. Rectal caeca |
| 7. Tube feet | 17. Pyloric stomach |
| 8. Ampulla | 18. Cardiac stomach |
| 9. Movable spine | 19. Hepatic caecum |
| 10. Immovable spine | 20. Gonad (ovary) |

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6. Locate the anal opening. Why is this side of the sea star called the aboral side?
7. Lightly run your fingers over the surface spines. These extend from the calcium carbonate plates that lie buried in the body wall beneath the surface. The plates form an endoskeleton of the animal.
8. Identify the **sieve plate (madreporite)**, a brownish circular spot between two arms where water enters the water vascular system.

Internal Anatomy

1. Place the sea star so that the aboral side is uppermost. Refer to Van De Graaf and Crawley as you dissect the sea star following these instructions:
2. Cut the tip of one of the arms and, with scissors, carefully cut through the body wall along each side of this arm.
3. Carefully lift up the upper body wall. Separate any internal organs that may be adhering so that all internal organs are left intact.
4. Cut off the body wall near the central disk, but leave the sieve plate (madreporite) in place.
5. Remove the body wall of the central disk, being careful not to injure the internal organs.
6. Identify the digestive system. The mouth leads into a short **esophagus**, which is connected to the saclike cardiac stomach. When a sea star eats, the **cardiac stomach** sticks out through the sea star's mouth and starts digesting the contents of a clam or oyster. Above the cardiac stomach is the **pyloric stomach**, which leads to a short intestine. Each arm contains one pair of **digestive glands**. To which stomach do the digestive glands attach?
7. Remove the digestive glands of one arm.
8. Identify the **gonads** extending into the arm. What is the function of gonads? It is not possible to distinguish male sea stars from females by this observation.
9. Remove both stomachs.
10. Identify the **water vascular system**. Try to find the stone canal that connects the sieve plate (madreporite) with the ring canal that surrounds the mouth. From the **ring canal**, the radial canals extend into each arm. Split the ambulacral ridge lengthwise to find a radial canal. Radial canals are connected by transverse canals to the **ampulla** (rounded body) and **tube feet** (suction-like disks). As ampullae contract and force water into

- the feet, the feet swing forward and attach so that the animal is pulled forward. Trace the path of water in the water vascular system.
11. Cut off a portion of an arm, and examine the cut edge. Identify the digestive glands, ambulacral groove, radial canal, ampullae, and tube feet.

Answer the following questions:

1. Echinoderms are more closely to chordates (our own phylum) than any other animal phylum. What feature/s of echinoderms support/s this observation?
2. Echinoderms lack cephalization. What characteristics of this group deemphasize the need for a head?
3. What part of the water vascular system extends into each arm?