

The Echinoderms and Chordates

Laboratory

12

Station 1 The Echinoderms

The echinoderms (phylum **Echinodermata**) are coelomate deuterostomes. All echinoderms are marine and are much different than the phyla studied recently; as adults, they have abandoned the evolutionary advantage of being bilaterally symmetrical. The adult echinoderms exhibit **pentaradial symmetry**. This pentaradial symmetry develops secondarily as the **larvae of echinoderms are clearly bilaterally symmetrical** and metamorphose into the pentaradial adults. The pentaradial symmetry of the adults results in a reduced degree of cephalization and the nervous system is simple and consists of a ring of nerves with radial nerves branching laterally; there is no centralized brain. Generally speaking, echinoderms are slow moving organisms.

Echinoderms possess a supportive **endoskeleton** of calcareous plates, spines, and ossicles. Many of these calcified structures protrude through the epidermis and give echinoderms a “spiny” appearance (hence the name of the phylum, *echinos* = spiny).

Perhaps the most distinguishing feature of an echinoderm is the **water-vascular system**. The water-vascular-system is used for locomotion, foraging, gas-exchange and the removal of metabolic wastes. The water-vascular system consists of a series of tubular ducts which can be used to move seawater. The movements of the seawater create hydrostatic pressure differences on the distal ends of the flexible **tube feet** and create suction.

Echinoderms also have the ability to **regenerate lost body parts** and many echinoderms can control the physical release of body parts to avoid predation. This may be due in part to the fact that echinoderms have **mutable connective tissue**. They have the unique ability to control the hardening and softening of their connective tissues at a moment's notice. The presence of this mutable connective tissue has made echinoderms important research subjects in understanding and possibly treating disorders like arthritis.

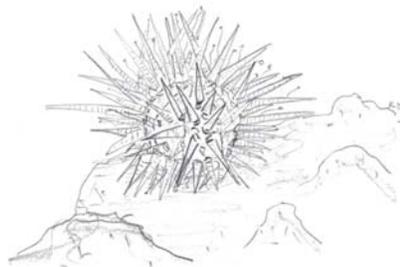


Bilateral symmetry in sea star larvae, 40x. Lateral view left; dorsal view, right

Examples of Echinoderms

Sea urchins

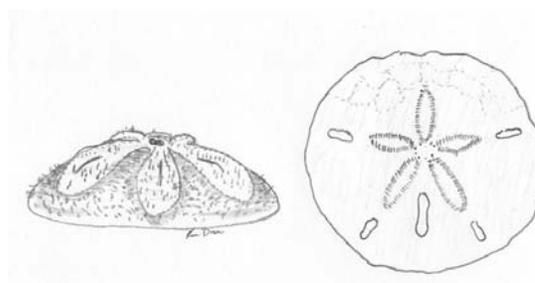
Sea urchins have pronounced spines protruding from their rounded, disc-shaped bodies. They truly resemble living pincushions. The spines are moveable and are used for defense and for anchoring the urchin in a burrow or rock crevice. Sea urchins use their elongated tube feet for locomotion and move about slowly to feed on algae.



Sea urchin crawling on coral

Sand dollars

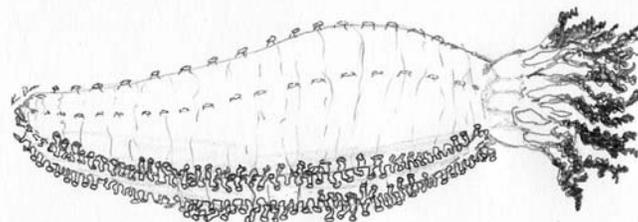
Sand dollars lack the elongated spines of their urchin relatives. Their flattened bodies are covered with tiny tube feet which gives them a “velvety” appearance. The movements of the tube feet help the sand dollar to burrow into the sand or silt where they feed on detritus which they filter from the water.



Sand dollar. Lateral view left; endoskeleton, right

Sea cucumbers

Sea cucumbers often lack visible elements of the calcareous endoskeleton. Their pentamerous, cylindrical bodies appear soft. Rows of tube feet are found on the ventral side of the body and provide for locomotion. The tube feet on the dorsal sides of the body are quite reduced and fewer in number. Surrounding the mouth on the anterior end are clusters of retractable **oral tentacles**. When the sea cucumber is feeding, the oral tentacles are extended to aid in food collection. Sea cucumbers may **eviscerate** (forcefully eject their organs) themselves when disturbed by a predator. These internal organs are regenerated later.



Sea cucumber with oral tentacles extended

Review Questions

1. List in the space below the characteristics previously described for a coelomate deuterostome.
2. Describe the symmetry of an adult echinoderm and compare it with the symmetry of a larval echinoderm.
3. List the functions of the water-vascular system.
4. What type of skeletal system do echinoderms have?
5. What is mutable connective tissue?
6. Name an echinoderm with pronounced moveable spines.
7. How is the body of a sand dollar adapted for burrowing in loose sediments like sand?
8. How may a sea cucumber defend itself from a predator?

Station 2A

Sea Star Anatomy

Sea Stars are some of the most recognizable echinoderms. Pentaradial symmetry is evident as five **arms** radiate out from a **central disk**. The sea star's body is compressed forming the **oral side** and the **aboral side** (note- not dorsal and ventral). The **mouth** and **tube feet** are located on the oral side while the **anus** is located on the aboral side. Numerous short, endoskeletal **spines** protrude through the epidermis on the aboral side and give the sea star a rough texture.

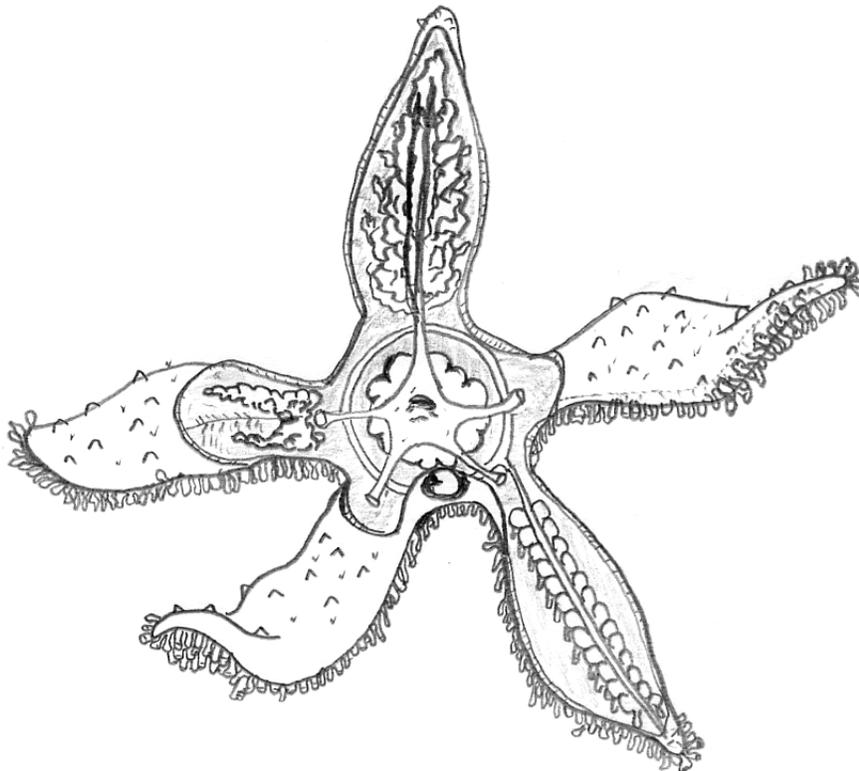
Each tube foot is connected to an **ampulla** which arise from a **radial canal** present in each arm. Each radial canal connects to the **ring canal** located in the central disk which leads to the external opening called the **madreporite**. Sea water is added or removed from these ducts through the madreporite located on the aboral surface.

Sea stars are dioecious but are not sexually dimorphic. During the breeding season, the **gonads** are evident within coelomic cavity of the arms where the arm joins the central disk.

Sea stars feed primarily on bivalves. Small bivalves may be ingested whole, but larger bivalves are consumed by a unique adaptive strategy. Sea stars actively hunt for bivalves by gliding along on their numerous tube feet. Once suitable prey is located, the sea star first positions its body over the two valves and rotates the bivalve with its tube feet so that the bivalve's ventral side is positioned near the sea star's mouth. Using the mutable connective tissue the sea star's body becomes very rigid to support the contractions of the body wall muscles. The tube feet anchor the sea star to its prey and the muscle contractions open the bivalve's shell slightly.

The sea star's stomach is divided into two regions; the **pyloric region** located near the anus and the **cardiac portion** positioned near the mouth. After the bivalve's shell is opened slightly, the cardiac portion of the stomach is everted through the mouth and into the bivalve. Digestive juices from large **digestive glands** found in each arm flow through the pyloric stomach, cardiac stomach and into the bivalve; the bivalve is digested within its own shell! Digested nutrients are absorbed in the pyloric stomach and waste is eliminated through the anus.

Use the models and laminated sheets to label the illustration below.



Sea star, aboral cut-a-way view. Label arm, central disk, gonad, anus, madreporite, ring canal, radial canal, ampulla, tube foot, digestive gland, pyloric stomach, cardiac stomach, spines

Review Questions

1. Name the large opening to the water-vascular system found on the aboral surface of a sea star.
2. Name the primary prey item for sea stars.
3. Which portion of the sea star digestive system is everted through the mouth as it feeds on larger prey?
4. Explain how a sea star moves in the space below.
5. Explain how you could identify the sex of a sea star using a microscope slide prepared from a sample of gonad tissue.

Station 2B

Sea Star dissection

(you may refer to the laminated sheets or the figure from station 2A to guide your dissection.)

- Obtain a preserved sea star and place it in a dissection tray.
- Observe the tube feet located on the oral surface of each arm.
- Place the sea star aboral side up and locate the madreporite. Also look for the short spines protruding through the epidermis.
- Using a pair of scissors, carefully snip off the distal ends (about 3 cm) of each arm.
- Insert the point of the scissors just under the body wall at these distal points and carefully cut through the body wall along the dorsolateral line from distal tip to central disk. You will be separating the sea star into aboral and oral sections. Be careful not to damage internal structures found in each arm
- Carefully uncover the central disk and take care to leave the madreporite intact.
- You will need to cut the digestive tract just below the anal opening to remove the aboral side.
- You should observe the prominent digestive glands in each arm.
- Carefully use your scissors to remove the digestive glands from one arm to view the gonads. The gonads (if present) are similar in color and texture to the digestive glands but are much smaller and are loosely attached to the body wall where the arm meets the central disk.
- Now remove the digestive glands from another arm to expose the water-vascular system. You should be able to observe the rows of ampullae attached to the radial canal. If you follow the radial canal back proximally to the central disk, you can locate where it is attached to the ring canal.
- The majority of the tissue in the central disk composes the pyloric and cardiac stomachs. These organs are very easily damaged during dissection, but take note of their bag-like appearance. Carefully cut into the stomach and look for evidence of feeding (bivalve shells or fragments).
- When you are finished observing the anatomy of the sea star, place all the portions of the specimen in the trash rinse off your instruments and pan and place on paper towels to dry.

Station 3A

The Chordates

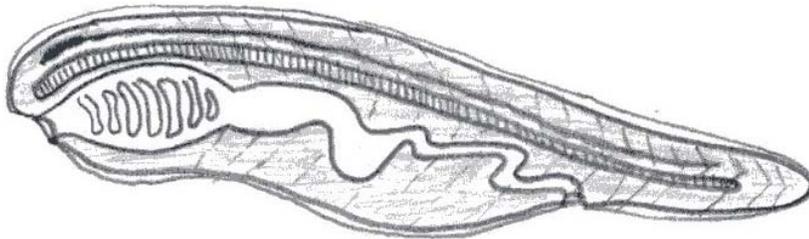
The chordates (**phylum Chordata**) are coelomate deuterostomes with closed circulatory systems, complete digestive systems with some degree of metamerism. Like the arthropods, there is a tremendous amount of diversity within members of the phylum; from very simple animals like the tunicates to very complex animals like humans.

All chordates possess at some point in their life cycle four main characteristics (the “big 4”).

1. **Notochord** – a slender supportive rod of cartilage which runs longitudinally through most of the length of the animal.
2. **Pharyngeal clefts** (or slits) – series of pairs slits or folds in the pharynx.
3. **Dorsal hollow nerve cord** – portion of the central nervous system located dorsal to the notochord and runs longitudinally through length of the animal. Unlike the longitudinal nerves in previous animal phyla, it is hollow and filled with fluid.
4. **Post-anal tail** – an extension of body beyond the anus.

In many chordates, these four characteristics are only observed in the larval stages while others retain them into adulthood.

The phylum Chordata is subdivided into three main groups. The urochordates, the cephalochordates and the vertebrates. This week’s lab will examine the urochordates and the cephalochordates; vertebrates will be examined in exercise 13.



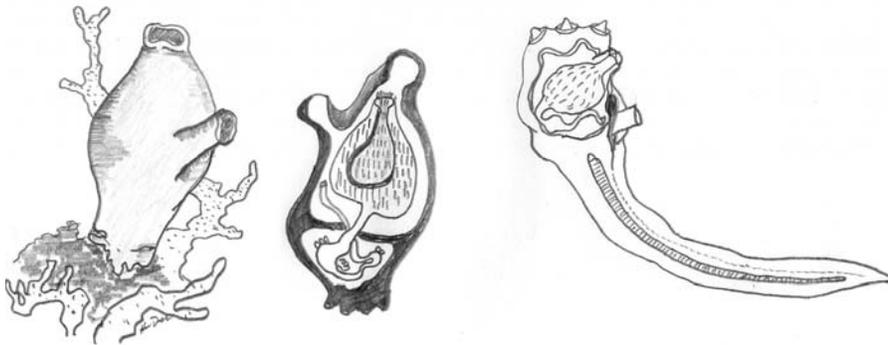
Generalized chordate. Label the notochord, dorsal hollow nerve cord, pharyngeal slits, post anal tail

Examples of Chordates

The urochordates – tunicates or sea squirts

The **tunicates** are strange looking animals. At first glance, they superficially resemble a lower animal like a cnidarian or mollusk. However, upon closer examination their chordate heritage is evident. Only the larval stages will possess the “Big 4” characteristics. The **larvae** are free-swimming and use the pharyngeal clefts to filter plankton from the water column. An **eyespot** is located at the anterior of the **dorsal hollow nerve cord** and is used for photoreception. At the end of the larval stage, the tunicate larva attaches itself to a suitable substrate (such as a piece of coral) using its **adhesive papillae** located on the anterior end. Once attached, the tunicate will undergo metamorphosis into the adult form. The adults have highly reduced cephalization and of the “Big 4”, only retain the **pharyngeal slits**.

A translucent **tunic**, a heavy coat of tissue that surrounds the body, covers the body of the adult tunicate. Usually visible through the tunic are the numerous **pharyngeal slits** used for filter-feeding plankton. The tunic is folded to form the **incurrent and excurrent** siphons. As the tunic contracts and relaxes, water is drawn into the body through the incurrent siphon and routed to the mouth where the plankton is filtered. Once filtered, the water is expelled through the excurrent siphon along with any digestive wastes eliminated from the **anus**.



Tunicate life cycle. Adult left and center (cut-a-way view); larva right (not to scale).

Review Questions

1. What do tunicates feed on?
2. How does the larva of a tunicate differ from the adult?
3. Which of the four main characteristics of chordates is found in the adult form of a tunicate?
4. What structures are used by the tunicate larva to attach itself to the substrate?

Station 3B

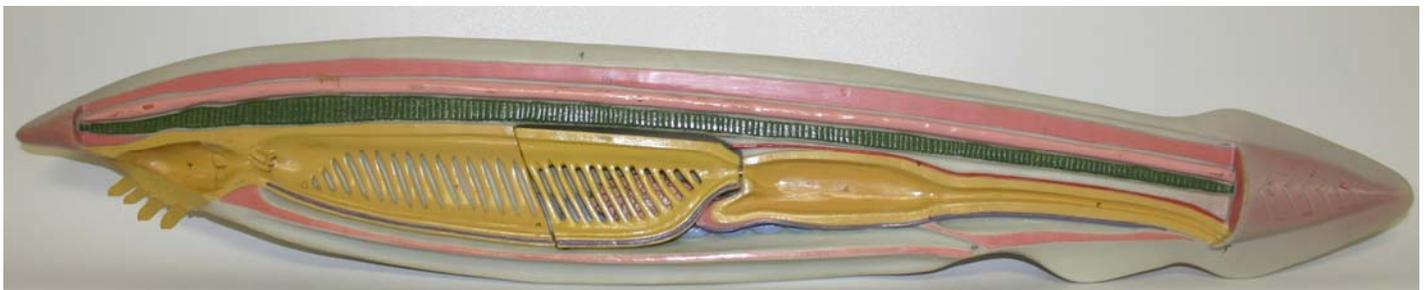
The Cephalochordates

The cephalochordate group includes the common marine **lancelets** (*Branchiostoma*) which are marine filter feeders. Lancelets use their **chevron shaped muscle segments** for swimming and to burrow into the sandy substrate. The adult lancelets are small (<8cm) and when feeding, only their **mouth** which is surrounded by **oral tentacles** is exposed. These tentacles move plankton and water into the mouth. This water is filtered by the **pharyngeal slits** and food is passed to the **intestine**. Gas exchange also occurs in the pharyngeal slits. The water will exit the body via the **atriopore** which is located ventrally just anterior to the anus.

A **hepatic cecum** (pouch near the junction of the pharynx and intestine) assists with the digestion of nutrients. Absorption of nutrients occurs in the intestine and waste is eliminated through the **anus**.

The **notochord** is present in the adults and forms a supportive rod longitudinally in the body. The **dorsal, hollow nerve cord** lies just dorsal to the notochord and forms the central nervous system of the lancelet.

When viewing the external anatomy of a lancelet, evidence of metamerism is quite clear and the muscle segments are clearly visible. A **dorsal fin** and a **caudal fin** (which surrounds the **post anal tail**) assist with stability during swimming.



Lancelet, *Branchiostoma*, anatomy. External above; internal below.
Label muscle segments, dorsal fin, caudal fin, oral tentacles, mouth, pharyngeal slits, intestine, hepatic cecum, anus, atriopore, notochord, dorsal hollow nerve cord, post anal tail

Review Questions

1. Describe the feeding habits of a lancelet.
2. Name the opening by which water enters the body of a lancelet.
3. Name the opening by which water exits the lancelet's body.
4. Name the "big 4" characteristics seen in an adult lancelet.
5. Describe the shape of the muscle segments seen externally in a lancelet.
6. How did this group of chordates become known as the "Cephalochordates"?