

EXERCISE 22



Phylum Echinodermata

Members of the Phylum Echinodermata [ee-KI-no-DER-mah-tah; G., *echinos*, a hedgehog + G., *derma*, skin] are among the most familiar invertebrates observed by people visiting the seashore. Echinoderms get their name from the fact that most have **spines** and **tubercles** that project from the surface of the animal. The endoskeleton is composed of calcareous **ossicles** or **plates** that vary in shape and their connection with each other. The skeleton is covered with a thin ciliated epidermis or is embedded in a rather thick, leathery body wall.

There are about 6,500 living species of echinoderms including sea lilies, sea stars (or starfishes), brittle stars, sand dollars, sea urchins, and sea cucumbers. Approximately 13,000 fossil species are known. Echinoderms are distributed widely, being especially abundant in the Indo-Pacific areas. This strictly marine phylum lacks parasitic and colonial members. None is segmented. The echinoderms are the major invertebrate phylum of **enterocoelous deuterostomes**.

A major characteristic of these largely bottom-dwellers is the basic **pentamerous**, radial symmetry of the adults. This means that an echinoderm's body is arranged typically into five (or multiples thereof) similar and equal parts that radiate from a central axis. The radiating areas, which bear the **tube feet** (or **podia**) of the unique **water-vascular** (or **ambulacral**) system, are called **arms** (or **ambulacra**, **rays**, or **radii**). Between two ambulacra is an **interambulacral** (or **interradial**) area. The oral surface contains the mouth and the aboral surface is away from the mouth.

The water-vascular system is the most distinguishing feature of echinoderms. It is basically an organ system of canals or tubes derived from the spacious, ciliated **enterocoelom**. The water-vascular system serves in locomotion, food gathering, respiration, chemosensation, and excretion.

Unlike most adult echinoderms, the microscopic larvae are bilaterally symmetrical. The first echinoderms were not radially symmetrical either; this results in a primary bilateral symmetry upon which the dominant radial symmetry is superimposed. This is why the echinoderms are placed in the Bilateria and not in the Radiata. The origins of this group including their bilateral beginnings lies deep in the early **Paleozoic Era** (Fig. 22.1).

Classification

Phylum Echinodermata is divided into six classes. The most recently discovered group of echinoderms, Class Concentricycloidea (composed of a few species), will not be examined here.

1. **Class Asteroidea**. Unattached, flattened, star-shaped echinoderms with a mouth that is centrally located on the underside of the body and with hollow arms that are not demarcated sharply from the central disc. Asteroids are commonly called sea stars or starfishes. An aboral madreporite and numerous pedicellariae are present in many species. Open ambulacral grooves, located on the oral side of the arms, contain tube feet with or without suckers. Examples: *Asterias*, *Pisaster*, *Astropecten*, *Luidia*, and *Solaster*.

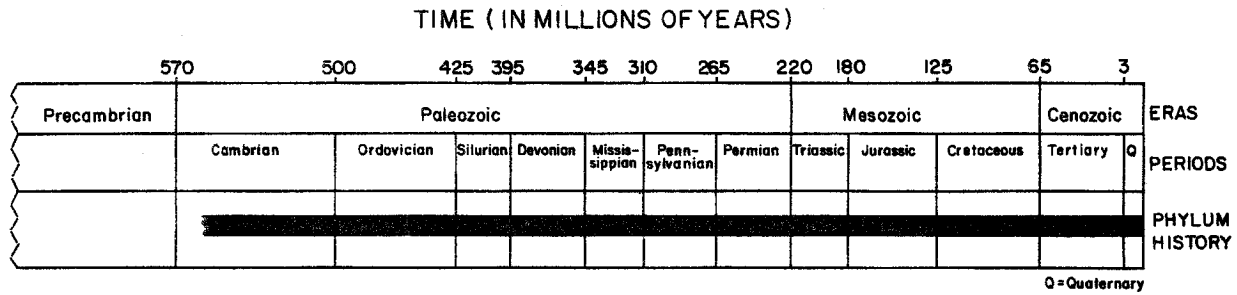
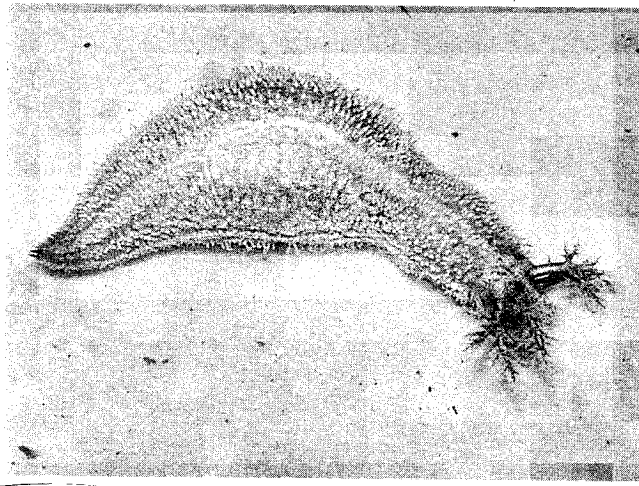


Figure 22.1. Geologic history of the Phylum Echinodermata.

2. **Class Ophiuroidea.** Unattached, flattened, star-shaped echinoderms with a mouth that is centrally located on the underside of the body and with elongated and movable solid arms that are demarcated sharply from the central disc. Ophiuroids are commonly called brittle stars or serpent stars and basket stars. The madreporite is located on the oral side. Pedicellariae and hepatic ceca are lacking. Ambulacral grooves are closed. Examples: *Ophioderma*, *Ophiothrix* (brittle stars) and *Gorgonocephalus* (basket star).
3. **Class Echinoidea.** Discoid, globoid, or cylindrical echinoderms lacking arms. Echinoids are commonly called sea urchins, heart urchins, and sand dollars. The madreporite is located on the aboral surface. Ambulacral grooves are closed. Most have a masticatory apparatus called Aristotle's lantern. Skeleton (test) is rigid with movable long and short spines. Examples: *Strongylocentrotus*, *Arbacia* (sea urchin), *Echinocardium*, *Moiria* (heart urchins), and *Mellita* and *Clypeaster* (sand dollars).
4. **Class Holothuroidea.** Echinoderms with a cylindrical and elongated body stretched on an oral-aboral axis. Holothuroids are commonly called sea cucumbers. Arms are absent and the madreporite is located internally. Tube feet at the anterior end are modified to form oral tentacles. Endoskeleton consisting of microscopic, separate ossicles are embedded in a usually leathery body wall. No spines or pedicellariae present. Ambulacra represented by closed canals. Examples: *Cucumaria*, *Thyone*, and *Leptosynapta*.
5. **Class Crinoidea.** Echinoderms with a cup-shaped body (theca) to which are attached 5, 10, or more long, hollow arms used to gather food. Crinoids are commonly called sea lilies and feather stars (comatulids). The oral surface, bearing the mouth and anus, faces upwards, while the crown or calyx contains all the visceral organs. Tube feet lack suckers. No madreporite, spines, or pedicellariae are present. Examples: *Florometra* and *Cenocrinus* (sea lilies), *Neometra*, and *Antedon* (feather stars).



(b)

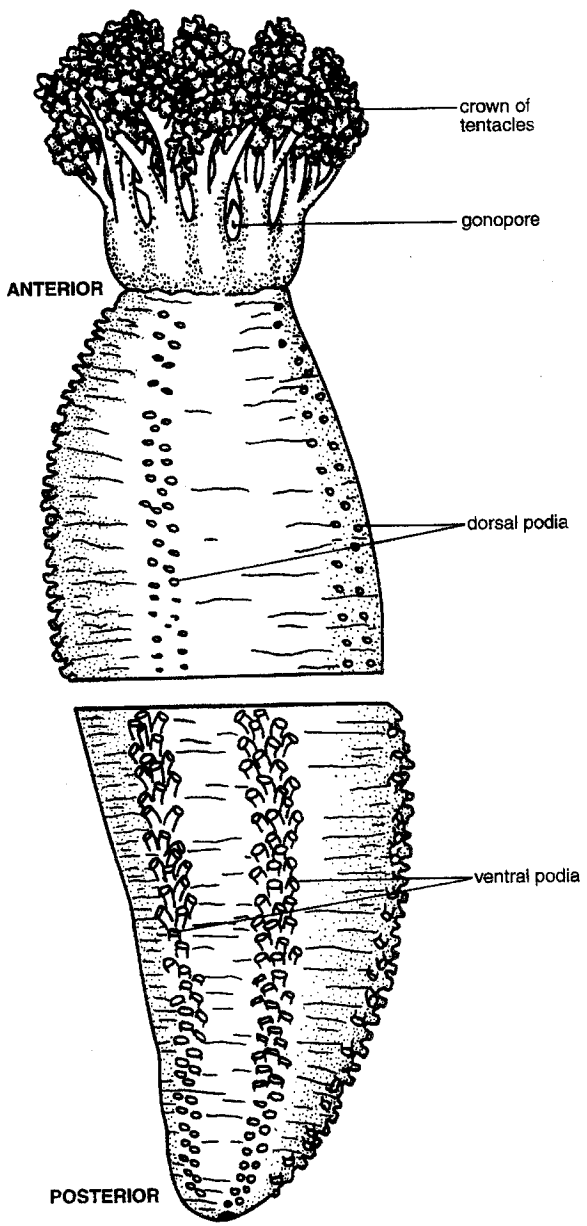
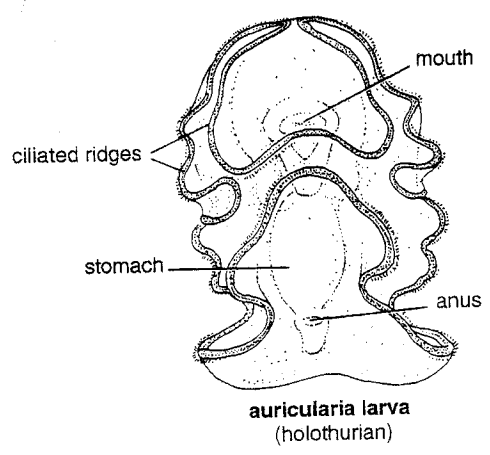
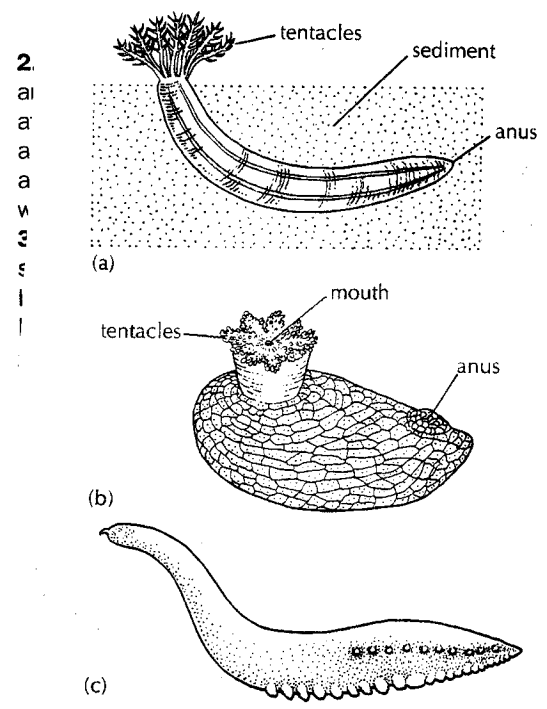


Figure 22.25. External view of a sea cucumber.



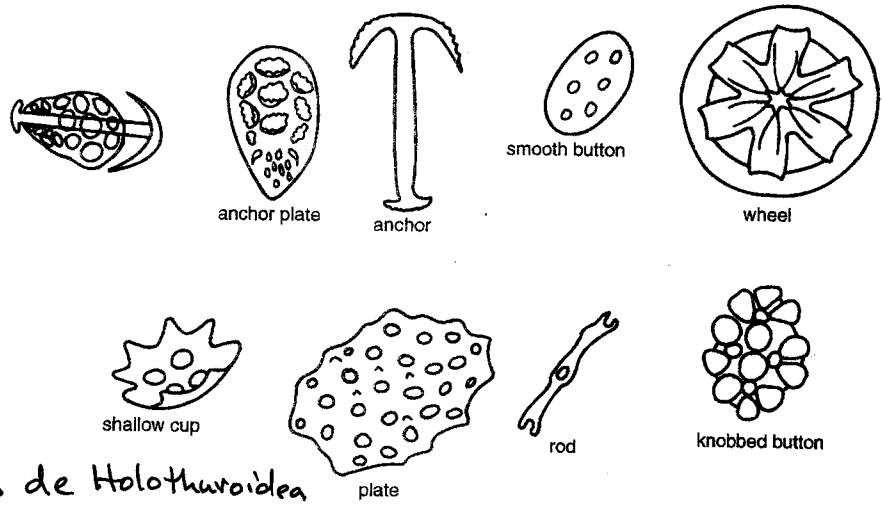
Larva de holothuroidea

D. Class Holothuroidea

Sea cucumbers are rather bizarre-looking echinoderms. Indeed they are unlike other members of the Echinodermata in a number of features. There are approximately 1,000 living species of the Class Holothuroidea [HOL-o-thur-OI-de-ah; G., *holothourion*, a kind of

zoophyte + G., *eidos*, form]. They are common in the littoral areas of the sea and also constitute an important fauna of the marine abyss.

The body of a sea cucumber is elongated on an oral-aboral (anteroposterior) axis (Fig. 22.25). The oral end



osículos de Holothuroidea

Figure 22.26. Ossicles of several types of sea cucumbers.

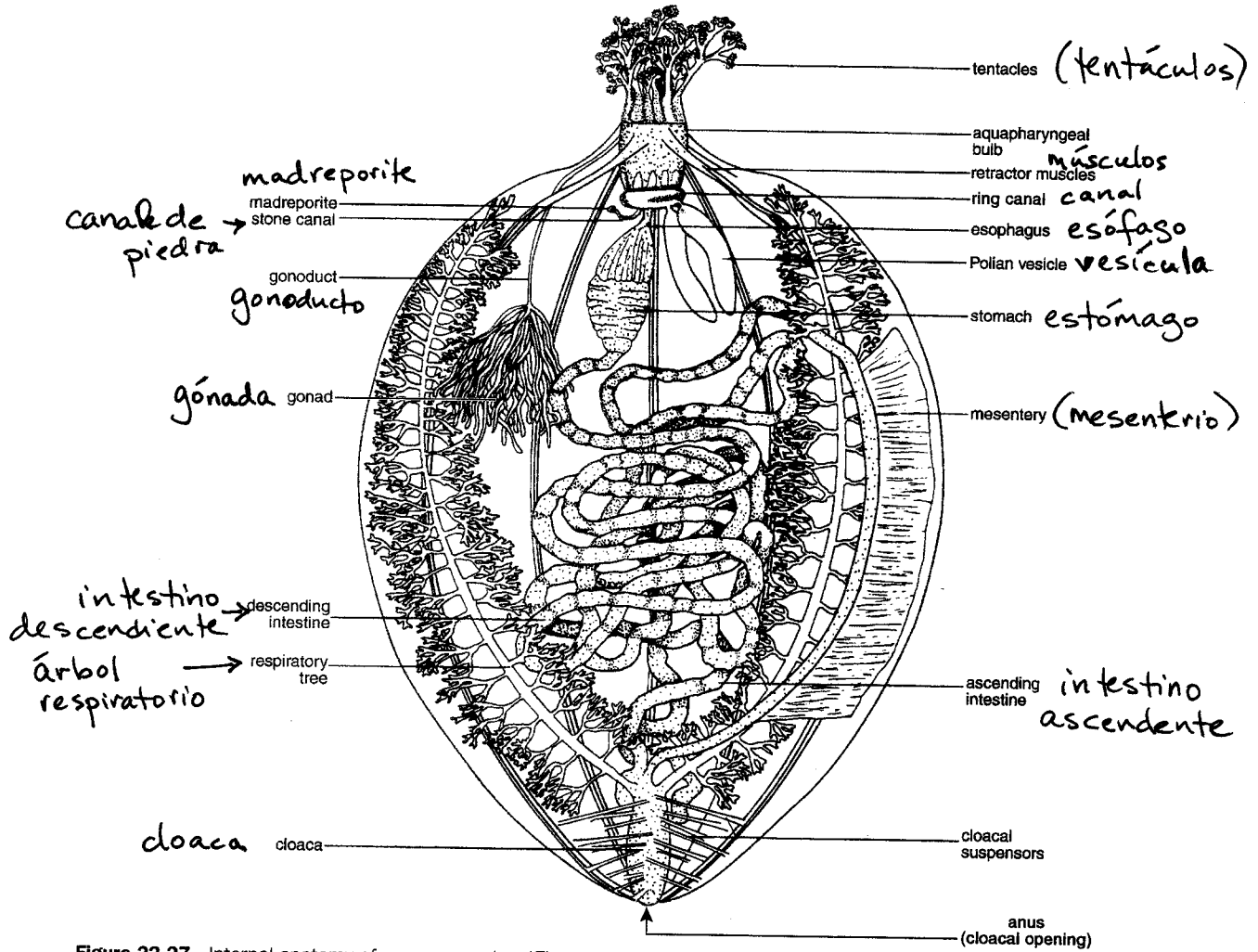


Figure 22.27. Internal anatomy of a sea cucumber (*Thyone*).

Anatomía interna de un pepino.

contains the mouth that is surrounded by a number of food-gathering **tentacles**. These mucus-covered structures are modified tube feet and usually can be retracted within the sea cucumber's body. The opposite end bears the anus. The spineless body wall of most sea cucumbers is leathery and contains an embedded endoskeleton of microscopic, calcareous ossicles that are not fused with each other. Tube feet are scattered over the body surface (*Thyone*), grouped in five ambulacral areas (*Cucumaria*), or totally lacking (*Leptosynapta*). Sea cucumbers move about by muscular contraction of their body, aided by the tube feet when present.

Sea cucumbers are typically dioecious and fertilization occurs in the water. During development many species pass through two larval stages: first, an **auricularia** and second, a **doliolaria**. These microscopic larvae resemble those found in other members of the Echinodermata.

Sea cucumbers are noted for their great powers of regeneration. When disturbed or under stress, the animal is unusual in being able to **eviscerate** the internal organs. This is perhaps a means of distracting predators; *Holothuria* and a few others, can eject a sticky mass of **Cuvierian tubules**, that entangle the predator. Regeneration of the lost organs then occurs after the sea cucumber crawls to safety.

■ Observational Procedure:

External Anatomy

Obtain a specimen of *Cucumaria* and/or *Thyone*, or a similar species suitable for dissection.

1. How is the body surface of the sea cucumber obviously different from the other echinoderms examined? Determine the oral-aboral axis of the specimen. Feel the body surface. How does it compare to the other echinoderms examined so far? Is there any evidence of ossicles?
2. In *Cucumaria* the tube feet are present in five distinct ambulacral areas, three on the ventral surface and two on the dorsal surface. Retrieve your sketch of the symmetry of the sea star and relate it to *Cucumaria*. Ray A is on the midventral line according to Carpenter's designation of the radii, discussed in the exercise on asteroids. The tube feet on the somewhat flattened, ventral surface (the **sole**) are better developed than are those on the dorsal surface. Do all the sea cucumbers available for study have the same arrangement of tube feet?
3. Isolate the endoskeletal ossicles for examination by removing a section of the body wall and boiling it in a small quantity of bleach (sodium hypochlorite). (NB: Be sure to do this under safe conditions: e.g., in a fume hood with the window guard down.) During this process the

body wall will be dissolved. When the bleach cools, decant it, rinse the ossicles in tap water, and examine them using a compound microscope (Fig. 22.26). Do these ossicles resemble in any way those of other echinoderms?

Internal Anatomy

1. Beginning at the posterior end, make a ventral incision through the body wall and extend this incision through the anterior end. Open the body wall laterally and pin it to the dissection pan. Cover the specimen with water. As you study the internal anatomy, refer to (Fig. 22.27).

2. The enterocoelom in sea cucumbers is spacious. In life the body cavity is filled with coelomic fluid containing various types of amoebocytes. The peritoneal cilia produce a current that moves the coelomic fluid throughout the enterocoelom.

Digestive System

1. This system consists of the mouth, expanded pharynx, short esophagus, muscular stomach, and long intestine that leads to the muscular rectum (Fig. 22.27). In *Cucumaria*, but not in *Thyone*, the esophagus is absent and the stomach is poorly developed. Note the muscles that attached the rectum to the inner surface of the body wall.

2. Find the pair of highly branched **respiratory trees** that extend off the rectum (Fig. 22.27). The muscular rectum pumps water into the trees and expels it back to the sea. Exchange of respiratory gases occurs within the trees, which are unique to seawater cucumbers. However, the burrowing forms, such as *Leptosynapta*, lack them and exchange of respiratory gases occurs across the body surface.

Water-vascular System

1. Surrounding the pharynx is a hard structure called the **calcareous ring** to which **retractor muscles** are attached posteriorly. These muscles retract the entire oral region inside the body. The calcareous-ring complex may be homologous with the Aristotle's lantern of echinoids.

2. At the base of the pharynx just behind the calcareous ring is the **ring canal**. The dorsal madreporite is connected to the ring canal by the stone canal. The internal position of the madreporite is unlike that of other echinoderms. One to several (often two) saclike, **Polian vesicles** arise from the ring canal. Follow these where they join the canal (Fig. 22.27). Some specimens may have small vesicles, whereas others may have greatly expanded vesicles. The Polian vesicles may maintain pressure within the water-vascular system.

3. Locate the five **radial canals** off the ring canal that run anteriorly to the oral tentacles and then descend to the aboral end of the body. The canals follow the large, **longitudinal muscles** that are attached to the inner

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surface of the body wall. These lie under the five ambulacral areas. The canals lead into numerous side canals that connect with the tube feet in the ambulacra. The longitudinal muscles also join the retractor muscles at the anterior end. In addition to these muscles, note that the inner body wall is lined with **circular muscles**. The circular and longitudinal muscles allow the sea cucumber to expand and contract its body.

Reproductive System

The reproductive system is simple in these dioecious animals (Fig. 22.27). Find the moplike **gonad** that consists of a tuft of fine filaments. The gonad increases in size with the approach of sexual maturity. Do you think that your specimen was sexually mature when it was taken? Holothurians are the only echinoderms with a single gonad. A gonoduct carries eggs or sperm anteriorly to a genital papilla located between two dorsal tentacles. Microscopic examination of crushed gonadal filaments will reveal the sex of your specimen. The round head and long tail of the sperm can be seen when stained with methylene blue and examined under oil immersion. Eggs of the female are large and ovoid.

Live Specimens

1. Focus your attention on the cloacal opening of a live animal. Is it slowly opening and closing? Using a Pasteur pipette, place a small amount of seawater that was colored with methylene blue stain near the opening of the cloaca. What happens to the stain? What does this indicate is going on?
2. Try rotating the animal onto a different side. Does it turn back around (right itself)?
3. Observe burrowing behavior in a sea cucumber by placing the animal in a large glass bowl filled with seawater and a sufficient quantity of sand to permit burrowing. How does the sea cucumber bury itself? Is this behavior anything like the burrowing observed in other echinoderms you studied?
4. How do sea cucumbers react to stimuli? Take care in these investigations; some sea cucumbers will eviscerate if abused. If it is appropriate to do so, your instructor will demonstrate this phenomenon. Examine the ejected organs to determine which ones were expelled. What possible advantage can this behavior provide the sea cucumber? What other animals ablate body parts when attacked? ■

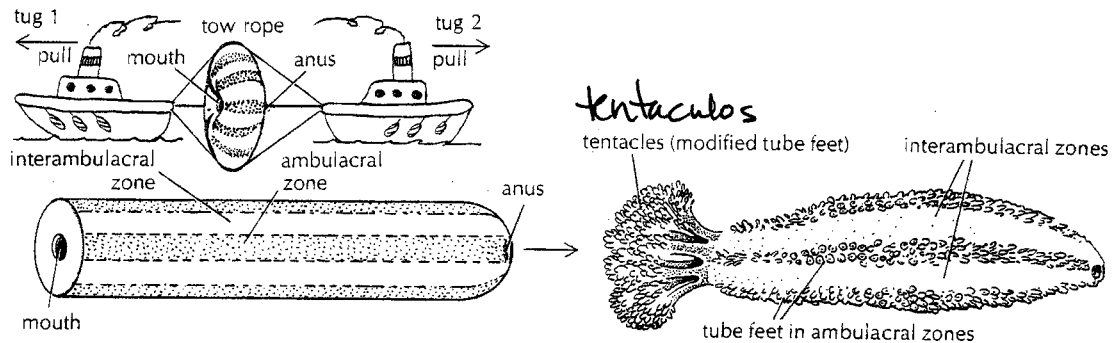


Figure 20.18

Relationship between the basic body plans of the echinoids and the holothurians. The holothurian shown at the end of the sequence is *Cucumaria frondosa*.

After Hyman.

