Section 28–4

1 FOCUS

Objectives

28.4.1 ***Identify*** the distinguishing features of echinoderms.
28.4.2 ***Describe*** the functions carried out by the water vascular system of echinoderms.
28.4.3 ***Compare*** the different classes of echinoderms.

Guide for Reading

Vocabulary Preview

Suggest that students preview the meaning of the Vocabulary terms in the section by skimming the text to find the highlighted, boldface words and their meanings.

Reading Strategy

Have students preview the photographs of the echinoderms shown in the section and make a list of questions they have about the form, function, and diversity of these animals. Then, as they read, they should write down the answers to their questions.

2 INSTRUCT

What Is an Echinoderm?

Use Visuals

Figure 28–22 Explain that the mouth of this brittle star is located on the underside of the animal. Similarly, the mouth of the familiar sea star, as well as other echinoderms, is also normally on the underside. Then, ask: **As you look at this photo of a brittle star, which surface are you looking at?** *(Aboral surface)* Point out that if students could touch this brittle star, its surface would feel rough. The outer covering of a lobster, which students learned about in Section 28–2, also feels rough. Ask: **Does this brittle star have an exoskeleton similar to a crustacean's?** *(No. A brittle star has an endoskeleton beneath its spiny skin.)*

28–4 Echinoderms

Guide for Reading

Key Concepts
- What are the distinguishing features of echinoderms?
- What functions are carried out by the water vascular system of echinoderms?
- What are the different classes of echinoderms?

Vocabulary
endoskeleton
water vascular system
madreporite
tube foot

Reading Strategy: Using Visuals Before you read, preview **Figure 28–23.** As you read, notice where in the sea star each function occurs.

One of the most unusual sights along the seashore might be the sea stars, sea urchins, and sand dollars that have washed up on the beach. These animals look like stars, pincushions, and coins. They are all echinoderms (ee-KY-noh-durmz), members of the phylum Echinodermata. *Echino-* means "spiny," and *dermis* means "skin." If you have ever touched a sea star, you will know why this name is appropriate. The skin of echinoderms is stretched over an internal skeleton, or **endoskeleton,** that is formed of hardened plates of calcium carbonate. These plates give the animal a bumpy and irregular texture. Echinoderms live only in the sea. Some are delicate, brightly colored, feathery-armed creatures. Others look like mud-brown half-rotten cucumbers!

What Is an Echinoderm?

The body plan of echinoderms is like no other in the animal kingdom. Adult echinoderms typically have no anterior or posterior end and lack cephalization. However, the bodies of most echinoderms are two-sided. The side in which the mouth is located is called the oral surface, and the opposite side is called the aboral surface.

Echinoderms are characterized by spiny skin, an internal skeleton, a water vascular system, and suction-cuplike structures called tube feet. Most adult echinoderms exhibit five-part radial symmetry. The body parts, which usually occur in multiples of five, are arranged around the central body like the spokes of a wheel. The brittle star in **Figure 28–22** exhibits this kind of symmetry. Although radial symmetry is characteristic of simpler animals such as cnidarians, echinoderms are actually more closely related to humans and other vertebrates. The larvae of echinoderms are bilaterally symmetrical, indicating that body symmetry evolved differently in this group than in simpler animals. Also, echinoderms are deuterostomes, animals in which the blastopore develops into an anus. This type of development is found in echinoderms and vertebrates, indicating that these groups are closely related.

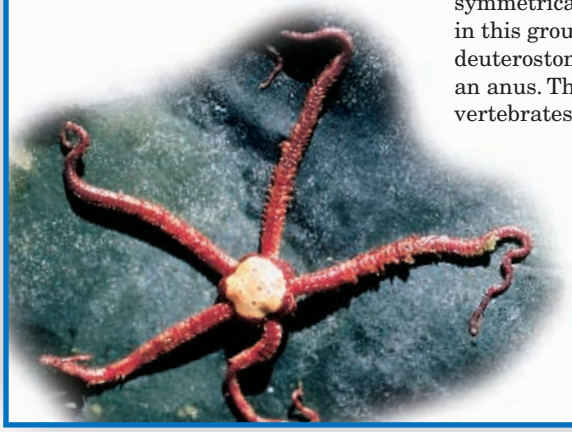
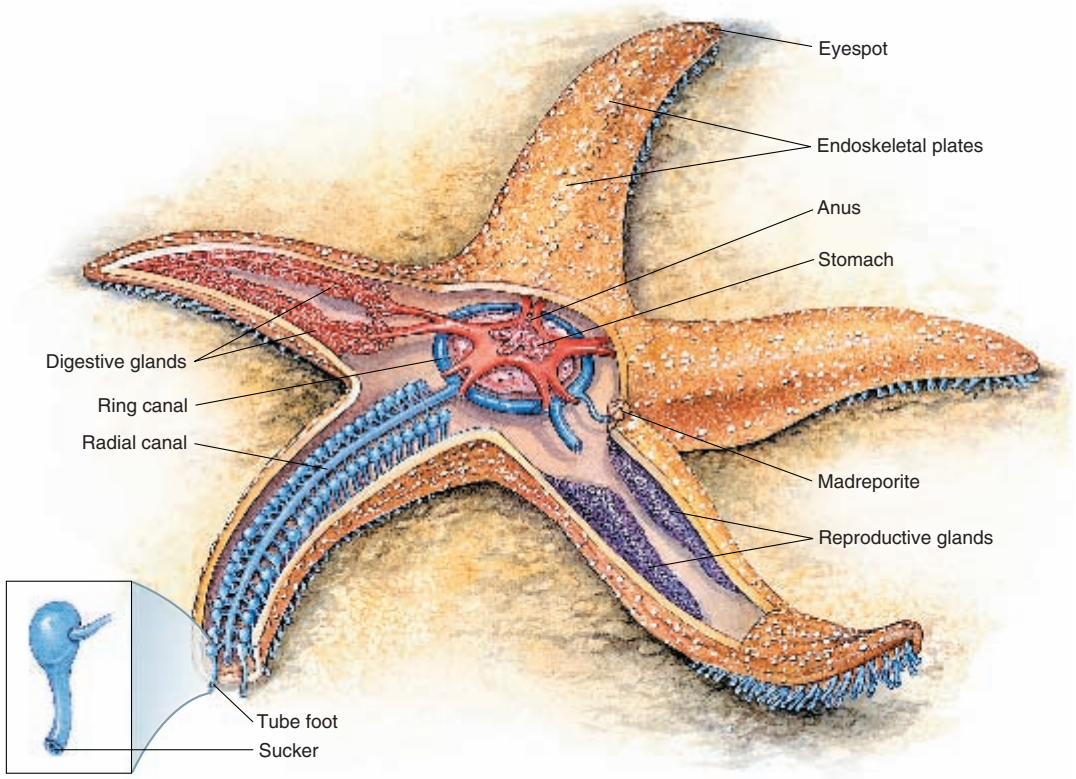


Figure 28–22 **Echinoderms such as this brittle star have spiny skin, five-part radial symmetry, an internal skeleton, a water vascular system, and suction-cuplike structures called tube feet.** Observe that the brittle star has five arms. The bodies of most echinoderms are divided into parts that are multiples of five.

SECTION RESOURCES

Print:
- ***Teaching Resources,*** Lesson Plan 28–4, Adapted Section Summary 28–4, Adapted Worksheets 28–4, Section Summary 28–4, Worksheets 28–4, Section Review 28–4
- ***Reading and Study Workbook A,*** Section 28–4
- ***Adapted Reading and Study Workbook B,*** Section 28–4
- ***Issues and Decision Making,*** Issues and Decisions 30
- ***Biotechnology Manual,*** Lab 7

Technology:
- ***iText,*** Section 28–4
- ***Transparencies Plus,*** Section 28–4



▲ **Figure 28–23** The most distinctive system of echinoderms is the water vascular system, shown here in a sea star. **The water vascular system, which extends throughout the body, functions in respiration, circulation, and movement.**

Form and Function in Echinoderms

A unique feature of echinoderms is a system of internal tubes called a **water vascular system,** which is shown in **Figure 28–23.** **The water vascular system, which is filled with fluid, carries out many essential body functions in echinoderms, including respiration, circulation, and movement.** It opens to the outside through a sievelike structure called a **madreporite** (MAD-ruh-pawr-yt). In sea stars, the madreporite connects to a ring canal that forms a circle around the animal's mouth. From the ring canal, five radial canals extend along body segments.

Attached to each radial canal are hundreds of tube feet. A **tube foot** is a structure that operates much like a suction cup. Each tube foot has a sucker on the end. Muscles pull the center of the sucker upwards, forming a cup shape. This action creates suction on the surface to which the foot is attached, so the tube foot pulls on the surface. Hundreds of tube feet acting together create enormous force, allowing echinoderms to "walk" and even to pull open shelled prey such as clams.

CHECKPOINT *What is the system of internal tubes in echinoderms?*

Go Online **active art**
For: Water Vascular System activity
Visit: PHSchool.com
Web Code: cbp-8284

UNIVERSAL ACCESS

English Language Learners
To help students understand the difference in the two sides of an echinoderm, explain that the word *oral* means "having to do with the mouth." The word often means "spoken," as in "oral instructions." In the case of echinoderms, the oral surface simply means the surface that the mouth is on. Also point out that the prefix *ab-* means "away from." Thus, the aboral surface literally means "the surface, or side, away from the mouth." L1 L2

Advanced Learners
Encourage students who need extra challenges to investigate further the threat that the crown-of-thorns poses to coral reefs, as mentioned on page 738. Suggest that students write a report on the threat using library and Internet sources. When students have finished their reports, ask them to share their findings with the class. L3

Form and Function in Echinoderms

Use Visuals

Figure 28–23 Ask students: **What body systems does a sea star have?** *(Digestive system, reproductive system, water vascular system, endoskeletal system, and nervous system)* **What structures are part of the water vascular system?** *(The madreporite, ring canal, radial canal, and tube feet)* **What essential body functions does the water vascular system carry out in an echinoderm?** *(Respiration, circulation, and movement)* L1 L2

Demonstration

Display a preserved sea star. (Rinse excess preservative from the specimen, and place it in a dissecting pan.) Have students put on disposable plastic gloves and safety goggles. Invite students to examine the sea star. After students have examined the sea star, ask: **What are some typical animal traits that a sea star appears not to have?** *(Answers will vary. Students might notice the absence of a head and sense organs.)* **Does the body appear to be segmented?** *(No)* Point out that the absence of segmentation is one indication that echinoderms are not close relatives of annelids and arthropods. Then, ask: **What type of symmetry does a sea star have?** *(A sea star exhibits radial symmetry.)* Review the difference between bilateral and radial symmetry, if necessary. Point out that most echinoderms, unlike cnidarians, have a five-part, or pentaradial, symmetry. L2

Go Online **active art**
For: Water Vascular System activity
Visit: PHSchool.com
Web Code: cbe-8284
Students explore the water vascular system of a sea star.

Answer to . . .
CHECKPOINT *The water vascular system*

Build Science Skills

Using Models Divide the class into small groups, and give each group a small suction cup. Challenge students to make the suction cup adhere to a vertical surface for at least one minute. (*Through trial and error, students will discover that the surface must be smooth and that the cup will stay in place longer if it is first moistened.*) Ask groups to share their findings. Discuss how an echinoderm's tube feet are like suction cups. L2 L3

Build Science Skills

Observing Divide the class into pairs, and give each pair a preserved or live sea star and a dissecting tray. Make sure students wear goggles, disposable gloves, and lab aprons for this activity. (Caution students to keep their hands away from their faces throughout this activity and to wash their hands with soap and warm water afterward, because the preservative used to preserve the organism may cause skin and eye irritation.) Students should observe the sea star, make a sketch of what they see, and label all structures they can identify. Advise students to compare the two sides of the sea star and look especially for its tube feet. Once they have finished their sketches, ask students to explain in writing the purpose of each part they labeled in their drawings. L2 L3

Go Online NSTA SCILINKS

Download a worksheet on echinoderms for students to complete, and find additional teacher support from NSTA SciLinks.

▲ **Figure 28–24** Echinoderms use all types of feeding methods. Sea stars, like the one shown above, are carnivores that typically feed on mussels and other bivalves.
Comparing and Contrasting *How do other groups of echinoderms feed?*

Go Online NSTA SCILINKS
For: Links on echinoderms
Visit: www.SciLinks.org
Web Code: cbn-8284

Feeding Echinoderms have several methods of feeding. Sea urchins use five-part jawlike structures to scrape algae from rocks. Sea lilies use tube feet along their arms to capture floating plankton. Sea cucumbers move like bulldozers across the ocean floor, taking in sand and detritus. Sea stars usually feed on mollusks such as clams and mussels, as shown in **Figure 28–24.** Once the prey's shell is open, the sea star pushes its stomach out through its mouth, pours out enzymes, and digests the mollusk in its own shell. Then, the sea star pulls its stomach and the partially digested prey into its mouth.

Respiration and Circulation Other than the water vascular system, echinoderms have few adaptations to carry out respiration or circulation. In most species, the thin-walled tissue of the tube feet provides the main surface for respiration. In some species, small outgrowths called skin gills also function in gas exchange.

Circulation of needed materials and wastes takes place throughout the water vascular system. Oxygen, food, and wastes are carried by the water vascular system.

Excretion In most echinoderms, digestive wastes are released as feces through the anus. Nitrogen-containing cellular wastes are excreted primarily in the form of ammonia. This waste product is passed into surrounding water through the thin-walled tissues of tube feet and skin gills.

Response Echinoderms do not have a highly developed nervous system. Most have a nerve ring that surrounds the mouth, and radial nerves that connect the ring with the body sections. Most echinoderms also have scattered sensory cells that detect light, gravity, and chemicals released by potential prey.

Movement Most echinoderms move using tube feet. An echinoderm's mobility is determined in part by the structure of its endoskeleton. Sand dollars and sea urchins have movable spines attached to the endoskeleton. Sea stars and brittle stars have flexible joints that enable them to use their arms for locomotion. In sea cucumbers, the plates of the endoskeleton are reduced and contained inside a soft, muscular body wall. These echinoderms crawl along the ocean floor by the combined action of tube feet and the muscles of the body wall.

Reproduction Echinoderms reproduce by external fertilization. Sperm are produced in testes, and eggs are produced in ovaries. Both types of gametes are shed into open water, where fertilization takes place. The larvae, which have bilateral symmetry, swim around for some time and then swim to the ocean bottom, where they develop into adults that have radial symmetry.

CHECKPOINT *How do echinoderms move?*

BIO INSIGHTS

FACTS AND FIGURES

Are echinoderms really invertebrates? Although the basic nervous system and lack of a brain appear to place echinoderms among the very simple animals, they have some structures more typical of complex animals, including a unique internal skeleton. Hard nodules of calcium carbonate called ossicles are embedded in the body walls and surrounded by living tissues, providing the strength and protection of a mollusk shell. Many scientists wonder if these animals should really be classified with the invertebrates. Although echinoderms do not have backbones, their larvae appear to have much in common with a wormlike ancestor of the vertebrates. Also, the ossicles of the brittle star fit together much like the vertebrae of a backbone.

Groups of Echinoderms

There are roughly 7000 species of echinoderms—all of which live in the world's oceans. **Classes of echinoderms include sea urchins and sand dollars; brittle stars; sea cucumbers; sea stars; sea lilies and feather stars.** Some of these echinoderms are shown in **Figure 28–25.**

Sea Urchins and Sand Dollars This class includes sea urchins and disk-shaped sand dollars. These echinoderms are unique in having large, solid plates that form a box around their internal organs. Many are detritivores or grazers that eat large quantities of algae. They defend themselves in different ways. Sand dollars often burrow under layers of sand or mud. Some sea urchins wedge themselves in rock crevices during the day, whereas others defend themselves using long, sharp spines.

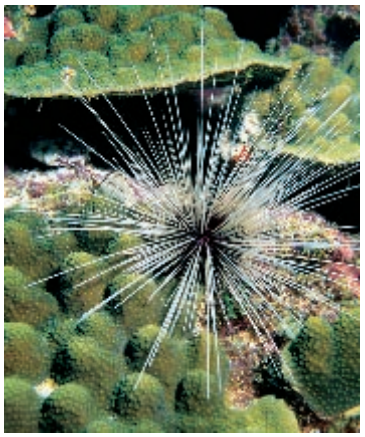
Brittle Stars Brittle stars are common in many parts of the sea, especially on coral reefs. They have slender, flexible arms and can scuttle around quite rapidly to escape predators. In addition to using speed for protection, brittle stars shed one or more arms when attacked. The detached arm keeps moving, distracting the predator while the brittle star escapes. Brittle stars are filter feeders and detritivores that hide by day and wander around under cover of darkness.

Sea Cucumbers Sea cucumbers look like warty, moving pickles. Most sea cucumbers are detritus feeders that move along the sea floor while sucking up organic matter and the remains of other animals and plants. Herds containing hundreds of thousands of sea cucumbers roam across the deep-sea floor.

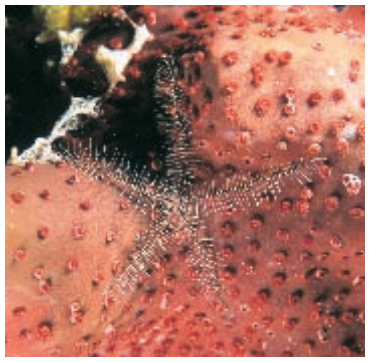
Sea Stars Sea stars are probably the best-known group of echinoderms. They move by creeping slowly along the ocean floor. Most are carnivorous, preying on bivalves that they encounter. Many sea stars have incredible abilities to repair themselves when damaged. If a sea star is pulled into pieces, each piece will grow into a new animal, as long as it contains a portion of the central part of the body.

Figure 28–25 **Sea urchins, brittle stars, sea cucumbers, and sea stars represent different classes of echinoderms.** Observe the characteristics of these representatives of each class.

Long-Spined Sea Urchin



Brittle Star



Sun Star

Red-Lined Sea Cucumber

Groups of Echinoderms

Address Misconceptions

Explain that sea stars and starfish are different names for the same kind of echinoderm. Many students, who may have seen sea stars on a beach or in a coastal souvenir shop, may think that a sea star is some kind of fish. Point out that echinoderms are invertebrates and fishes are vertebrates, and thus a sea star cannot be classified as a fish. Similarly, some students may be misled by the echinoderm names *sea cucumber* and *sea lily.* Discuss how these animals may have gotten their names, and emphasize that they are animals, not plants. L1 L2

Build Science Skills

Classifying To reinforce understanding of echinoderm classification, show students photos or slides of a variety of different echinoderms, making sure that all classes of echinoderms are represented by at least one example. Ask volunteers to classify each echinoderm as it is shown according to the class to which it belongs. As each echinoderm class is mentioned, call on students at random to review the characteristics of members of that class, such as how they feed or move. L2

BIO INSIGHTS

FACTS AND FIGURES

Millions of brittle stars

Brittle stars are the most abundant echinoderms, in terms of numbers both of species and of individuals. About 2000 species are found worldwide, from the seashore to depths as great as 6000 meters. In some places, millions of individuals live in clusters on the ocean floor. Brittle stars move by crawling or clinging with their flexible arms. The arms are quite flexible moving back and forth—that is, on a plane perpendicular to the line from the oral surface to the aboral surface. But the arms of a brittle star are not at all flexible moving up and down—that is, on a plane parallel to the same line. For that reason, the arms are "brittle" and break off easily.

Answers to . . .

CHECKPOINT *Most echinoderms move by using tube feet and muscle.*

Figure 28–24 *Sea urchins use five-part jaws to scrape algae from rocks. Sea lilies use tube feet along their arms to capture floating plankton. Sea cucumbers move like bulldozers across the ocean floor, taking in sand and detritus.*

Ecology of Echinoderms

Build Science Skills

Predicting After students have read the section on the ecology of echinoderms, ask them to write a prediction of what might happen if an area of the ocean experienced a decline of sea urchins or an increase in sea stars. Students' predictions should reflect an understanding of both the ecology of echinoderms and the dynamics of a food web. L2 L3

3 ASSESS

Evaluate Understanding

Ask students to write a description of an echinoderm's water vascular system and what functions it serves.

Reteach

Have students make their own drawing of the labeled sea star in Figure 28–23. Have students also define each of the terms shown as labels.

Focus on the BIG Idea

Both a sea star and a cnidarian exhibit radial symmetry, which means that body parts extend from the center of the body. In a cnidarian, any number of imaginary planes can be drawn through the center, each dividing the body into equal halves. By contrast, most echinoderms exhibit five-part radial symmetry, which means that the bodies are divided into parts that are multiples of five.

Interactive Textbook

If your class subscribes to the iText, use it to review the Key Concepts in Section 28–4.

Answer to . . .

Figure 28–26 *Sea lilies live attached to the ocean floor by a long stalk.*

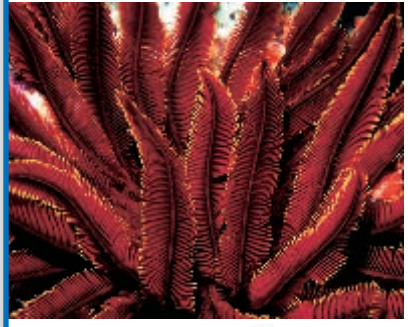


Figure 28–26 Sea lilies belong to the most ancient class of echinoderms, known as crinoids. The red crinoid (top) is one of the few species of this class that are alive today. This stalked crinoid fossil (bottom) is an example of the types of crinoids that dominated Earth during the Paleozoic Era. **Comparing and Contrasting** *How are sea lilies different from other echinoderms?*

Sea Lilies and Feather Stars These filter feeders, which have long, feathery arms, make up the oldest class of echinoderms. Sea lilies and feather stars are common in tropical oceans today, and a rich fossil record shows that they were distributed widely throughout ancient seas. Like modern sea lilies, their fossilized ancestors lived attached to the ocean bottom by a long, stemlike stalk, as seen in **Figure 28–26.** Many modern feather stars live on coral reefs, where they perch on top of rocks and use their tube feet to catch floating plankton.

Ecology of Echinoderms

Echinoderms are common in a variety of marine habitats. In many areas, a sudden rise or fall in the number of echinoderms can cause major changes to populations of other marine organisms. Sea urchins help control the distribution of algae and other forms of marine life. Sea stars are important predators that help control the numbers of other organisms such as clams and corals.

A major threat to coral reefs is one kind of sea star called the crown-of-thorns. This echinoderm is named for the rows of poisonous spines located along its arms. It feeds almost exclusively on coral. In the Great Barrier Reef of Australia—one of the largest reef systems in the world—this organism has destroyed extensive areas of coral.

28–4 Section Assessment

1. **Key Concept** What is an echinoderm?
2. **Key Concept** What is the water vascular system? How is it important to echinoderms?
3. **Key Concept** List the major classes of echinoderms and describe their characteristics.
4. What are tube feet? What functions do they perform, and how do they perform them?
5. Echinoderms are deuterostomes. What does this indicate about their relationship to other animals?
6. **Critical Thinking** **Inferring** Why is tearing a sea star apart and throwing it back into the water an ineffective way of trying to reduce sea star populations?

Focus on the BIG Idea

Structure and Function
In Chapter 26, you learned about the different kinds of body symmetry exhibited by animals. What kind of body symmetry do adult sea stars have? How is this kind of symmetry similar to that of a cnidarian? How is it different?

28–4 Section Assessment

1. An echinoderm has a spiny skin, an internal skeleton, and a water vascular system with tube feet. Most have five-part radial symmetry.
2. The water vascular system is a system of internal tubes. The system carries out respiration, circulation, and movement.
3. Students should list the classes and characteristics described on pages 737–738.
4. Tube feet are structures attached to the radial canal of echinoderms. Each has a sucker on the end, and muscles pull the center of the sucker upward, creating suction. Tube feet allow echinoderms to walk and to pull open shelled prey.
5. Echinoderms are more closely related to chordates than to other invertebrates, most of which are protostomes.
6. If a sea star is pulled into pieces, each piece will usually grow into a new animal.