SB3c. Examine the evolutionary basis of modern classification systems. **SB5b.** Explain the history of life in terms of biodiversity, ancestry, and the rates of evolution. **Also covers: SCSh1a, SCSh6a, SB3b, SB4f, SB5d**

Objectives

- **Interpret** the features of invertebrate chordates that place them in the phylum Chordata.
- **Analyze** the features of invertebrate chordates that place them with invertebrates.
- **Compare** the adaptations of lancelets with those of sea squirts.

Review Vocabulary

deuterostome: an animal whose mouth develops from cells other than those at the opening of the gastrula

New Vocabulary

chordate
invertebrate chordate
notochord
postanal tail
dorsal tubular nerve cord
pharyngeal pouch

Invertebrate Chordates

MAIN Idea **Invertebrate chordates have features linking them to vertebrate chordates.**

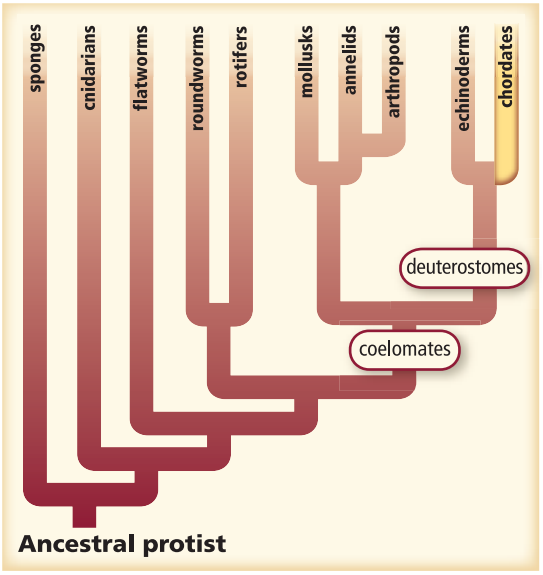
Real-World Reading Link Worms, snails, bees, fishes, birds, and dogs are all animals because they share common characteristics. Think about the features these animals have in common and the features that make them different from each other. The animals that share the most features are related more closely than the animals that share only a few features.

Invertebrate Chordate Features

Look at **Figure 27.15,** the evolutionary tree of animal phylogeny. Notice that invertebrate chordates, such as lancelets and tunicates, are deuterostomes like echinoderms, but as you will learn, they have additional chordate features that echinoderms do not have.

If you were to guess the most celebrated and famous animal among zoologists—scientists who study animals—you might not guess that it is one of the animals in **Figure 27.15.** This small, eel-like animal is an amphioxus (am fee AHK sus), also called a lancelet, and spends most of its life buried in sand. If you go to a beach and carefully dig in the sand at the shoreline, it would be unlikely for you to find an amphioxus. They are inconspicuous creatures with translucent, fish-shaped bodies about 5 cm long. With its headless body half-burrowed in the sand, the amphioxus quietly filter feeds, not at all aware of its fame. Fossil evidence and recent molecular data show that the amphioxus is one of the closest living relatives of vertebrates. You are related more closely to this fishlike creature than you are to any other invertebrate—yet related very distantly compared to other vertebrates.

Figure 27.15 Like echinoderms, invertebrate chordates, such as lancelets and tunicates, show deuterostome development.



Lancelet

Tunicate

(l)G.I. Bernard/OSF/Animals Animals, (r)Bruce Watkins/Animals Animals

PDF processed with CutePDF evaluation edition www.CutePDF.com

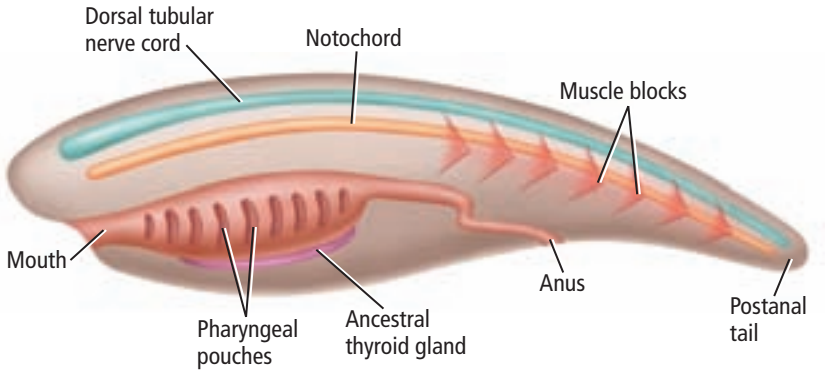


Figure 27.16 Chordates have a dorsal tubular nerve cord, a notochord, pharyngeal pouches, a postanal tail, and, possibly, some form of a thyroid gland.
Infer *Which of these features did you have when you were an embryo?*

Chordates are animals belonging to the phylum Chordata (kor DAH tuh) that have four distinctive features—a dorsal tubular nerve cord, a notochord, pharyngeal pouches, and a postanal tail—at some point during their development. Recent evidence suggests that all chordates also might have some form of a thyroid gland. In addition, they have a coelom and segmentation. Study **Figure 27.16** to see the main features of chordates. Recall that vertebrates are animals with backbones. Most chordates are vertebrates. **Invertebrate chordates,** which belong to two of the subphyla of chordates—Cephalochordata and Urochordata, also have a dorsal tubular nerve cord, a notochord, pharyngeal pouches, a postanal tail, and, possibly, an ancestral thyroid gland. They have no backbone, however.

Notochord The **notochord** (NOH tuh kord) is a flexible, rodlike structure that extends the length of the body. It is located just below the dorsal tubular nerve cord. In most vertebrates, the notochord eventually is replaced by bone or cartilage. In invertebrate chordates, the notochord remains. The flexibility of the notochord enables the body to bend, rather than shorten, during contractions of the muscle segments. An animal with a notochord can make side-to-side movements of the body and tail, the first time in the course of evolution that fishlike swimming is made possible.

Postanal tail A free-swimming animal moves efficiently by using a postanal tail. A **postanal tail** is a structure used primarily for locomotion and is located behind the digestive system and anus. In most chordates, the postanal tail extends beyond the anus. Tails in nonchordates have parts of the digestive system inside and the anus is located at the end of the tail. The postanal tail with its muscle segments can propel an animal with more powerful movements than the body structure of invertebrates without a postanal tail.

Dorsal tubular nerve cord In nonchordates, the nerve cords are ventral to, or below, the digestive system and are solid. Chordates have a **dorsal tubular nerve cord** that is located dorsal to, or above, the digestive organs and is a tube shape. The anterior end of this cord becomes the brain and the posterior end becomes the spinal cord during development of most chordates.

Reading Check **Analyze** How is a notochord important to invertebrate chordates?

VOCABULARY
WORD ORIGIN
Notochord
noto- prefix; from Greek, meaning *back.*
-chord from Greek, meaning *chord* or *string.*

FOLDABLES
Incorporate information from this section into your Foldable.

Study Tip

Cooperation Form a group with four other students. Each group member should pick one of the five boldfaced headings under the heading *Invertebrate Chordate Features*. Each group member should read the selected section and then teach the rest of the group the material presented in that section of text.

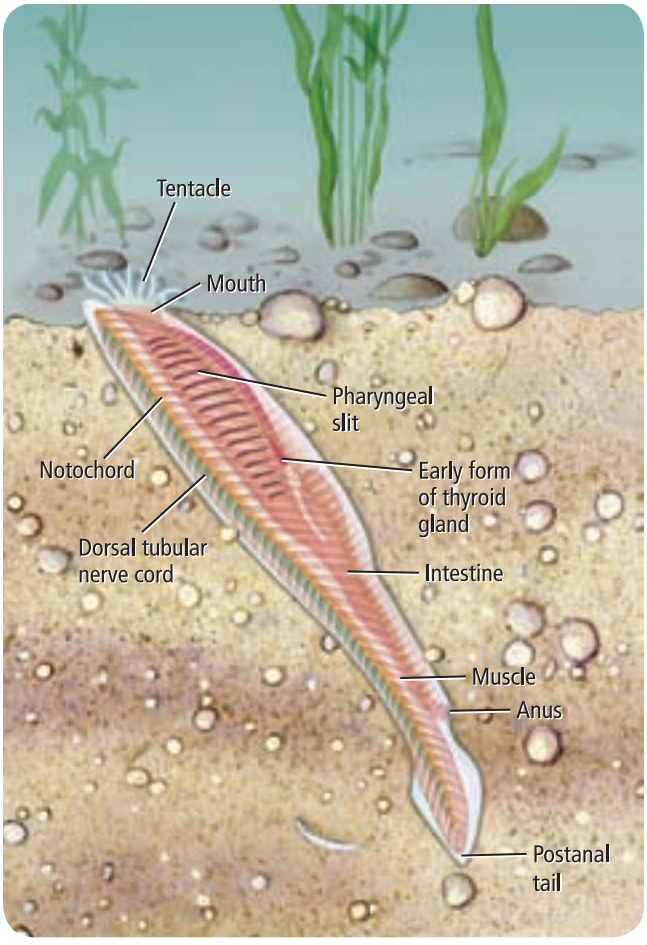


Figure 27.17 The lancelet is an invertebrate chordate that has the main features of chordates.

Infer ***How might the short tentacles surrounding the lancelet's mouth function?***

Pharyngeal pouches In all embryos, paired structures called **pharyngeal pouches** connect the muscular tube that links the mouth cavity and the esophagus. In aquatic chordates, the pouches contain slits that lead to the outside. These structures were used first for filter feeding and later evolved into gills for gas exchange in water. In terrestrial chordates, the pharyngeal pouches do not contain slits and develop into other structures, such as the tonsils and the thymus gland. Pharyngeal pouches are thought to be evidence of the aquatic ancestry of all vertebrates.

Ancestral thyroid gland The thyroid gland is a structure that regulates metabolism, growth, and development. An early form of a thyroid gland had its origins in cells of early chordates that secreted mucus as an aid in filter feeding. Invertebrate chordates have an endostyle—cells in this same area that secrete proteins similar to those secreted by the thyroid gland. Only vertebrate chordates have a thyroid gland.

Connection to Health Iodine is concentrated in the endostyle and plays an important role in thyroid gland function. It is essential for the production of thyroid hormones. In the United States, iodine is added to salt to prevent iodine deficiency. Other sources of iodine include fish, dairy products, and vegetables grown in iodine-rich soil.

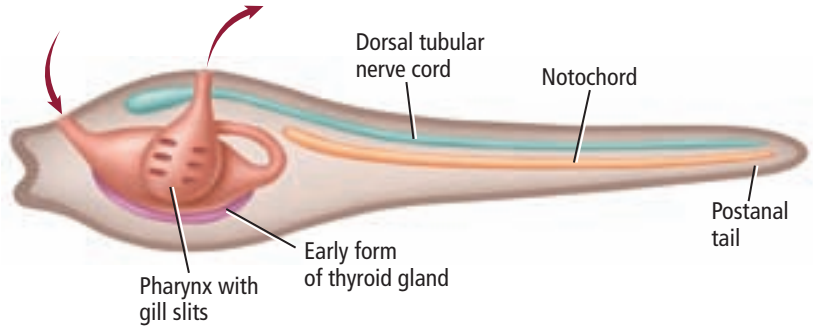
Reading Check **Explain** why an endostyle might be considered an early form of a thyroid gland.

Diversity of Invertebrate Chordates

Like echinoderms, all invertebrate chordates are marine animals. There are about 23 species of lancelets belonging to subphylum Cephalochordata. Tunicates, in subphylum Urochordata, consist of about 1250 species.

Lancelets Recall the amphioxus at the beginning of this section. Most lancelets belong to the genus *Branchiostoma* (formerly *Amphioxus*). They are small, fishlike animals without scales. As shown in **Figure 27.17,** lancelets burrow their bodies into the sand in shallow seas.

Lancelets lack color in their skin, which is only one cell layer deep, enabling an observer to view some body functions and structures. Water flowing through the body can be observed as a lancelet filter feeds. To get food, water enters the mouth of the lancelet and passes through pharyngeal gill slits. Food is trapped and passed on to a stomachlike structure to be digested. Water exits through the gill slits.



■ **Figure 27.18** Larval tunicates look like tadpoles and have all of the chordate features. The arrows indicate where water flows into and out of the body.

Just as filter feeding can be observed in the amphioxus, its muscles also can be seen. Observe the internal structures of a lancelet in **Figure 27.17.** The arrangement of segmented muscle blocks is similar to that in vertebrates, enabling lancelets to swim with a fishlike motion. Unlike vertebrates, they have no heads or sensory structures other than light receptors and small sensory tentacles near the mouth. The nervous system consists of main branching nerves and a simple brain at the anterior end of the animal. Blood passes through the body by the action of pumping blood vessels, as there is no true heart. Lancelets have separate sexes, and fertilization is external.

Tunicates Often called sea squirts, tunicates (TEW nuh kayts) are named for the thick outer covering, called a tunic, that covers their small, saclike bodies. Most tunicates live in shallow water; some live in masses on the ocean floor. In general, tunicates are sessile, and only in the larval stages do they show typical chordate features. Locate the notochord, postanal tail, dorsal tubular nerve cord, pharyngeal pouches, and ancestral thyroid gland on the tunicate larva in **Figure 27.18.**

Water is drawn into the saclike body of an adult tunicate through the incurrent siphon, as shown in **Figure 27.19,** by the action of beating cilia. Food particles are trapped in a mucous net and moved into the stomach where digestion takes place. In the meantime, water leaves the body, first through gill slits in the pharynx and then out through the excurrent siphon.

Circulation in the body of the tunicate is performed by a heart and blood vessels that deliver nutrients and oxygen to body organs. The nervous system consists of a main nerve complex and branching neurons. Tunicates are hermaphrodites—they produce both eggs and sperm—with external fertilization.

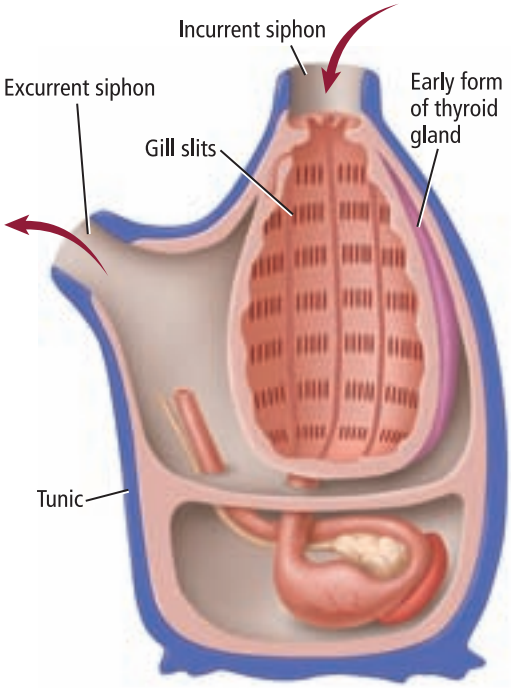
Why are tunicates called sea squirts? When they are threatened, they can eject a stream of water with force through the excurrent siphon, possibly distracting a potential predator.

Reading Check **Compare** tunicates and lancelets.

■ **Figure 27.19** Adult tunicates look like sacs. The only chordate feature that remains in the adult is pharyngeal gill slits. The arrows indicate water flow in and out of the body.

Compare ***What other invertebrates have you studied that are filter feeders?***

Interactive Figure To see an animation of a tunicate's anatomy, visit biologygmh.com.



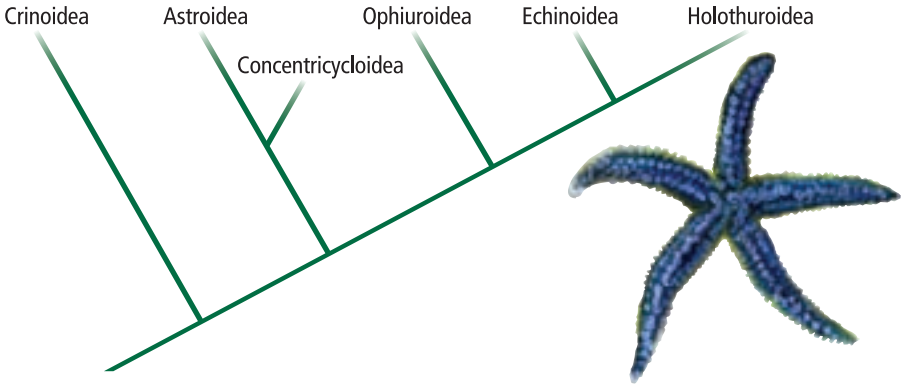


Figure 27.20 This cladogram shows the phylogeny of echinoderms.
Interpret *Which is the most recent class of echinoderms to evolve?*

CAREERS IN BIOLOGY

Evolutionary Biologist Scientists in this field study how organisms have changed over time. For more information on biology careers, visit biologygmh.com.

Evolution of Echinoderms and Invertebrate Chordates

Biologists are studying fossil and molecular evidence to learn how echinoderms and invertebrate chordates are related to the vertebrates that evolved later.

Phylogeny of echinoderms The fossil record of echinoderms extends back to the Cambrian. Scientists think that they evolved from ancestors with bilateral symmetry because echinoderms have bilaterally symmetrical larvae. Their radial symmetry develops later in the adult stage. Many biologists think that ancient echinoderms were sessile and attached to the ocean floor by a long stalk, just as the sea lily does today.

Echinoderms also undergo deuterostome development. Recall that this type of development links them phylogenetically to chordates, which also have deuterostome development. The cladogram in **Figure 27.20** shows one interpretation of the evolution of echinoderms.

DATA ANALYSIS LAB 27.1

Based on Real Data*

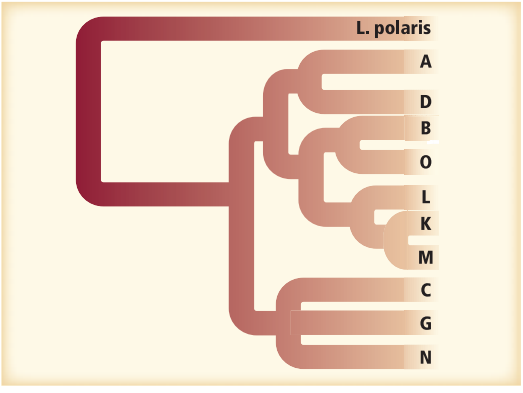
Interpret Scientific Illustrations

How does an evolutionary tree show relationships among sea stars? This evolutionary tree is a representation of various species of sea stars and their phylogenetic history based on molecular data. Each letter represents a specific sea star species.

Think Critically

1. **Identify** Which sea star is most closely related to sea star A?
2. **Interpret** Which is the oldest sea star?
3. **Analyze** Which group of sea stars has the most diversity—C,G,N or L,K,M? How did you decide?

Data and Observations



*Data obtained from: Hrincevich, A.W., et al. 2000. Phylogenetic analysis of molecular lineages in a species-rich subgenus of sea stars (*Leptasterias* subgenus *Hexasterias*). *American Zoologist* 40: 365-374.

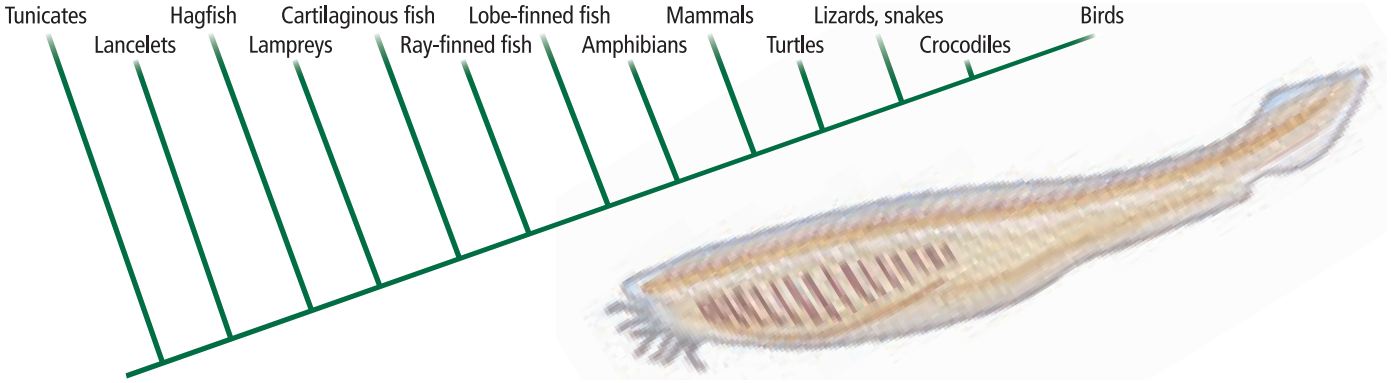


Figure 27.21 This cladogram shows a possible phylogeny of invertebrate chordates and other chordates that evolved later.

Phylogeny of invertebrate chordates How could sleek, burrowing, fishlike lancelets be close relatives of saclike, sessile sea squirts? They are related because of their dorsal tubular nerve cords, notochords, pharyngeal gill slits, and postanal tails, even if sea squirts have all these features only in their larvae. Beyond this answer, scientists debate about the evolution of these animals and raise still unanswered questions. For example, from which invertebrate chordate did the fishlike tadpole larvae arise? What was the original form of that first fishlike animal?

One thing is certain: the notochord, that flexible tough rod, provided support for the animal, and it also provided a place for muscles to attach. With this arrangement, chordates could swing their backs from side to side and swim through the water, a key development in the evolution of chordates. This advance also led to the first large animals. Examine the cladogram in **Figure 27.21** to see one interpretation of how chordates are related.

Section 27.2 Assessment

Section Summary

- Chordates have four main features that make them different from animals that are not chordates.
- Invertebrate chordates have all the features of chordates, except they do not have the main feature of vertebrate chordates.
- The notochord is an adaptation that enabled animals to move in ways they had never moved before.
- Lancelets are fish-shaped invertebrate chordates that, as adults, have all the main features of chordates.
- Tunicates are sac-shaped invertebrate chordates that have chordate features as larvae.

Understand Main Ideas

1. MAIN Idea **Summarize** the main features of invertebrate chordates that show their close relationship to vertebrate chordates.
2. **Describe** the characteristic of invertebrate chordates that places them with other invertebrates rather than with vertebrates.
3. **Model** Make models of a lancelet and a sea squirt from clay or salt dough. Identify features that place these animals in the phylum Chordata.
4. **Compare** the adaptations of sea squirts with those of lancelets that enable them to live in their environments.

Think Scientifically

5. *Design an experiment* to determine if lancelets prefer a light environment or a dark environment.
6. *Interpret* Use **Figure 27.21** to determine which subphylum of chordates evolved next after the cephalochordates.
7. WRITING in Biology Write a paragraph describing how sponges and tunicates are alike. Write another paragraph describing how they are different from each other.

CUTTING-EDGE BIOLOGY

Echinoderms Aid Medical Research

How did the comic book character the Incredible Hulk increase his body size without ripping his body to pieces?

Believe it or not, producers consulted an expert on echinoderms before creating a film about this character, because they wondered if any living creature could actually perform such feats. Sea cucumbers, specifically, can stretch and then shrink back to their normal size, much like the Incredible Hulk does in the film.

Connective tissue When Greg Szulgit was a graduate student in biology, he discovered the amazing power of sea cucumbers to increase their body size and then shrink back to their normal size. How do sea cucumbers change their body size? It's all due to their connective tissue—the tissue that connects, supports, and surrounds other tissues and organs in the body.

A sea cucumber's connective tissue is similar to a human's connective tissue. Connective tissue fibers contain a protein called collagen. In humans, collagen is a fixed part of the tissue. Szulgit and other researchers found that the collagen in the connective tissue of echinoderms is not fixed, but instead slides back and forth. When the collagen particles in the endoskeleton are sliding past each other, a sea cucumber's body is soft and flexible. A sea cucumber's cells can release a substance that locks the collagen and stops it from sliding. This stiffens its endoskeleton, making it immobile.

Connective-tissue disorders Szulgit studies the sea cucumber's body-stretching abilities with the hope of someday being able to treat connective-tissue disorders in humans. These disorders include Ehlers-Danlos syndrome, osteogenesis imperfecta, and Marfan syndrome.

Because the collagen in a sea cucumber's connective tissue is not fixed, its body can change from the consistency of liquid gelatin to a rigid structure and back again in seconds.

People with Ehlers-Danlos syndrome have abnormally fragile connective tissue, resulting in joint problems and weakened internal organs. In osteogenesis imperfecta, the body doesn't produce enough collagen or it produces poor quality collagen, leading to fragile bones that break easily. People with Marfan syndrome have connective tissue that isn't as stiff as it should be, causing skeletal abnormalities and weakened blood vessels.

By studying the connective tissue in echinoderms such as the sea cucumber, researchers are moving closer to successfully treating debilitating illnesses that prevent people from having freedom of movement in their joints due to connective tissue diseases.

WRITING in Biology

Journal Visit biologygmh.com to learn more about scientific research involving echinoderms. Create a biologist's research journal describing his or her work with an echinoderm. The journal should include thorough descriptions, charts, graphs, and sketches of echinoderms.

BIOLAB

INTERNET: HOW DO ECHINODERMS SURVIVE WITHOUT A HEAD, EYES, OR A BRAIN?

Background: **Echinoderms have evolved unlike any other animals on Earth. Lacking eyes and a brain, they also have no heart, and pump seawater through their bodies rather than blood. Echinoderms can change their endoskeletons from rock hard to nearly liquid within seconds. Some can purposely break off an arm to distract a predator. Sound unusual? Not for echinoderms.**

Question: *How do echinoderms survive in the competitive marine environment?*

These sea stars, basket stars, and sea urchins are from the Gulf of Maine.

Materials

Internet access
Echinoderm reference book
field journal

Procedure

1. Read and complete the lab safety form.
2. Design and construct a data table for recording the species; physical characteristics; food sources/strategies for obtaining food; predators; defense strategies; reproduction and development; and other interesting facts about six animals.
3. Choose one species from each of the six major classes of echinoderms to study. List the species in your data table.
4. Research the species you chose and fill in information in your data table. Observe the echinoderms in their natural habitat by visiting a local zoo or aquarium. If you cannot observe the animals in their natural habitats, obtain information about the echinoderms from a reference book or visit biologygmh.com.
5. Record your observations in your field journal. Transfer the information to your data table.
6. Post your results at biologygmh.com. Use data posted by other students to complete missing portions of your table.

Analyze and Conclude

1. **Describe** some basic physical characteristics shared by echinoderms.
2. **Compare** sexual and asexual reproductive strategies used by echinoderm species.
3. **Think Critically** Echinoderm larvae and mature echinoderms differ in several important ways. Describe the differences, and infer the advantages they provide.
4. **Interpret Data** What are the major food sources of the echinoderms you studied?
5. **Draw Conclusions** Are echinoderms well-adapted to survive in the marine environment? Justify your answer.
6. **Error Analysis** Describe advantages and disadvantages of obtaining information about echinoderms from the Internet.

WRITING in Biology

Resource Book Use the data you gathered to create a fact sheet including photos and interesting information about each echinoderm you studied. Combine your fact sheets with those developed by other students to create an echinoderm resource book for your school's media center. To find out more about echinoderms, visit Biolabs at biologygmh.com.

Andrew J. Martinez/Photo Researchers

CHAPTER 27

Study Guide

STUDY TO GO

Download quizzes, key terms, and flash cards from **biologygmh.com.**

FOLDABLES **Analyze** Use what you have learned in this chapter to debate the placement of invertebrate chordates in the phylum Chordata.

Vocabulary

Key Concepts

Section 27.1 Echinoderm Characteristics

- ampulla (p. 795)
- madreporite (p. 795)
- pedicellaria (p. 793)
- tube foot (p. 795)
- water-vascular system (p. 795)

MAIN Idea Echinoderms are marine animals with spiny endoskeletons, water-vascular systems, and tube feet; they have radial symmetry as adults.

- Adult echinoderms can be identified by four main structural features.
- Larval echinoderms have features that link them to relatives that evolved after them.
- Echinoderms have a water-vascular system and tube feet.
- Echinoderms have a variety of adaptations for feeding and movement.
- There are six major classes of living echinoderms.

Section 27.2 Invertebrate Chordates

- chordate (p. 803)
- dorsal tubular nerve cord (p. 803)
- invertebrate chordate (p. 803)
- notochord (p. 803)
- pharyngeal pouches (p. 804)
- postanal tail (p. 803)

MAIN Idea Invertebrate chordates have features linking them to vertebrate chordates.

- Chordates have four main features that make them different from animals that are not chordates.
- Invertebrate chordates have all the features of chordates, except they do not have the main feature of vertebrate chordates.
- The notochord is an adaptation that enabled animals to move in ways they had never moved before.
- Lancelets are fish-shaped invertebrate chordates that, as adults, have all the main features of chordates.
- Tunicates are sac-shaped invertebrate chordates that have chordate features as larvae.

(t)Robert L. Dunne/Photo Researchers, (b)G.I. Bernard/OSF/Animals Animals

Section 27.1

Vocabulary Review

Distinguish between the terms in each of the following pairs.

1. tube foot, ampulla

2. madreporite, water-vascular system

Understand Key Concepts

3. Which is not an echinoderm?

A. 

B. 

C. 

D. 

A. A
B. B
C. C
D. D

4. Which echinoderm is sessile for part of its life?
A. sea cucumber
B. sea lily
C. brittle star
D. sea urchin

5. What three functions do tube feet perform?
A. reproduction, feeding, respiration
B. feeding, respiration, neural control
C. feeding, respiration, movement
D. development, reproduction, respiration

6. Which is not associated with deuterostomes?
A. a pattern of development
B. mouth develops from somewhere on the gastrula away from the opening
C. echinoderms
D. arthropods

7. Which are involved in protecting an echinoderm?
A. endoskeleton, pedicellariae, spines
B. madreporite, tentacles, endoskeleton
C. water-vascular system, ampulla, pedicellariae
D. exoskeleton, pedicellariae, spines

8. What is the main difference between echinoderm larvae and adults?
A. Larvae are protostomes and adults are deuterostomes.
B. Larvae are deuterostomes and adults are protostomes.
C. Larvae have bilateral symmetry and adults have radial symmetry.
D. Larvae have radial symmetry and adults have bilateral symmetry.

9. Which group of echinoderms has respiratory trees with many branches?
A. sea cucumbers
B. sea stars
C. sea lilies and feather stars
D. sea urchins and sand dollars

Constructed Response

Use the diagram below to answer questions 10 and 11.

10. Short Answer Examine the circle graph and estimate the percentage of echinoderms that are sea cucumbers.

11. Open Ended Examine the circle graph and explain why class Concentricycloidea does not appear with the other classes of living echinoderms.

12. Open Ended Scientists have discovered a fossil that has the following characteristics: an endoskeleton similar to that of echinoderms, a tail-like structure with an anus at the end of the tail, a structure that might be a gill, and symmetry similar to echinoderms. How might scientists explain this animal in terms of echinoderm classification?

13. Open Ended Tidal animals suffer when water and air temperatures rise beyond the limits of tolerance of the animals. The temperature of sea stars remain about 18 degrees cooler than those of the surrounding mussels on a hot day. Make a hypothesis about why sea stars have a lower body temperature.

Think Critically

14. Observe and Infer You are walking on the beach and find an animal that has many feathery arms and tube feet. What kind of animal might this be?

15. Hypothesize Some sea urchins seem to have relatively long lifespans. Make a hypothesis about why they live so long.

Section 27.2

Vocabulary Review

Using the vocabulary terms from the Study Guide page, replace the underlined words with the correct term.

16. Animals that have the features of chordates, but do not have backbones are the close relatives of chordates.

17. Located just below the nerve cord is a structure in chordates that enables invertebrate chordates to swim by moving their tails back and forth.

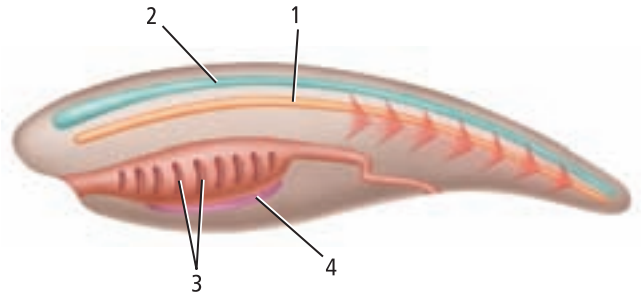
18. The connections between the muscular tube that links the mouth cavity and the esophagus develop slits and are used for filter feeding in some invertebrate chordates.

Understand Key Concepts

19. Chordates have which features at some time in their lives?
- **A.** water-vascular system, notochord, pharyngeal pouches, postanal tail
- **B.** tunic, pharyngeal pouches, dorsal tubular nerve cord, postanal tail
- **C.** tube feet, notochord, pharyngeal pouches, postanal tail
- **D.** dorsal tubular nerve cord, notochord, pharyngeal pouches, postanal tail

20. Which is the main function of a postanal tail?
- **A.** circulation
- **B.** digestion
- **C.** flexibility
- **D.** locomotion

Use the diagram below to answer questions 21 and 22.



21. Fishlike swimming is made possible by which labeled structure above?
- **A.** 1
- **B.** 2
- **C.** 3
- **D.** 4

22. Which structure develops into the brain and spinal cord in most chordates?
- **A.** 1
- **B.** 2
- **C.** 3
- **D.** 4

23. Which describes adult sea squirts?
- **A.** They are bilaterally symmetrical.
- **B.** They have the same adult features as lancelets.
- **C.** As adults, they have only one chordate feature.
- **D.** They are actively swimming predators.

24. In invertebrate chordates, what does the endostyle secrete?
- **A.** proteins similar to thyroid hormone
- **B.** mucus
- **C.** the notochord
- **D.** pharyngeal pouches

25. The phylogeny of echinoderms indicates that echinoderms are related to chordates because they both have which feature?
- **A.** pharyngeal pouches
- **B.** deuterostome development
- **C.** protostome development
- **D.** pseudocoeloms

Chapter Test biologygmh.com

26. Which structure might be an early form of the thyroid gland?
- **A.** dorsal tubular nerve cord
- **B.** endostyle
- **C.** notochord
- **D.** pharyngeal pouches

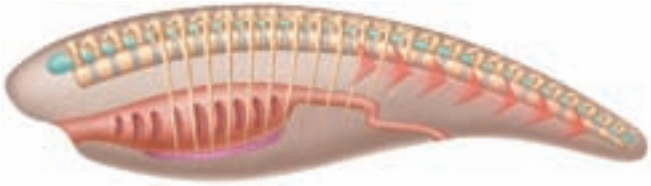
27. Which chordate feature enabled large animals to develop?
- **A.** dorsal tubular nerve cord
- **B.** notochord
- **C.** pharyngeal pouches
- **D.** postanal tail

Constructed Response

28. Open Ended Infer why there are no freshwater invertebrate chordates.

29. Open Ended What would happen if all lancelets disappeared?

Use the diagram below to answer questions 30 and 31.



30. Short Answer Examine the diagram and explain why this animal could not be an invertebrate chordate.

31. Short Answer What features does this animal share with invertebrate chordates?

Think Critically

32. Analyze How do the larvae of organisms help scientists classify and determine the phylogeny of animals?

33. Use the Internet Make a visual report of the newest information, both molecular and fossil evidence, gathered by scientists on the origins of chordates.

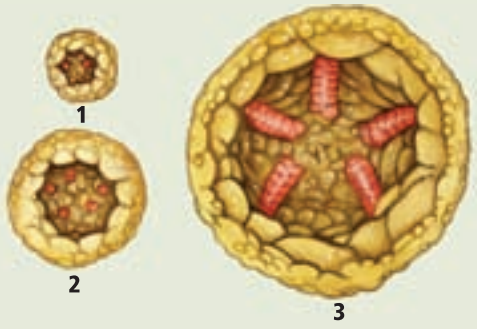
Additional Assessment

34. WRITING in Biology **Create** a poem that describes your favorite echinoderm. Make sure you point out the actual features of the echinoderm.

Document-Based Questions

Study the illustration of the progression of development of arms in a specific sea star.

Diagram based on examples from: Sumrall, Colin D., 2005. Unpublished research on the growth stages of *Neoisorophusella lanei*. The University of Tennessee. http://web.eps.utk.edu/Faculty/sumrall/research2.htm



35. What kind of symmetry is shown in the diagram labeled 1?

36. Infer how additional arms might develop.

37. How does the number of arms in diagram 3 reflect the characteristics of all echinoderms?

Cumulative Review

38. Compare Neanderthals and modern humans. **(Chapter 16)**

39. Compare and contrast the animal-like, plantlike, and funguslike protists. **(Chapter 19)**

40. Prepare a list of vocabulary words that describe general fungal structures, and sketch illustrations of each one. **(Chapter 20)**

41. Name three hormones and the effects they can have on plants. **(Chapter 22)**

42. Sequence the steps involved in the production of the pollen grain and egg in anthophytes. **(Chapter 23)**

Standards Practice for the EOCT

Cumulative

Multiple Choice

1. In which structure of a flowering plant do eggs develop?
- **A.** anther
- **B.** ovule
- **C.** seed
- **D.** stigma

Use the diagram below to answer question 2.

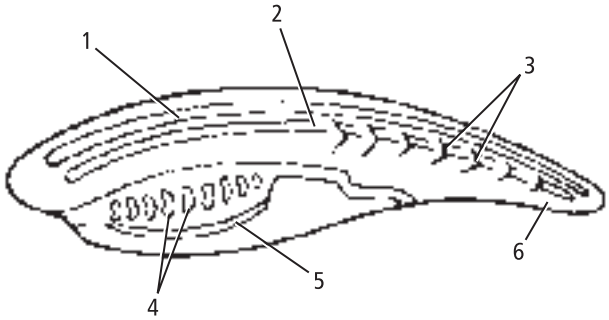
2. Arthropods have specialized mouthparts for feeding. For which type of feeding method is this mouthpart specialized?
- **A.** getting nectar from flowers
- **B.** sponging liquids from a surface
- **C.** sucking blood from a host
- **D.** tearing and shredding leaves

3. Which statement about a group of invertebrates is correct?
- **A.** Cnidarians have collar cells.
- **B.** Flatworms have flame cells.
- **C.** Flatworms have nematocysts.
- **D.** Sponges have a nervous system.

4. Echinoderms have which characteristic that is an evolutionary connection to vertebrates?
- **A.** bilateral symmetry as adults
- **B.** free-swimming larvae
- **C.** deuterostome development
- **D.** radial symmetry as larvae

5. Which special adaptation would be essential for an insect that swims in water?
- **A.** compound eyes
- **B.** modified legs
- **C.** sticky foot pads
- **D.** sharp mouth parts

Use the diagram below to answer questions 6 and 7.



6. Which structure is replaced by bone or cartilage in vertebrate chordates?
- **A.** 1
- **B.** 2
- **C.** 4
- **D.** 5

7. Which structure is a bundle of nerves protected by fluid?
- **A.** 1
- **B.** 3
- **C.** 5
- **D.** 6

8. What kind of body organization or body structure first appeared with the evolution of flatworms?
- **A.** bilateral symmetry
- **B.** coelomic cavity
- **C.** nervous system
- **D.** radial symmetry

9. Suppose a cell from the frond of a fern contains 24 chromosomes. How many chromosomes would you expect to find in the spores?
- **A.** 6
- **B.** 12
- **C.** 24
- **D.** 48

Short Answer

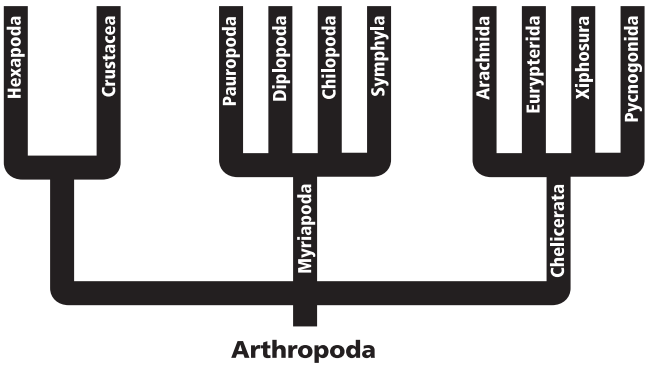
10. Use what you know about the body structure of a sponge to explain how it obtains food.

11. Sea stars are echinoderms that feed on oysters. Justify why oyster farmers should not cut up sea stars and toss the parts back into the water.

12. Evaluate the defense adaptations of the two groups of invertebrate chordates.

13. Contrast the main characteristics of echinoderms with the characteristics of the organisms in another phylum that you already know.

Use the diagram below to answer questions 14 and 15.



14. Write a hypothesis about why horseshoe crabs (in class Xiphosura) are more closely related to spiders than to regular crabs and lobsters.

15. Write a hypothesis about where trilobites would fit into this phylogenetic tree.

Extended Response

16. Explain how echinoderms and annelids are similar, and how they are different.

17. In animals, how are mitosis and meiosis different?

18. Evaluate the idea that it was not a large evolutionary jump for aquatic arthropods to move onto land.

19. Suppose that one crow in an area's population is born with longer claws on its feet than other crows in the same population. According to Darwin's theory of natural selection, under what circumstances would this trait become common in the area's crow population?

Essay Question

In the past, many horror movies have featured giant arthropods attacking major cities. These giant arthropods have included ants, grasshoppers, crabs, and spiders. Actually, the largest living insects are not very big. The longest insect, a walking stick, is about 40 cm long. Some marine arthropods grow larger. The largest arthropod is the Japanese spider crab that can grow up to 4 m wide. Some fossil marine arthropods are even larger. However, none of these are nearly as large as the size of the giant arthropod villains in the movies.

Using the information in the paragraph above, answer the following question in essay format.

20. Write an essay about why real-life arthropods cannot become as large as the giant arthropods shown in horror movies.

If You Missed Question . . .	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Review Section . . .	23.3	26.1	25.1	27.1	26.3	27.2	27.2	25.1	21.3	24.3	27.1	27.2	27.2	26.2	26.3	24.2	10.1	26.2	15.1	26.1
Georgia Standards	B4e	B3b	B3b	B5b	B4f	B3b	B3b	B5b	B2e	S6c	B1a	B4f	B3b	S3a	B5b	B3b	B1a	S6c	B5d	S6c

B = Biology Content Standard, S = Characteristics of Science Standard

UNIT 8

Vertebrates

Chapter 28
Fishes and Amphibians
BIG Idea Fishes have adaptations for living in aquatic environments. Most amphibians have adaptations for living part of their lives on land.

Chapter 29
Reptiles and Birds
BIG Idea Reptile and bird adaptations enable them to live and reproduce successfully in terrestrial habitats.

Chapter 30
Mammals
BIG Idea Mammals have evolved to have a variety of adaptations for maintaining homeostasis and living in a variety of habitats.

Chapter 31
Animal Behavior
BIG Idea Many animal behaviors are influenced by both genetics and environmental experiences.

CAREERS IN BIOLOGY
Veterinarian
Veterinarians are medical specialists trained to prevent, diagnose, and treat medical conditions in domestic, wildlife, zoo, and laboratory animals. Some veterinarians conduct research to expand knowledge of a particular species, much like this giant panda bear researcher is doing.

WRITING in Biology Visit biologygmh.com to learn more about veterinarians. Write a paragraph to compare and contrast the duties of veterinarians in private practices and in public institutions.

China Photos/Getty Images

Biology online

To read more about veterinarians in action, visit biologygmh.com.