

SECTION PREVIEW

Objectives

Summarize the characteristics of chordates.

Explain how invertebrate chordates are related to vertebrates.

Distinguish between sea squirts and lancelets.

Vocabulary

notochord
dorsal hollow
nerve cord
gill slit

Section

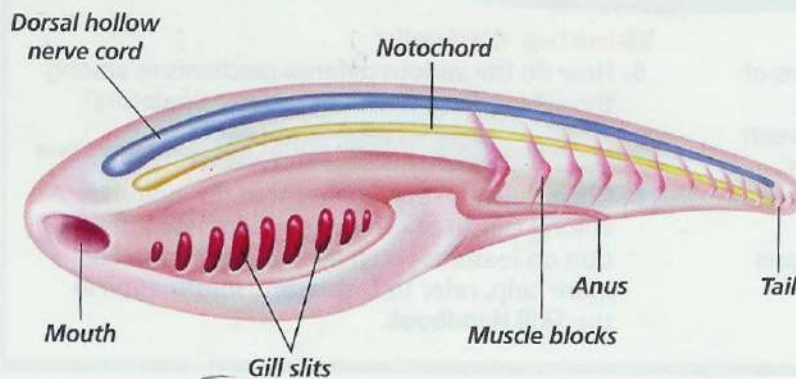
29.2 Invertebrate Chordates

The brightly colored object pictured here is a sea squirt. As one of your closest invertebrate relatives, it is placed, along with humans, in the phylum Chordata. At first glance, this sea squirt may seem to resemble a sponge more than its fellow chordates. It is sessile, and it filters food particles from water it takes in through the opening at the top of its body. What characteristics could a human—or a fish or a lizard, for that matter—share with this colorful, ocean-dwelling organism?



Sea squirt and a human (inset)

Figure 29.7 Chordate characteristics—the notochord, dorsal hollow nerve cord, gill slits, and muscle blocks—are shared by invertebrate as well as vertebrate chordates.



What Is an Invertebrate Chordate?

The chordates most familiar to you are the vertebrate chordates—chordates that have backbones, such as birds, fishes, and mammals, including humans. But the phylum Chordata (kor DAHT uh) includes three subphyla: Urochordata, the tunicates

(sea squirts); Cephalochordata, the lancelets; and Vertebrata, the vertebrates. In this section you will examine the tunicates and lancelets— invertebrate chordates that have no backbones. You will study the vertebrate chordates in the next unit.

Invertebrate chordates may not look much like fishes, reptiles, or humans, but like all other chordates, they have a notochord, a dorsal hollow nerve cord, gill slits, and muscle blocks at some time during their development. In addition, all chordates have bilateral symmetry, a well-developed coelom, and segmentation. The features shared by invertebrate and vertebrate chordates are illustrated in *Figure 29.7*. You can observe these features in invertebrate chordates in the *Problem-Solving Lab* later in this section.

All chordates have a notochord

All chordate embryos have a **notochord** (NOHT uh kord)—a long, semirigid, rodlike structure located between the digestive system and the dorsal hollow nerve cord. The notochord is made up of large, fluid-filled cells held within stiff, fibrous tissues. In invertebrate chordates, the notochord is retained into adulthood. But in vertebrate chordates, this structure is replaced by a backbone. Invertebrate chordates do not develop a backbone.

The notochord develops just after the formation of a gastrula from mesoderm on what will be the dorsal side of the embryo. The physical support provided by a notochord enables invertebrate chordates to make powerful side-to-side movements of

the body. These movements propel the animal through the water at a great speed.

All chordates have a dorsal hollow nerve cord

The **dorsal hollow nerve cord** in chordates develops from a plate of ectoderm that rolls into a hollow tube. This occurs at the same time as the development of the notochord. The sequence of development of the dorsal hollow nerve cord is illustrated in *Figure 29.8*. This tube is composed of cells surrounding a fluid-filled canal that lies above the notochord. In most adult chordates, the cells in the posterior portion of the dorsal hollow nerve cord develop into the spinal cord. The cells in the anterior portion develop into a brain. A pair

WORD Origin

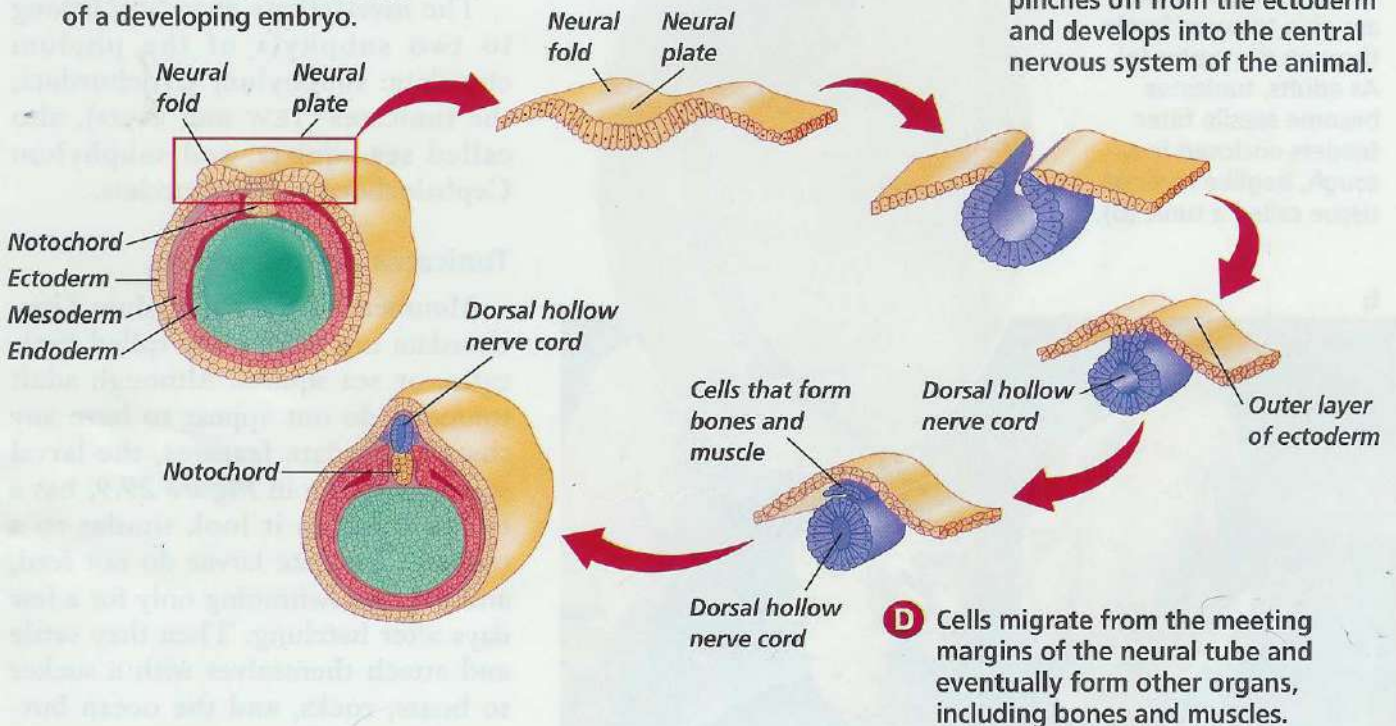
chordata

From the Latin word *chorda*, meaning “cord.” The phylum Chordata consists of animals with notochords.

Figure 29.8

After gastrulation, organs begin to form in a chordate embryo.

- A** The notochord forms from mesoderm on the dorsal side of a developing embryo.



of nerves connects the nerve cord to each block of muscles.

All chordates have gill slits

The **gill slits** of a chordate are paired openings located in the pharynx, behind the mouth. Many chordates have several pairs of gill slits only during embryonic development. Invertebrate chordates that have gill slits as adults use these structures to strain food from the water. In some vertebrates, especially the fishes, the gill slits develop into internal gills that are adapted to exchange gases during respiration.

All chordates have muscle blocks

Muscle blocks are modified body segments that consist of stacked muscle layers. You have probably seen muscle blocks when you ate a cooked fish. The blocks of muscle cause the

meat to separate easily into flakes. Muscle blocks are anchored by the notochord, which gives the muscles a firm structure to pull against. As a result, chordates tend to be more muscular than members of other phyla.

Muscle blocks also aid in movement of the tail. At some point in development, all chordates have a muscular tail. As you know, humans are chordates, and during the early development of the human embryo, there is a muscular tail that disappears as development continues. In most animals that have tails, the digestive system extends to the tip of the tail, where the anus is located. Chordates, however, usually have a tail that extends beyond the anus. You can observe many of the chordate traits in a lancelet in the *MiniLab* on the next page.

Figure 29.9

Tunicate larvae are about 1 cm long and are able to swim freely through the water (a). As adults, tunicates become sessile filter feeders enclosed in a tough, baglike layer of tissue called a tunic (b).



Diversity of Invertebrate Chordates

The invertebrate chordates belong to two subphyla of the phylum chordata: subphylum Urochordata, the tunicates (TEW nuh kaytz), also called sea squirts, and subphylum Cephalochordata, the lancelets.

Tunicates are sea squirts

Members of the subphylum Urochordata are commonly called tunicates, or sea squirts. Although adult tunicates do not appear to have any shared chordate features, the larval stage, as shown in *Figure 29.9*, has a tail that makes it look similar to a tadpole. Tunicate larvae do not feed, and are free swimming only for a few days after hatching. Then they settle and attach themselves with a sucker to boats, rocks, and the ocean bottom. Many adult tunicates secrete a

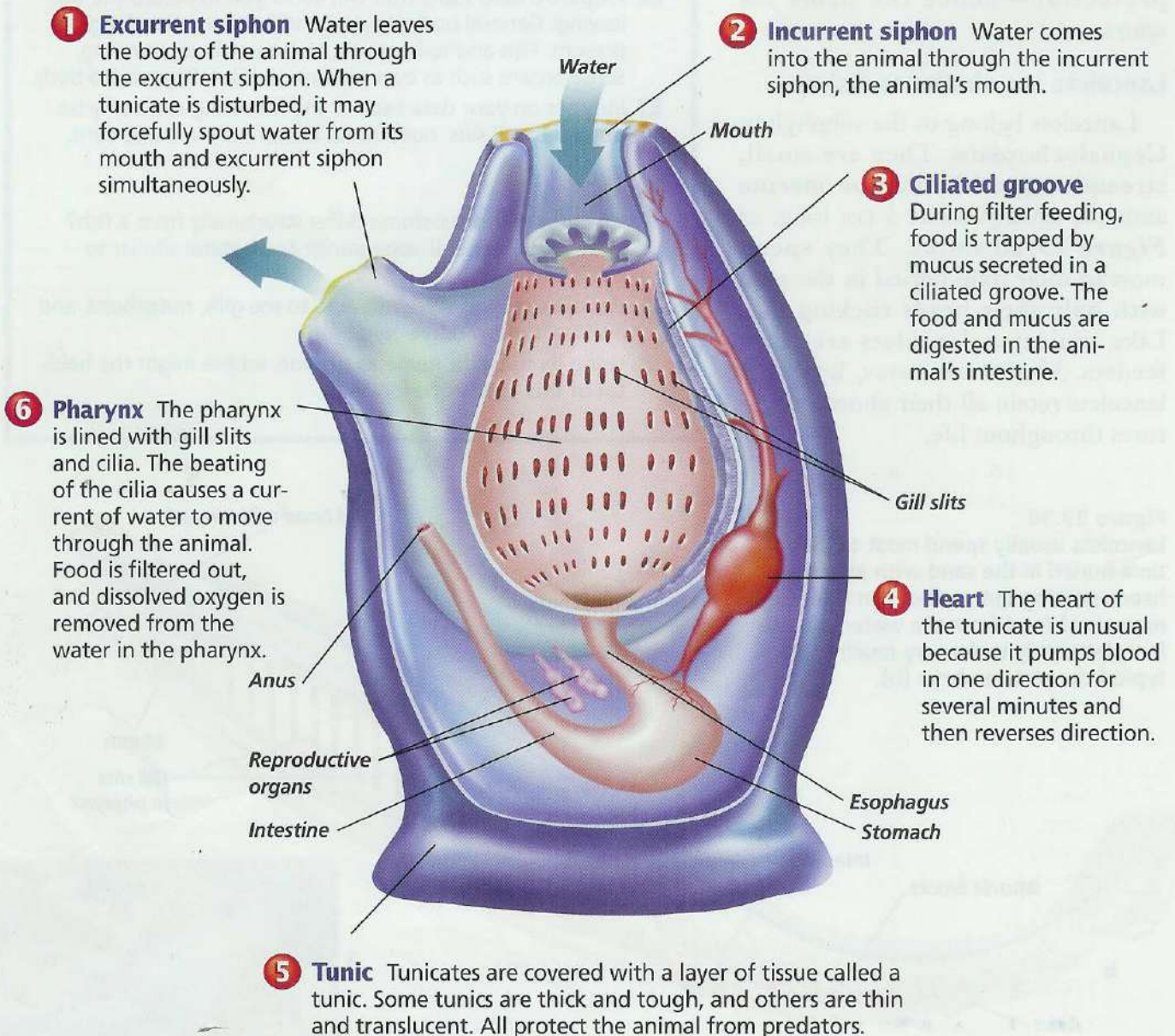
A Tunicate

Tunicates, or sea squirts, are a group of about 1250 species that live in the ocean. They may live near the shore or at great depths. They may live individually, or several animals may share a tunic to form a colony.

Critical Thinking In what ways are sponges and tunicates alike?



Purple bell tunicate



tunic, a tough sac made of cellulose, around their bodies. Colonies of tunicates sometimes secrete just one big tunic that has a common opening to the outside. You can find out how tunicates eat in the *Inside Story* on the next page.

Only the gill slits in adult tunicates indicate their chordate relationship. Adult tunicates are small, tubular animals that range in size from microscopic to several centimeters long, about as big as a large potato. If you remove a tunicate from its sea home, it might squirt out a jet of water for protection—hence the name *sea squirt*.

Lancelets are similar to fishes

Lancelets belong to the subphylum Cephalochordata. They are small, streamlined, and common marine animals, usually about 5 cm long, as *Figure 29.10* shows. They spend most of their time buried in the sand with only their heads sticking out. Like tunicates, lancelets are filter feeders. Unlike tunicates, however, lancelets retain all their chordate features throughout life.

MiniLab 29-2 Observing

Examining a Lancelet *Branchiostoma californiense* is a small, sea-dwelling lancelet. At first glance, it appears to be a fish. However, its structural parts and appearance are quite different.

Procedure

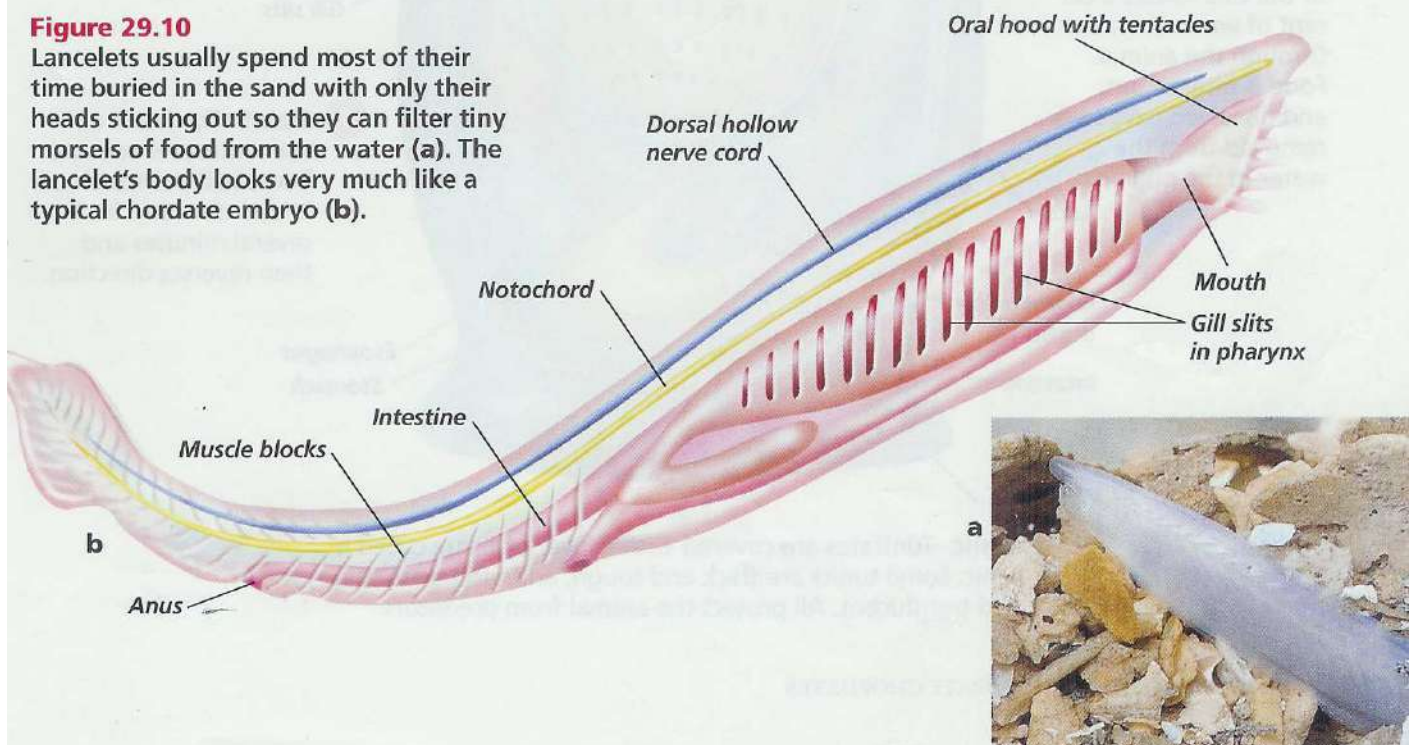
- 1 Place the lancelet onto a glass slide.
CAUTION: Wear disposable latex gloves and handle preserved material with forceps.
- 2 Use a dissecting microscope to examine the animal. **CAUTION: Use care when working with a microscope and slides.**
- 3 Prepare a data table that will allow you to record the following: General body shape, Length in mm, Head region present, Fins and tail present, Nature of body covering, Sense organs such as eyes present, Habitat, Segmented body.
- 4 Indicate on your data table if the following can easily be observed: gill slits, notochord, dorsal hollow nerve cord.

Analysis

1. How does *Branchiostoma* differ structurally from a fish? How are its general appearance and habitat similar to those of a fish?
2. Explain why you were not able to see gills, notochord, and a dorsal hollow nerve cord.
3. Using its scientific name as a guide, where might the habitat of this species be located?

Figure 29.10

Lancelets usually spend most of their time buried in the sand with only their heads sticking out so they can filter tiny morsels of food from the water (a). The lancelet's body looks very much like a typical chordate embryo (b).



Problem-Solving Lab 29-2

Although lancelets look somewhat similar to fishes, they have only one layer of skin, with no pigment and no scales. Lancelets do not have a distinct head, but they do have light sensitive cells on the anterior end. They also have a hood that covers the mouth and the sensory tentacles surrounding it. The tentacles direct the water current and food particles toward the animal's mouth.

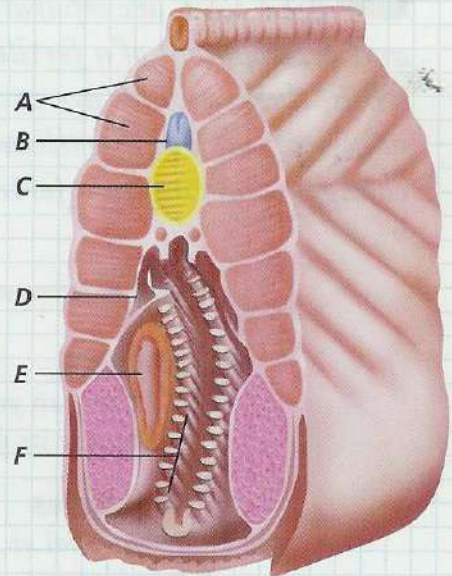
Origins of Invertebrate Chordates

Because sea squirts and lancelets have no bones, shells, or other hard parts, their fossil record is incomplete. Biologists are not sure where sea squirts and lancelets fit in the phylogeny of chordates. According to one hypothesis, echinoderms, invertebrate chordates, and vertebrates all arose from ancestral sessile animals that fed by capturing food in tentacles. Modern vertebrates probably arose from the free-swimming larval stages of ancestral invertebrate chordates. Recent discoveries of fossil forms of organisms that are similar to living lancelets in rocks 550 million years old show that invertebrate chordates probably existed before vertebrate chordates.

What does a slice through an invertebrate chordate show? Why are tunicates and lancelets important? Being invertebrate chordates, they show three major structures that are present at some time during all chordate development.

Analysis

The diagram at right shows a cross section of an invertebrate chordate. Your task is to determine what the various structures marked A-F are.



Thinking Critically

1. What three structures are present in all chordates at some time during their development? Does the cross-section diagram of the lancelet confirm your answer? Explain.
2. How would you know that the cross section was not from an echinoderm?
3. How might the cross section differ if it were taken from an adult tunicate? A young developing tunicate?

Section Assessment

Understanding Main Ideas

1. Describe the four features of chordates.
2. How are invertebrate chordates different from vertebrates?
3. Compare the physical features of sea squirts and lancelets.
4. How do sea squirts and lancelets protect themselves?

Thinking Critically

5. What features of chordates suggest that you are

more closely related to invertebrate chordates than to echinoderms?

SKILL REVIEW

6. **Designing an Experiment** Assume that you have found some tadpolelike animals in the water near the seashore and that you can raise them in a laboratory. Design an experiment in which you will determine whether the animals are larvae or adults. For more help, refer to *Practicing Scientific Methods* in the **Skill Handbook**.