30–1 The Chordates

At first glance, fishes, amphibians, reptiles, birds, and mammals appear to be very different from one another. Some have feathers; others have fins. Some fly; others swim or crawl. These variations are some of the characteristics that biologists use to separate these animals into different classes, yet all are members of the phylum Chordata (kawr-DAHT-uh).

What Is a Chordate?

Members of the phylum Chordata are called **chordates** (KAWR-dayts). To be classified as a chordate, an animal must have four key characteristics, although these characteristics need not be present during the entire life cycle. **A chordate is an animal that has, for at least some stage of its life, a dorsal, hollow nerve cord; a notochord; pharyngeal (fuh-RIN-jee-ul) pouches; and a tail that extends beyond the anus.** Refer to **Figure 30–1** as you read about each of these characteristics.

The hollow nerve cord runs along the dorsal (back) part of the body. Nerves branch from this cord at regular intervals and connect to internal organs, muscles, and sense organs.

The **notochord** is a long supporting rod that runs through the body just below the nerve cord. Most chordates have a notochord only when they are embryos.

Pharyngeal pouches are paired structures in the throat (pharynx) region. In some chordates—such as fishes and amphibians—slits develop that connect the pharyngeal pouches to the outside of the body. These slits may then develop gills that are used for gas exchange.

At some point in their lives, all chordates have a tail that extends beyond the anus. The tail can contain bone and muscle and is used in swimming by many aquatic species.

CHECKPOINT *What is a notochord?*

Guide for Reading

Key Concepts
- What characteristics do all chordates share?
- What are the two groups of nonvertebrate chordates?

Vocabulary
chordate
notochord
pharyngeal pouch
vertebra

Reading Strategy: Building Vocabulary
Before you read, preview new vocabulary by skimming the section and making a list of the highlighted, boldface terms. As you read, make notes next to each term.

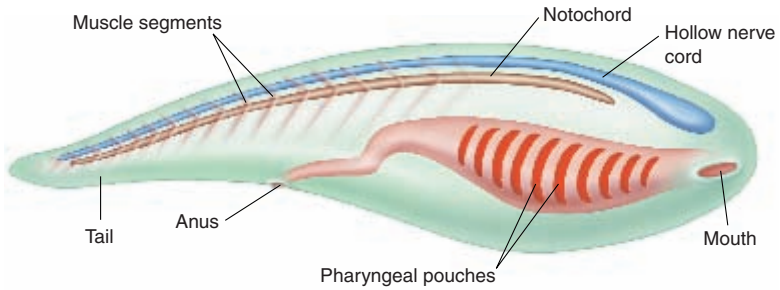


Figure 30–1 **All chordates share four characteristics: a dorsal, hollow nerve cord; a notochord; pharyngeal pouches; and a tail that extends beyond the anus.** Some chordates possess all these characteristics as adults; others possess them only as embryos.

SECTION RESOURCES

Print:
- ***Teaching Resources,*** Lesson Plan 30–1, Adapted Section Summary 30–1, Adapted Worksheets 30–1, Section Summary 30–1, Worksheets 30–1, Section Review 30–1
- ***Reading and Study Workbook A,*** Section 30–1
- ***Adapted Reading and Study Workbook B,*** Section 30–1

Technology:
- ***iText,*** Section 30–1
- ***Transparencies Plus,*** Section 30–1

Section 30–1

1 FOCUS

Objectives
30.1.1 ***Identify*** the characteristics that all chordates share.
30.1.2 ***Explain*** what vertebrates are.
30.1.3 ***Describe*** the two groups of nonvertebrate chordates.

Guide for Reading

Vocabulary Preview
Explain that *notochord* comes from the Greek words *noto*, meaning "back," and *chord*, meaning "string." The notochord is the structure for which chordates are named. Also explain that *pharyngeal* is an adjective used to describe objects located in the pharynx, or throat. Ask: **Where would pharyngeal pouches be located?** *(In the pharynx, or throat)*

Reading Strategy
Before students read the section, have them preview Figures 30–1, 30–3, and 30–5. Challenge them to predict how tunicates and lancelets are related. Then, as students read the section, ask them to reassess their predictions.

2 INSTRUCT

What Is a Chordate?

Build Science Skills
Applying Concepts Show students pictures of the embryos of various animals, such as humans, birds, frogs, snakes, and fishes. Invite students to identify chordate structures in each embryonic picture. Emphasize that these characteristics need not be present during the entire life cycle of a chordate. In fact, most chordates have these characteristics for only a short time during the embryonic stage. L2

Answer to . . .

CHECKPOINT *A notochord is a long supporting rod located just below the nerve cord.*

Most Chordates Are Vertebrates

Go Online NSTA SCILINKS
Download a worksheet on nonvertebrate chordates for students to complete, and find additional teacher support from NSTA SciLinks.

Use Visuals

Figure 30–2 As students study the evolutionary tree, remind them that chordates located on the same branch are more closely related to each other than to other chordates. Also tell them that the points of branching represent common ancestors. Ask: **Which two of these chordate groups are most closely related—birds, fishes, reptiles?** *(Birds and reptiles)* Explain that scientists determine the relationships among organisms by their similarities in structure, embryological development, and DNA sequences. Ask: **What structure do vertebrate chordates have in common?** *(Vertebral column)* L1 L2

Build Science Skills

Observing Display skeletons of various vertebrates for students to observe. If skeletons are not available, substitute pictures or diagrams. Encourage students to observe the skeletons and locate the vertebral column for each. Make sure they can also identify the vertebrae. Have students describe similarities and differences. Ask: **How are these vertebrates similar?** *(All have backbones and internal skeletons.)* Briefly discuss their differences, explaining that students will learn more about these differences in later chapters. L1 L2

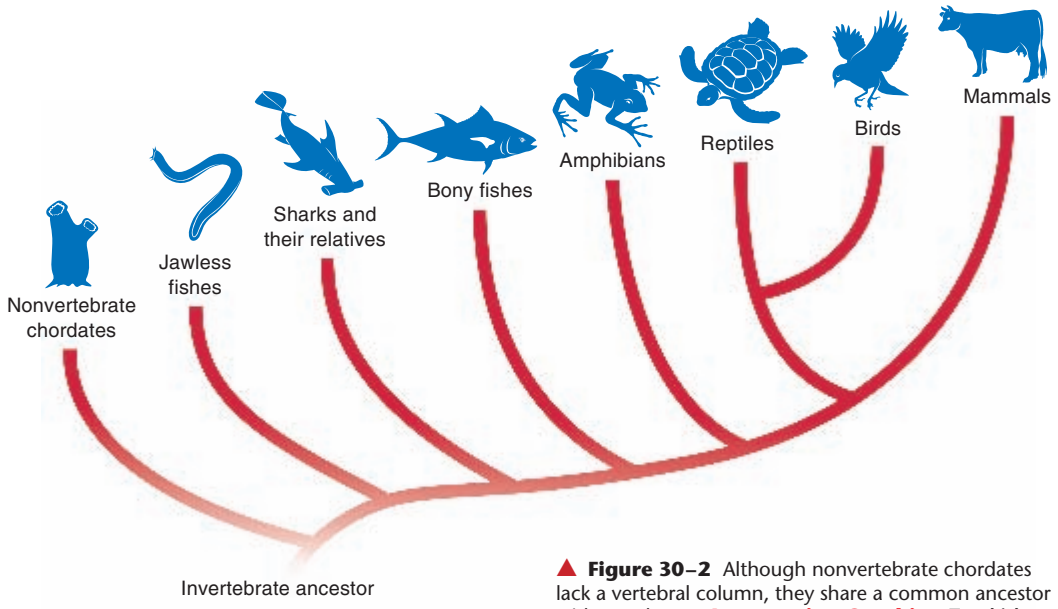
Go Online NSTA SCILINKS
For: Links on nonvertebrate chordates
Visit: www.SciLinks.org
Web Code: cbn-9301

Most Chordates Are Vertebrates

The diagram in **Figure 30–2** shows the current understanding of the phylogeny, or evolutionary relationships, of chordates. About 96 percent of all chordate species are placed in the subphylum Vertebrata and are called vertebrates. Most vertebrates have a strong supporting structure known as the vertebral column, or backbone. In vertebrates, the dorsal, hollow nerve cord is called the spinal cord. As a vertebrate embryo develops, the front end of the spinal cord grows into a brain. The backbone, which replaces the notochord in most developing vertebrates, is made of individual segments called **vertebrae** (singular: vertebra). In addition to providing support, vertebrae enclose and protect the spinal cord.

A vertebrate's backbone is part of an endoskeleton, or internal skeleton. Like an arthropod's exoskeleton, a vertebrate's endoskeleton supports and protects the animal's body and gives muscles a place to attach. However, unlike an arthropod's exoskeleton, a vertebrate's skeleton grows as the animal grows and does not need to be shed periodically. In addition, whereas an arthropod's skeleton is made entirely of nonliving material, a vertebrate's skeleton contains living cells as well as nonliving material. The cells produce the nonliving material in the skeleton.

CHECKPOINT *What is the function of the vertebral column?*



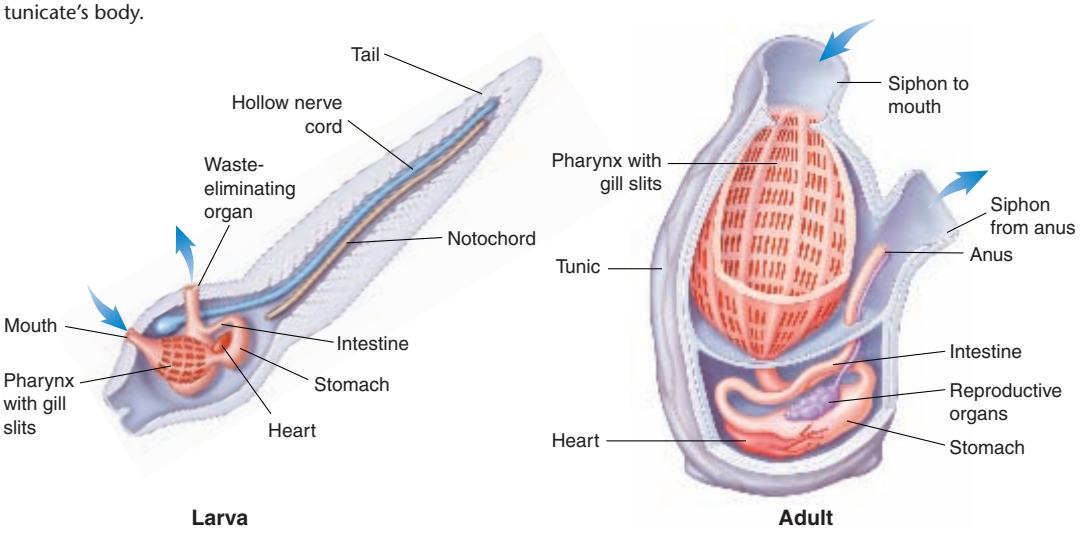
▲ **Figure 30–2** Although nonvertebrate chordates lack a vertebral column, they share a common ancestor with vertebrates. **Interpreting Graphics** *To which other vertebrate group are birds most closely related?*

UNIVERSAL ACCESS

Inclusion/Special Needs
Students with impaired vision can examine the chordate characteristics by exploring with their fingers a dissected lancelet and bony fish from the Chapter Inquiry Activity. Pair these students with others who will help them identify the structures and verbally describe their functions. Students should wear plastic gloves and wash their hands with soap and warm water afterward. L1

Less Proficient Readers
Encourage students to construct a Venn diagram that compares and contrasts tunicates and lancelets. Venn diagrams should show the characteristics specific to tunicates, those specific to lancelets, and those shared by both. Then, have students write a sentence that explains why tunicates are classified as chordates. L1

▼ **Figure 30–3** **Tunicates are one of two groups of nonvertebrate chordates.** The tadpole-shaped tunicate larva (left) has all four chordate characteristics. When most tunicate larvae grow into adults, they lose their tails and attach to a solid surface. Adult tunicates (right) look nothing like the larvae, or even like other adult chordates. Both larvae and adults are filter feeders. The blue arrows show where water enters and leaves the tunicate's body.



Nonvertebrate Chordates

There are two subphyla of chordates that do not have backbones. **The two groups of nonvertebrate chordates are tunicates and lancelets.** Both are soft-bodied marine organisms. Like all chordates, these animals have a hollow nerve cord, a notochord, pharyngeal pouches, and a tail at some stage of their life cycle.

In some ways, studying nonvertebrate chordates is like using a time machine to investigate the ancestors of our own subphylum, Vertebrata. Similarities in anatomy and embryological development indicate that vertebrates and nonvertebrate chordates evolved from a common ancestor. Fossil evidence from the Cambrian Period places this divergence at more than 550 million years ago. Although they seem to be simple animals, tunicates and lancelets are relatives of ours—very distant ones.

Tunicates Filter-feeding tunicates (subphylum Urochordata) certainly do not look as if they are related to us. **Figure 30–3** shows the body structure of a tunicate larva and an adult. Observe that the larval form has all of the chordate characteristics. In contrast, adult tunicates, like the ones in **Figure 30–4,** have neither a notochord nor a tail.

▲ **Figure 30–4** Tunicates get their name from the adult's body covering—the tough, nonliving tunic. Most tunicates are commonly known as sea squirts, because of the stream of water they sometimes eject. **Inferring** ***In what kind of ecosystem are you likely to find tunicates?***

TEACHER TO TEACHER

To help my students actually see the relationship between the spinal cord and the vertebrae, I have them examine chicken necks. These are easy to obtain from the local grocery store or butcher, and I boil them prior to students' handling them. First, I encourage students to locate the vertebrae and observe how they are shaped and how they allow movement. Then, I instruct students to use dissecting probes to locate the spinal cord. I also point out that the vertebrae developed from the notochord and the spinal cord came from the dorsal, hollow nerve cord in the embryo. When they have finished examining the chicken necks, I instruct my students to draw labeled diagrams of their observations.

—*Heidi Busa*
Biology Teacher
Marcellus High School
Marcellus, NY

Make Connections

Physics Explain to students that the pull of muscles against the bones of the skeleton is responsible for most voluntary movement in vertebrates. Muscles and bones work together as levers to produce movement. A lever is a rigid object that moves around a pivot point. The fulcrum is the pivot point of a lever. The input force is the force used to move the lever. Tell students to lift their heads. Explain that the fulcrum is the joint between the topmost vertebra and the skull. Ask: **What provided the input force?** *(The muscles at the back of the neck)* L2 L3

Nonvertebrate Chordates

Build Science Skills

Formulating Hypotheses Explain that scientists have two theories that describe the chordate ancestor. In one theory, the ancestor was like a lancelet from which a sessile line evolved to become the tunicates. Another line remained motile and evolved into vertebrates. A second theory describes the ancestor as a tunicate from which lancelets and vertebrates arose from adaptations of the tadpole-shaped tunicate larva. Challenge students to hypothesize whether the chordate ancestor was like a tunicate or a lancelet. They should give reasons for their choice. L2

Use Visuals

Figure 30–3 Ask volunteers to point out the chordate structures in the illustration of the tunicate larva. Ask: **What chordate structure is found in the adult?** *(Pharynx with gill slits)* **In what ways do tunicates differ from vertebrates?** *(The notochord is not replaced by a vertebral column.)* L1 L2

Answers to . . .

CHECKPOINT *To enclose and protect the spinal cord and give support*

Figure 30–2 *Reptiles*

Figure 30–4 *In the ocean*

30–1 (continued)

Build Science Skills

Classifying All students will benefit from reexamining the preserved lancelet used in the Chapter Inquiry Activity. Encourage students to draw diagrams of the lancelet anatomy and label the four chordate characteristics. Remind students that the lancelet is one of the few chordates that have all four chordate characteristics present in the adult. Ask: **Why are lancelets classified as nonvertebrates?** *(They do not have a backbone.)* L1 L2

3 ASSESS

Evaluate Understanding

Invite student volunteers to name the four chordate characteristics. Make a table on the board entitled *Nonvertebrate Chordates* with the headings *Tunicates* and *Lancelets*. Call on students to complete the table by describing their key characteristics.

Reteach

Use Figure 30–1 to reinforce some of the Vocabulary words from this section. You might have students write down the definitions of the words on a chordate diagram that they draw themselves.

Writing in Science

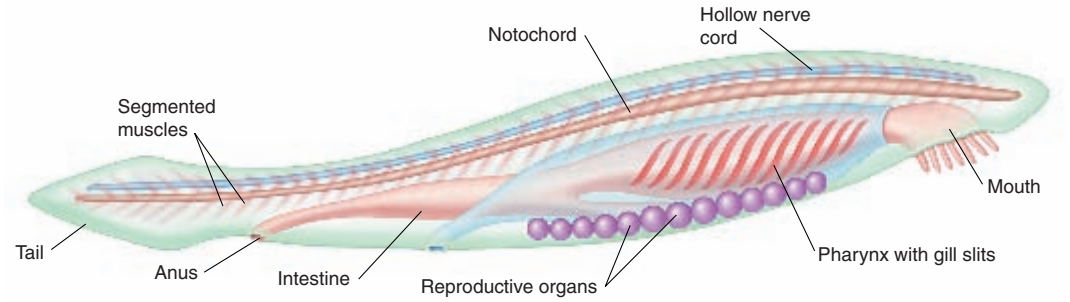
Students' articles should be written in the style of the typical newspaper article. Their articles should describe one of the nonvertebrate chordates discussed in this section. You might provide students with copies of *Science News* or *The New York Times* science section as examples of the style and format to use for their articles.

Interactive Textbook

If your class subscribes to the iText, use it to review Section 30–1.

Answer to . . .

Figure 30–5 *All four chordate characteristics*



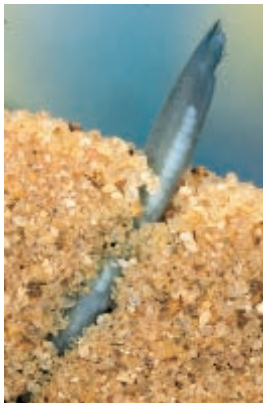


Figure 30–5 Lancelets are small nonvertebrate chordates that often live with their bodies half buried in sand. Because lancelets do not have fins or legs, they can move only by contracting the paired muscles on their bodies. **Interpreting Graphics** ***Which chordate characteristics do lancelets have?***

Lancelets The small, fishlike creatures called lancelets form the subphylum Cephalochordata. Lancelets live on the sandy ocean bottom. You can see a lancelet's body structure in **Figure 30–5.** Observe that, unlike an adult tunicate, an adult lancelet has a definite head region that contains a mouth. The mouth opens into a long pharynx with up to 100 pairs of gill slits. As water passes through the pharynx, a sticky mucus catches food particles. The lancelet then swallows the mucus into the digestive tract. Lancelets use the pharynx for gas exchange. In addition, lancelets are thin enough to exchange gases through their body surface.

Lancelets have a closed circulatory system. They do not have a true heart. Instead, the walls of the major blood vessels contract to push blood through the body. The fishlike motion of lancelets results from contracting muscles that are organized into V-shaped units. The muscle units are paired on either side of the body.

30–1 Section Assessment

1. **Key Concept** Describe four characteristics of chordates.
2. **Key Concept** How do lancelets and tunicates differ?
3. What one characteristic distinguishes most vertebrates from the other chordates?
4. How is a vertebrate's skeleton similar to that of an arthropod? How is it different?
5. Describe two ways in which lancelets obtain oxygen.
6. **Critical Thinking Inferring** How would a free-swimming larval stage be an advantage for tunicates?

Writing in Science

Creative Writing
Imagine that a scientist has just discovered the existence of one of the nonvertebrate chordate groups. Write a short newspaper article describing what the scientist has discovered. *Hint:* Before you write, list the characteristics of the chordate group. Then, identify these characteristics in the article.

30–1 Section Assessment

1. Hollow nerve cord: runs along back, nerves branch from it to rest of body; notochord: long supporting rod below nerve cord; pharyngeal pouches: paired structures in the throat region; tail that extends beyond anus
2. Unlike adult tunicates, adult lancelets have a definite head region containing a mouth.
3. The vertebral column, or backbone
4. Similarities: supports and protects body, gives muscles a place to attach. Differences: does not need to be shed and contains living cells.
5. Gas exchange occurs in the pharynx and through the body surface.
6. Adult tunicates are immobile. Free-swimming larvae disperse the young throughout a wide area. This reduces competition for food and space.