SECTION 4

Vertebrates

Key Concept All vertebrates have a backbone, which supports other specialized body structures and functions.

What You Will Learn

- Vertebrates have an endoskeleton that provides support and protection.
- Vertebrates have organ systems that perform life functions.
- Nearly all vertebrates reproduce by only sexual reproduction.

Why It Matters

The characteristics of vertebrates show how vertebrates have adapted to living in their environment.

Vocabulary

- cartilage
- small intestine
- large intestine

READING STRATEGY

Outlining In your **Science Journal,** create an outline of the section. Use the headings from the section in your outline.

7.1.f Students know that as multicellular organisms develop, their cells differentiate.
7.2.a Students know the differences between the life cycles and reproduction methods of sexual and asexual organisms.
7.5.a Students know plants and animals have levels of organization for structure and function, including cells, tissues, organs, organ systems, and the whole organism.
7.5.b Students know organ systems function because of the contributions of individual organs, tissues, and cells. The failure of any part can affect the entire system.
7.5.c Students know how bones and muscles work together to provide a structural framework for movement.
7.5.g Students know how to relate the structures of the eye and ear to their functions.

You may have seen a dinosaur skeleton at a museum. You have probably also seen many fish. Have you ever thought about what these animals might have in common with each other? These animals have backbones, which makes them vertebrates.

Vertebrate Characteristics

Vertebrates live in the oceans, in freshwater, and on land. Vertebrates swim, crawl, burrow, hop, run, and fly. Like many invertebrates, vertebrates have organ systems to perform their life functions. However, vertebrates also have features that other organisms do not have. For example, only vertebrates have a backbone, which is part of a skeleton that is made of bone. Bone is a special type of very hard tissue that is found only in vertebrates.

Vertebrates also have a well-developed head that is protected by a skull. The skull is made of either cartilage or bone. **Cartilage** is a flexible material made of cells and proteins. The skeletons of all embryos are made of cartilage. But as most vertebrates grow, the cartilage is replaced by the much harder bone.

Body Symmetry

All vertebrates, such as the frog in **Figure 1,** are bilaterally symmetrical. In vertebrates, the head is distinct from the rest of the body. A bilaterally symmetrical body has at least four main parts. For example, the upper body surface, or back, is the *dorsal* side. The lower surface or belly is the *ventral* side. The head is in the front, or *anterior* of the body. The tail is in the back, or *posterior* of the body.

Figure 1 *This frog has bilateral symmetry.*

Figure 2 Body Coverings in Vertebrates

Scales | Feathers | Fur | Skin

Body Coverings

The body of a vertebrate is covered by skin. One function of skin is to protect the body from the external environment. The skin of vertebrates varies in structure. For example, reptiles, such as the chameleon in **Figure 2,** and most fish are covered in small, thin plates called *scales*. However, fish scales have a different structure than reptile scales do. The scales of fish are also covered in a slippery fluid called *mucus* (MYOO kuhs), while the scales of reptiles are dry. The skin of amphibians is also covered in mucus and functions in part as a respiratory organ. Feathers on birds and the hair and fur on mammals help keep the organisms' body temperatures stable. Some body coverings display colors and patterns that allow vertebrates to hide from predators.

cartilage (KAHRT uhl ij) a flexible and strong connective tissue

Support of the Body

The body of a vertebrate is supported by an endoskeleton. **Figure 3** shows the endoskeleton of a bird. The three main parts of an endoskeleton are the skull, the backbone, and the limb bones. The skull surrounds and protects the brain of the vertebrate. The backbone is made up of many vertebrae. Vertebrae surround and protect the spinal cord. Limb bones, such as leg bones, are an important part of movement in vertebrates. Bones provide a place for muscles to attach. As muscles contract and relax, the bones move. For example, in arms and in legs, pairs of muscles work together to move the limb. Vertebrates need large bones and muscles for support and movement on land.

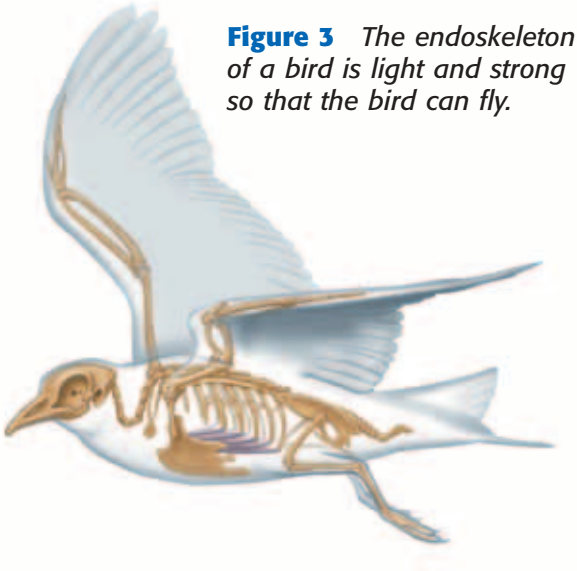
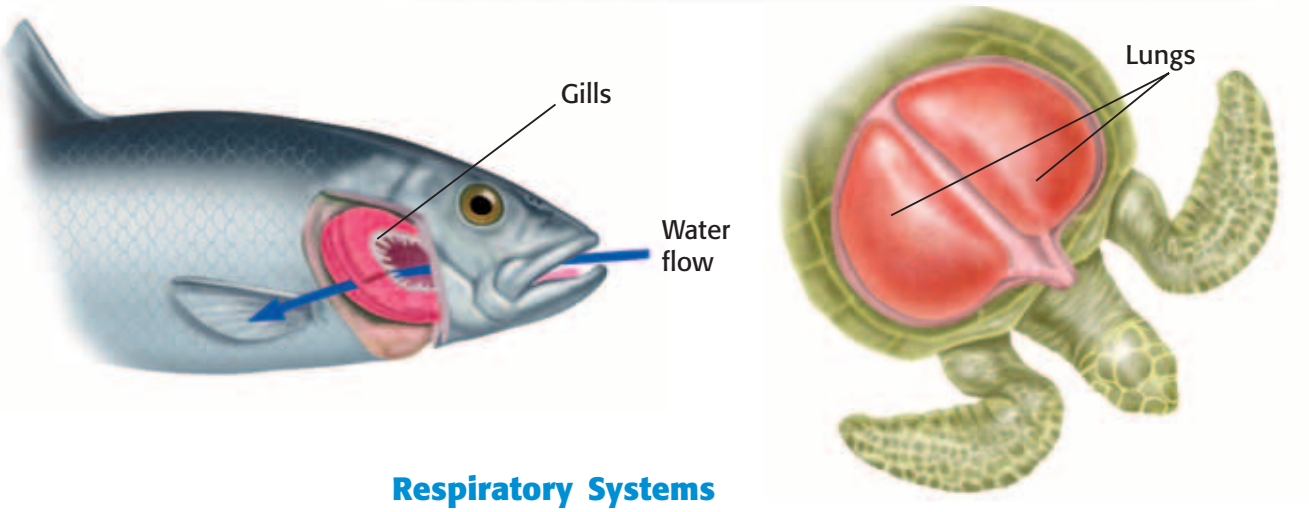


Figure 3 *The endoskeleton of a bird is light and strong so that the bird can fly.*

Standards Check **Describe the three main parts of an endoskeleton.** 7.5.c

Figure 4 Respiratory Systems in Vertebrates



Respiratory Systems

Like invertebrates, vertebrates have a respiratory system to perform respiration. **Figure 4** shows the two kinds of respiratory systems in vertebrates. The main respiratory organs in vertebrates are either lungs or gills. These organs have many blood vessels that provide the organs with a steady blood supply. In fish, water flows into the mouth and over the gills. Oxygen from the water moves across the gills and into the bloodstream. At the same time, carbon dioxide moves from the bloodstream, across the gills, and into the water.

In vertebrates that live on land, respiratory organs must be protected from drying out. Therefore, the main respiratory organs are inside the body. Lungs are sacs that are kept moist by the body's fluids. The internal surface of the lungs is made up of small pockets that increase the area available for the exchange of oxygen and carbon dioxide.

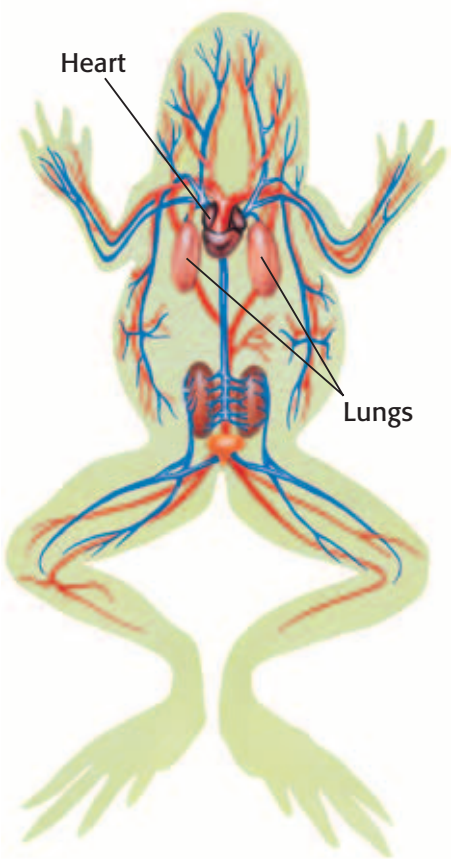


Figure 5 *The frog has a closed circulatory system. The arteries are shown in red, and the veins are shown in blue.*

Circulatory Systems

Vertebrates have a closed circulatory system made up of blood, vessels, and a pump. Blood is pushed through the vessels by a pump, or *heart*. Vessels that carry blood away from the heart are called *arteries*. Vessels that carry blood to the heart are called *veins*. Arteries are connected to veins by a network of *capillaries*. Capillaries are the smallest blood vessels in the body. **Figure 5** shows the circulatory system of a frog.

In land vertebrates, the heart first pumps the blood to the lungs or gills. In lungs or gills, oxygen moves into the blood. At the same time, carbon dioxide moves out of the body from the blood. Then, the oxygen-rich blood returns to the heart and is pumped to the rest of the body. The circulatory system also transports nutrients and other substances around the body.

Standards Check **Describe how the circulatory system and the respiratory system in a vertebrate work together.** 7.5.b

Digestive and Excretory Systems

Vertebrates have digestive systems to break down food. The digestive system is made up of a long tube called the *digestive tract*. Some vertebrates, such as fish and snakes, swallow their food whole. Other vertebrates crush or chew their food before swallowing. Food passes from the mouth to the stomach. Acids and other chemicals in the stomach turn the food into a kind of soup. This soup then moves into the next part of the digestive tract, an organ called the **small intestine.** Blood vessels in the small intestine absorb nutrients. Then, the materials move into an organ called the **large intestine.** The large intestine absorbs excess water and converts undigested material into feces.

Some cell activities result in the formation of nitrogen compounds, such as ammonia. Ammonia diffuses into the blood and is removed from the body by the excretory system. In mammals, the liver converts ammonia into urea. Then, the *kidneys* filter urea from the blood. Urea is then combined with excess water to form urine, which is expelled from the body.

Nervous Systems

In the nervous system of a vertebrate, the brain is part of the spinal cord. The brain is an organ that serves as the main control center of the body. Nerves from the spinal cord branch throughout the body. Nerves carry impulses between the brain and the body. For example, when a sound reaches the ear, the ear sends an impulse through *sensory nerves* and the spinal cord, to the brain. To make the body react, the brain interprets the impulses and sends command impulses throughout the body through *motor nerves*.

The brain of a fish is much smaller than the brain of a dog, as **Figure 6** shows. Animals that have larger brains depend more on learning than on instinct. Learning is a behavior that changes the reaction of an animal based on new experiences.

Standards Check **Describe what happens when a sound reaches the ear.** 7.5.g

Quick Lab

Amplifying Sound

7.5.g

1. Roll a **sheet of paper** into a loose cone.
2. Wrap the smaller open end of the cone around the stem of a **funnel.** Use **tape** to secure the shape of the cone.

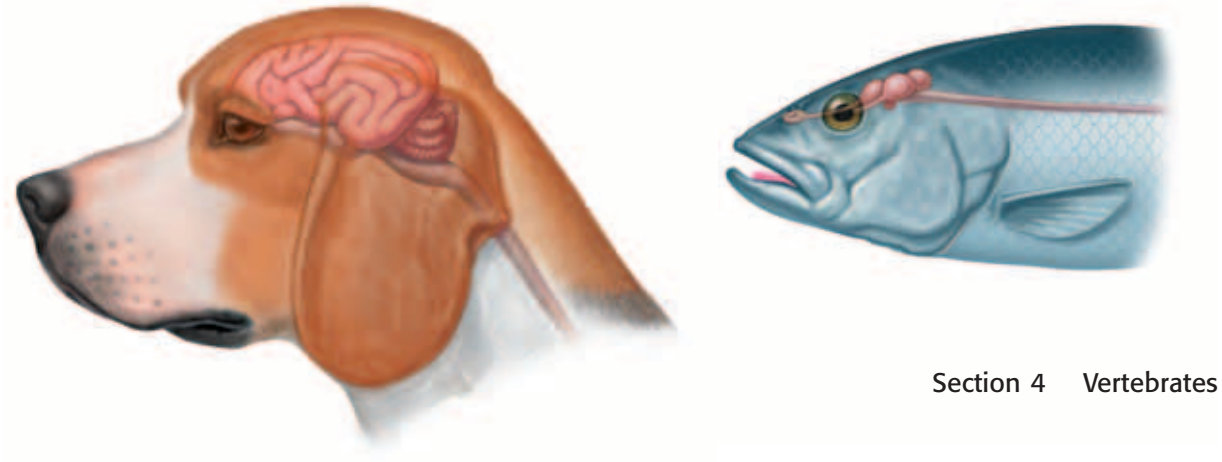
3. Place the funnel over an ear.
4. Move the cone towards a faint sound and then away from the sound. How does the sound change?
5. Make a new cone with several sheets of paper. Repeat step 4. How does the size of the cone affect what you hear?

15 min

small intestine (SMAWL in TES tuhn) the organ between the stomach and the large intestine where most of the breakdown of food happens and most of the nutrients from food are absorbed

large intestine (LAHRJ in TES tuhn) the wider and shorter portion of the intestine that removes water from mostly digested food and that turns the waste into semisolid feces, or stool

Figure 6 Nervous Systems in Vertebrates



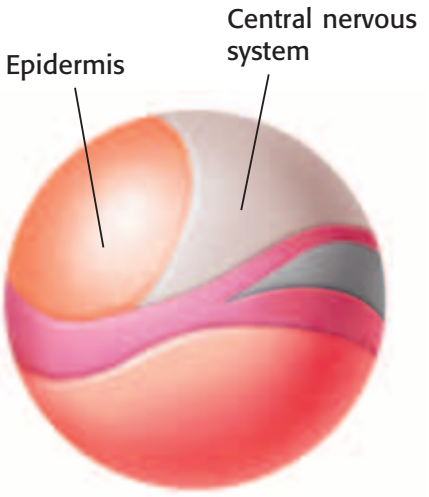


Figure 7 *Parts of a frog embryo are beginning to differentiate into the kind of cells they will become.*

Reproduction and Development

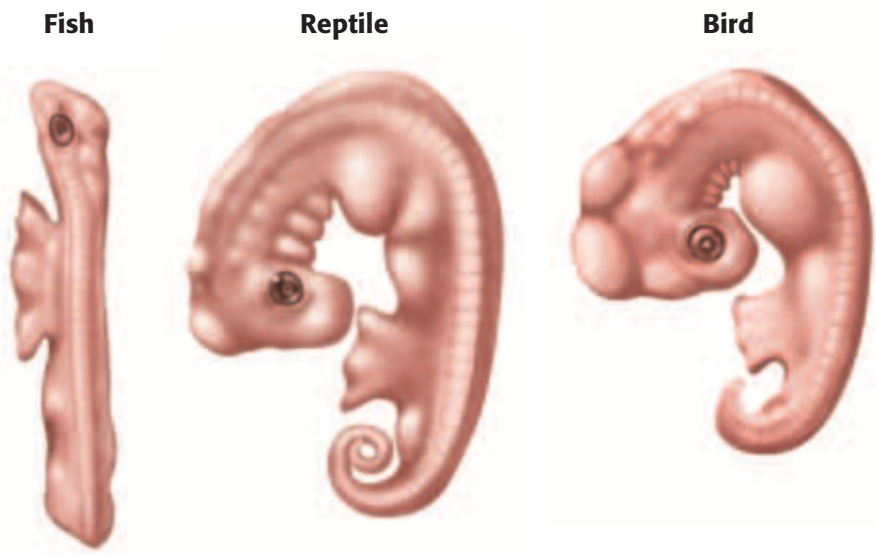
Most vertebrates reproduce by sexual reproduction. Fertilization happens when the nucleus of a sperm cell fuses with the nucleus of an egg cell. A fertilized egg cell divides many times as it becomes a multicellular embryo. As the embryo develops, its cells differentiate. Differentiation is the process in which cells become specialized. For example, cells that will perform different functions, such as skin cells and blood cells, will develop different structures. **Figure 7** shows the differentiation of some tissues of a frog embryo.

In most fish and amphibians, larvae hatch in the water and live on their own. These larvae behave similarly to adults. However, larvae cannot reproduce. Eventually, the larvae metamorphose into adults.

Reptiles, birds, and mammals do not have a larval stage in their lifecycle. The eggs of reptiles, birds, and mammals are protected by special membranes. The eggs of reptiles, birds, and some mammals also have a shell. Eggs that have shells are laid on land. Most mammals do not lay eggs, and the embryo develops in the female until the offspring is born. **Figure 8** shows the embryos of vertebrates during early stages of their development. Embryos of different species are similar to each other at early stages of development. Embryos begin to look more like the adults of their own species as they develop. Offspring of reptiles, birds, and mammals look similar to adults when they are born. These offspring gradually develop into adults.

Standards Check **Why do cells in a developing embryo undergo differentiation? 7.1.f**

Figure 8 The Embryos of Different Vertebrates



Parental Care

Some vertebrates do not care for their young. The female simply lays the eggs and leaves. These animals lay hundreds of eggs, so at least a few offspring will survive. Many fish species and reptile species guard the nest until the eggs hatch. Afterward, the offspring are left on their own. Birds and mammals are very different. Birds and mammals have only a few offspring at a time. Therefore, birds and mammals spend a lot of time and energy feeding and protecting their offspring. The fish shown in **Figure 9** is unusual because it cares for its offspring after they hatch. The parent fish holds its offspring in its mouth to protect them as they develop. Parental care increases the chances of offspring surviving.

Figure 9 *This fish will hold its offspring in its mouth to protect them from predators.*

SECTION Review

7.1.f, 7.2.a, 7.5.a, 7.5.b, 7.5.c, 7.5.g

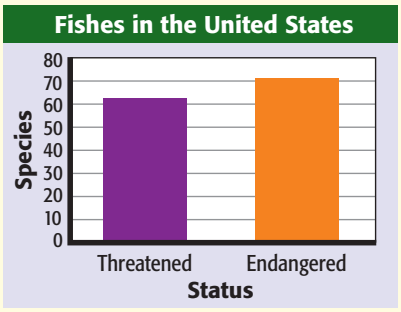
Summary

- Skin protects the body from the environment. Skin of vertebrates may be covered in scales, feathers, or fur.
- Most vertebrates have an endoskeleton made of bone. The endoskeleton provides support, protection, and a place for muscles to attach.
- Major organs systems of vertebrates are the respiratory system, circulatory system, digestive system, excretory system, nervous system, and reproductive system.
- Cells of embryos differentiate and specialize as the embryo develops.
- The amount of parental care given to offspring varies among species of vertebrates.

Understanding Concepts

1. **Demonstrating** How do different kinds of cells develop in an embryo?
2. **Describing** Describe the structure of the backbone and what it provides the vertebrate body.
3. **Identifying** What kind of circulatory system do vertebrates have?

INTERPRETING GRAPHICS Use the graph below to answer the next two questions.



4. **Evaluating** How many fish species in the United States are endangered?
5. **Calculating** What is the total number of endangered and threatened fish species in the United States?

Critical Thinking

6. **Making Comparisons** How does gas exchange in gills differ from gas exchange in lungs?
7. **Applying Concepts** What is an advantage and a disadvantage of depositing a large number of eggs?
8. **Applying Concepts** How does an egg become fertilized? Is this sexual or asexual reproduction? Explain your answer.

Challenge

9. **Making Inferences** What factors might limit the maximum body size to which land vertebrates can grow?
10. **Applying Concepts** Why might large ears be better able to hear a sound than small ears?

Internet Resources

For a variety of links related to this chapter, go to www.scilinks.org

Topic: Vertebrates

SciLinks code: HY71602