

Chapter Outline

Chapter 30 Fishes and Amphibians

Section 1: The Fish Body

KEY IDEAS

- > What are the main characteristics of fishes?
- > What structures do fish use to swim and sense their environment?
- > How do fish obtain oxygen from the environment?
- > How do fish maintain their salt and water balance?
- > How do fish reproduce?

CHARACTERISTICS OF FISHES

- > What are the main characteristics of fishes?
- > Fishes have endoskeletons, gills, closed-loop circulation, and kidneys.
 - Fishes are the most ancient vertebrates.
 - The diversity of fishes found today reflects various adaptations that enable fishes to live in the oceans and freshwater habitats around the world.

MOVEMENT AND RESPONSE

- > What structures do fish use to swim and sense their environment?
- > Fishes have many important structures for swimming and sensing their underwater environment, including endoskeletons, fins, swim bladders, and lateral lines.
 - All fishes have an endoskeleton, or internal skeleton, made of either cartilage or bone.
 - The fins on the backs and bellies of fishes increase stability and help them turn, dive, or climb rapidly.
 - Many fishes have a swim bladder, a gas-filled sac that allows them to regulate their vertical position in the water.
 - Fishes have a variety of sensory organs that allow them to sense light, smells, tastes, sounds, and water vibrations.
 - Fishes have a unique sense organ called a *lateral line*.
 - The lateral line is a system of small canals in the skin that are lined with sensitive cells that detect vibrations in water.

Fishes and Amphibians *continued*

RESPIRATION AND CIRCULATION

- > How do fish obtain oxygen from the environment?
- > Fishes are able to obtain the oxygen they need from water.
 - The major respiratory organ of a fish is the gill.
 - Gills are made up of rows of filaments—fingerlike projections through which gases enter and leave the blood.
 - The filaments hang between a fish’s mouth and cheeks.
 - The opening at the rear of a fish’s cheek is called a *gill slit*.
 - Countercurrent Flow
 - The opening and closing of a fish’s mouth helps pump a large amount of water over the gills and drive countercurrent flow.
 - In countercurrent flow, water passes over the gills in one direction as blood flows in the opposite direction through the gills’ capillaries, allowing oxygen to diffuse into the blood over the entire length of the capillaries.
 - Fish gills can extract up to 85% of the dissolved oxygen in the water passing over them.
 - Single-Loop Blood Circulation
 - Fishes have a simple chamber-pump heart.
 - Blood collects in the heart’s atrium. Then the heart’s ventricle pumps the blood back to the gills, completing a single loop through the fish’s body.
 - All fishes, except lungfishes, have single-loop circulation.

EXCRETION

- > How do fish maintain their salt and water balance?
- > Although the gills play a major role in maintaining a fish’s salt and water balance, another key element is a pair of kidneys.
 - Even fishes must cope with the problem of water loss. Vertebrates will die if they lose too much water.
 - Osmosis causes a net movement of water through membranes, such as gills and skin, toward regions of higher ion concentration.
 - Because the ion (salt) concentration of sea water is 3 times that of most marine fishes’ tissues, marine fishes lose water to their environment through osmosis.
 - Freshwater fishes have the opposite problem. Their bodies contain more salt than the surrounding water, so they tend to take in water by osmosis, diluting their body salts.

Fishes and Amphibians *continued*

- Because of these two opposite challenges, few fishes can move between salt water and fresh water.
- A kidney is an organ that regulates the body's salt and water balance and removes metabolic wastes from the blood.
- Excess water and body wastes leave the kidneys in the form of a fluid called *urine*.
- Marine fishes excrete only a small amount of urine that has a high salt concentration.
- Freshwater fishes excrete large amounts of dilute urine.

REPRODUCTION

- > How do fish reproduce?
- > Most fishes reproduce sexually through external fertilization.
 - In a process called *spawning*, male and female gametes are released near one another in the water.
 - Spawning may occur between two individuals, or in large groups of males and females.
 - In sharks, skates, and rays, eggs are fertilized inside the female's body. During mating, the male uses organs called *claspers* to insert sperm into the female.

Fishes and Amphibians *continued*

Section 2: Groups of Fishes

KEY IDEAS

- > What are the characteristics of jawless fishes?
- > What are the main traits of cartilaginous fishes?
- > Why have bony fishes been so successful compared to the other groups of fishes?

JAWLESS FISHES

- > What are the characteristics of jawless fishes?
- > Jawless fishes have skeletons made of cartilage, a strong fibrous connective tissue. They retain their notochord into adulthood. Jawless fishes are the only modern vertebrates without a backbone.
 - Jawless fishes are primitive animals that have changed little during the past 330 million years.
 - Hagfishes and lampreys are jawless fishes.
 - Hagfishes are scavengers and predators that live at great depths on the ocean floor.
 - Lampreys are parasitic, using a suction-cuplike mouth to attach itself to a host.

CARTILAGINOUS FISHES

- > What are the main traits of cartilaginous fishes?
- > Cartilaginous fishes have paired fins and jaws. They also have skeletons made of cartilage strengthened by calcium carbonate (the material that makes up oyster shells).
 - Sharks, skates, rays, and ratfishes are cartilaginous fishes.
 - A shark's teeth are actually modified scales. They are triangular in shape and are arranged in 6 to 10 rows along the shark's jaw.
 - Most sharks are predators of large marine animals, but the largest sharks, such as whale sharks, consume plankton.
 - Skates and rays have flattened bodies that are adapted to life on the sea floor.
 - Most species of skates and rays have flattened teeth that are used to crush their prey, mainly small fishes and invertebrates.

Fishes and Amphibians *continued*

BONY FISHES

- > Why have bony fishes been so successful compared to the other groups of fishes?
- > Bony fishes have a strong endoskeleton made completely of bone. Bony fishes also have structural adaptations, such as lateral lines, opercula, and swim bladders, that contribute to their success.
 - Bony fishes are perhaps the most successful vertebrates.
 - Bony fishes have a fully developed lateral line system that allows the fish to be aware of its position and rate of movement and to detect objects in its environment.
 - Most bony fishes have a hard plate called an *operculum* that covers the gills on each side of the head.
 - Movements of the opercula and nearby muscles draw water over the gills, allowing the fish to move water over its gills while remaining in one place.
 - Unlike many sharks, a bony fish doesn't have to swim forward with its mouth open to move water over its gills.
 - Bony fishes adjust the gas content of their swim bladder to regulate their buoyancy.
 - A swim bladder allows a fish to maintain or change its depth.
 - Unlike sharks, bony fishes do not have to swim to keep from sinking.
 - Bony fishes also have highly mobile, paired fins that enable them to turn sharply and paddle backward.
 - Most bony fishes have fins that are supported by bony structures called *rays*.
 - Teleosts are the most advanced type of ray-finned fish, with very mobile fins, thin scales, and completely symmetrical tails. About 95% of all living fish species are teleosts.
 - The fins of lobe-finned fishes are very different from the fins of ray-finned fishes. Many lobe-finned fishes have fleshy, muscular fins supported by bones.
 - Only seven species of lobe-finned fishes exist today.

Fishes and Amphibians *continued***Section 3: The Amphibian Body****KEY IDEAS**

- > Which characteristics do most amphibians share?
- > How do amphibians sense their environment?
- > Which amphibian body structures work together to provide oxygen to body tissues?
- > How does an amphibian circulatory system differ from those of most fishes?

CHARACTERISTICS OF AMPHIBIANS

- > Which characteristics do most amphibians share?
- > Most amphibians share five key characteristics: legs, lungs, double-loop circulation, a partially divided heart, and cutaneous respiration.
 - Amphibians were the first vertebrates to live on land.
 - Amphibians include salamanders, newts, frogs, toads, and caecilians.
 - Amphibian eggs do not have a watertight shell that can prevent water loss. Therefore, most amphibians need to reproduce in a wet area.

MOVEMENT AND RESPONSE

- > How do amphibians sense their environment?
- > The senses of sight and hearing are well developed in most amphibians. The primary sense organs of amphibians are the eyes and ears.
 - Skeleton
 - Unlike fishes, terrestrial vertebrates must rely on the support of a strong internal skeleton to move around.
 - Frog skeletons have several specializations for jumping and landing.
 - Sense Organs
 - The eyes of amphibians are covered by a transparent, movable membrane called a *nictitating membrane*.
 - Sounds are transmitted to the inner ear by the tympanic membrane, or eardrum, and a small bone that extends between the tympanic membrane and the inner ear.
 - Vibrations of the tympanic membrane cause small movements that are transmitted to the fluid-filled inner ear where sensitive hair cells change sound vibrations to nerve impulses.

Fishes and Amphibians *continued*

RESPIRATION

- > Which amphibian body structures work together to provide oxygen to body tissues?
- > In amphibians, the skin, lungs, double-loop circulation, and a partially divided heart work together to ensure that sufficient oxygen reaches the body tissues.
 - One of the biggest challenges that amphibians faced when they left the water was gathering oxygen from the air.
 - Although larval amphibians have gills, most adult amphibians breathe with lungs.
 - A lung is an internal, baglike organ that allows oxygen and carbon dioxide to be exchanged between the air and the bloodstream.
 - Air contains about 20 times as much oxygen as sea water does.
 - Many amphibians also obtain oxygen through a process called *cutaneous respiration*.
 - Cutaneous respiration allows gases and water to pass directly through the skin.

CIRCULATION

- > How does an amphibian circulatory system differ from those of most fishes?
- > The structure of the amphibian circulatory system—including a partially divided heart and double-loop circulation— allows oxygen to be delivered to the body more efficiently than in fishes.
 - The two chambers at the top of the amphibian heart are called the *right atrium* and the *left atrium*. They are divided by a wall known as the *septum*.
 - The large chamber at the bottom of the heart is called the *ventricle*. This chamber is not divided.
 - The *conus arteriosus* is a large vessel that sends blood to the lungs and the body.
 - Some amphibians have a spiral valve that divides the conus arteriosus and helps keep the two streams of blood separate as they leave the heart.
 - The second circulatory loop in amphibians allows more oxygen to be delivered to their bodies. In this loop, blood vessels connect an amphibian's heart to its lungs.
 - Pulmonary veins are vessels that carry oxygen-rich blood from the lungs back to the heart.

Fishes and Amphibians *continued***Section 4: Groups of Amphibians****KEY IDEAS**

- > What are the main characteristics of salamanders?
- > What are the key traits of caecilians?
- > What are the kinds of environments in which frogs and toads are adapted to live?

SALAMANDERS

- > What are the main characteristics of salamanders?
- > Salamanders have elongated bodies, long tails, and smooth, moist skin.
 - Most salamanders are unable to stay away from water for long periods because they need to keep their skin moist.
 - Salamanders lay their eggs in water or in moist places. Fertilization is usually external.

CAECILIANS

- > What are the key traits of caecilians?
- > Caecilians are a highly specialized group of burrowing amphibians with small, bony scales embedded in their skin.
 - Most caecilians are blind, wormlike animals found in swamps in tropical regions.
 - During breeding, a male caecilian deposits sperm directly into a female. Some species of caecilians lay eggs while other species have young that are born alive.

FROGS AND TOADS

- > What are the kinds of environments in which frogs and toads are adapted to live?
- > There are about 4,000 species of frogs and toads, also known as *anurans*, which live in environments ranging from deserts to rain forests, valleys to mountains, and ponds to puddles.
 - Adult anurans are carnivores that eat a variety of
 - small prey.
 - The frog body, particularly its skeleton, is adapted for jumping. Frogs have smooth skin.
 - Toads are very similar to frogs but have squat bodies, shorter legs, and skin that is covered with bumps.
 - Frogs depend on water to complete their life cycle. The female frog releases her eggs into the water and a male's sperm fertilizes the eggs externally.

Fishes and Amphibians *continued*

- The fertilized eggs hatch into swimming, fishlike larval forms called *tadpoles*.
- Tadpoles breathe with gills and feed mostly on algae.
- The process of great physical change that a tadpole undergoes as it grows into an adult frog is called *metamorphosis*.