Summary

33–1 Chordate Evolution

Scientists have learned the most about chordates by studying the embryos of living organisms. Scientists have found evidence of early chordates in the fossilized remains of *Pikaia*. *Pikaia* had a notochord and paired muscles.

Chordates include both vertebrates and nonvertebrates. These groups both share a common invertebrate ancestor. Modern amphibians, reptiles, birds, and mammals share more recent common ancestors.

Scientists infer how vertebrates have evolved by studying fossils and the characteristics of living chordates. Scientists believe that the appearance of new adaptations, such as jaws and paired appendages, have led to adaptive radiations. Adaptive radiation results in many new species with different adaptations. Even though these species might look different, they are related.

Another trend in evolution, called convergent evolution, occurs when unrelated species adapt to similar environments. Convergent evolution produces species that look and behave alike even though they are not related.

33–2 Controlling Body Temperature

Controlling body temperature is important for maintaining homeostasis. The chemical reactions that carry out life functions can occur only within a certain temperature range. Vertebrates have different ways to control body temperature. These depend on a source of body heat, a way to conserve heat, and a way to get rid of excess heat.

Ectotherms rely on the temperature of the environment for body heat. Ectotherms have low rates of metabolism. They do not have good insulation and easily lose heat to the environment.

Endotherms generate their own body heat. They have high metabolic rates. They conserve heat within their bodies with outer coverings, such as feathers, fat, and fur or hair. They get rid of excess heat by sweating or panting.

Endotherms can survive in cool temperatures. However, they require a lot of food. Ectotherms need much less food. However, they cannot survive in very cold environments.

The first land vertebrates were most likely ectotherms. Scientists do not know exactly when endothermy evolved. Some scientists think that dinosaurs were endotherms, others do not. Evidence suggests that endothermy might have evolved more than once.

33–3 Form and Function in Chordates

Organ systems of different vertebrates are specialized to perform specific functions. The complexity of these systems increases from fishes to mammals.

The skulls and teeth of vertebrates are adapted for feeding on a wide variety of foods. For example, the hummingbird's long bill and the narrow snout of the honey possum are adaptations for feeding on nectar. Invertebrates' digestive systems are also adapted for different feeding habits. Carnivores have shorter digestive tracts than herbivores. Herbivores often house bacteria to help break down plant fibers.

Chordates have two basic structures for respiration. Animals that live in water use gills for respiration. Animals that live on land use lungs. As you move from amphibians to mammals, the surface area of the lungs increases. Birds have the most efficient gas exchange. The combination of air sacs and tubes ensures that oxygen-rich air is always in the lungs.

Vertebrates with gills have a single-loop circulatory system. Blood travels from the heart to the gills, then to the rest of the body, and back to the heart. Vertebrates with lungs have a double-loop circulatory system. The first loop carries blood between the heart and the lungs. The second loop carries blood between the heart and the body.

As chordates evolved, the heart developed chambers to separate oxygen-rich blood from oxygen-poor blood. Fish have two chambers: an atrium to receive blood from the body and a ventricle to pump blood. Amphibians have three chambers: two atria and one ventricle. Most reptiles also have a three-chambered heart, but the ventricle has a partial partition. Birds, mammals, and crocodiles have a four-chambered heart. Oxygen-rich blood is completely separated from oxygen-poor blood.

The excretory system removes nitrogenous wastes from the body. It also controls the amount of water in the body. In nonvertebrate chordates and fishes, wastes leave the body through gills and gill slits. These wastes are in the form of ammonia. In most other vertebrates, the kidneys filter out wastes. Vertebrates that live on land excrete wastes in less toxic forms such as urea or uric acid. This enables land vertebrates to conserve water.

Nonvertebrate chordates have a relatively simple nervous system. They do not have specialized sense organs. Vertebrates have a much more complex brain. Each region of the brain is distinct and has a different function. The sense organs and nerve cells in vertebrates are concentrated at the front of the body. From fishes to mammals, the size and complexity of the cerebrum and cerebellum increase.

Vertebrates are much more mobile than nonvertebrate chordates. All vertebrates, except jawless fishes, have an internal skeleton of bone, or in some fishes, cartilage. The bones are held together with tough, flexible tissues that allow movement and keep the bones in place. Body muscles and limb placement help vertebrates move. Amphibians have limbs that stick out sideways. Reptiles, birds, and mammals have limbs directly under the body. This supports more body weight.

Almost all chordates reproduce sexually. Fishes and amphibians have external fertilization. The eggs of reptiles, birds, and mammals are fertilized internally.

Chordates may be oviparous, ovoviviparous, or viviparous. In oviparous species, the eggs develop outside the mother's body. Most fishes, amphibians, reptiles, and all birds are oviparous. In ovoviviparous species like sharks, the eggs develop inside the mother's body. The embryo gets nutrients from the egg yolk. The young are born alive. In viviparous species like most mammals, the embryos get nutrients directly from the mother.