What You’ll Learn

■ You will compare and contrast various reptiles and birds.
■ You will identify reptile and bird adaptations that make these groups successful.

Why It’s Important

Studying reptiles, the first animals to become independent of water, can help you understand the adaptations required for life on land. Birds are unique in that they have feathers and wings—adaptations that contribute to birds living in a wide variety of habitats throughout the world.

Understanding the Photo

Birds of prey, such as this barn owl, use their keen eyesight to find their prey. Barn owls are nocturnal hunters of rodents. They are uncommon, but are easily identified because of the heart-shaped appearance of the face, small dark eyes, and long legs.

Biology Online

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- study the entire chapter online
- access Web Links for more information and activities on reptiles and birds
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SECTION PREVIEW

Objectives
Explain how reptile adaptations make them suited to life on land.
Compare the characteristics of different groups of reptiles.

Review Vocabulary
embryo: the earliest stage of growth and development of both plants and animals (p. 402)

New Vocabulary
amniotic egg
Jacobson’s organ

What is a reptile?

At first glance, it may be difficult to determine how a legless snake is related to a tortoise. Snakes, turtles, alligators, and lizards are an extremely diverse group of animals, yet all share certain traits that place them in the class Reptilia.

Early reptiles, called the stem reptiles, as shown in Figure 31.1, were the first animals to become adapted to life on land. All reptiles have adaptations that enable them to complete their life cycles entirely on land. These adaptations released the stem reptiles and other reptiles from the need to return to swamps, lakes, rivers, ponds, or oceans for reproduction.

Figure 31.1
This is an example of an early reptile, called a stem reptile, that was probably an ancestor of the long-extinct dinosaurs as well as of today’s living reptiles, birds, and mammals.
Reptiles have scaly skin

Unlike the moist, thin skin of amphibians, reptiles have a dry, thick skin covered with scales. Scaly skin, as shown in Figure 31.2, prevents the loss of body moisture and provides additional protection from predators. Because gas exchange cannot occur through scaly skin, reptiles are dependent on lungs as their primary organ of gas exchange.

Reptiles reproduce on land

Most reptiles reproduce by laying eggs on land, as shown in Figure 31.3. Some snakes give live birth to well-developed young. Unlike amphibians, reptiles have no aquatic larval stage, so reptile young are not as vulnerable to water-dwelling predators.

Although all of these adaptations enabled reptiles to live successfully on land, the evolution of the amniotic (am nee AH tihk) egg was the adaptation that liberated reptiles from a dependence on water for reproduction. An amniotic egg provides nourishment to the embryo and contains membranes that protect it while it develops in a terrestrial environment. The egg functions as the embryo’s total life-support system.

Skeletal changes in reptiles

Look again at Figure 31.1. This early reptile had legs that were placed more directly under the body rather than at right angles to the body as in early amphibians. This positioning of the legs provides greater body support and makes walking and running on land easier for most reptiles. They have a better chance of catching prey or avoiding other predators. Reptiles that have legs also have claws that help them obtain food and protect themselves. Additional evolutionary changes in the structure of the jaws and teeth of early reptiles allowed them to use other resources and niches on land.

Some reptiles have four-chambered hearts

Most reptiles, like amphibians, have three-chambered hearts. Some reptiles, notably the crocodilians, have a four-chambered heart that completely separates the supply of blood with oxygen from blood without oxygen. The separation enables more oxygen to reach body tissues. This separation is an adaptation that supports the higher level of energy use required by land animals.

Figure 31.2
Scales on a reptile’s skin overlap like tiles on a roof.

The scales of reptiles, unlike the separate glossy scales of fishes, are made of protein and are part of the skin itself. The scales are all connected to one another by hinges of skin.

This snake is shedding. Old scaly skin is discarded after new skin grows beneath it.

Explain How are overlapping scales an adaptation to life on land?
An Amniotic Egg

Figure 31.3
The evolution of the amniotic egg was a major step in reptilian adaptations to land environments. Amniotic eggs enclose the embryo in amniotic fluid, provide a source of food in the yolk, and surround both embryo and food with membranes and a tough, leathery shell. These structures in the egg help prevent injury and dehydration of the embryo as it develops on land. Critical Thinking **How is the leathery covering of a reptile egg more suited to being laid deep in the sand than a hard-shelled bird egg would be?**

**A** Amnion The amnion (am nee ahn) is a membrane filled with fluid that surrounds the developing embryo. The fluid-filled amnion cushions the embryo and prevents dehydration.

**B** Shell The reptile egg is encased in a leathery shell. Most reptiles lay their eggs in protected places beneath sand, earth, gravel, or bark.

**C** Yolk The main food supply for the embryo is the yolk, which is enclosed in a sac that is also attached to the embryo. The clear part of the egg is albumen (al BYE Wmun), a source of additional food and water for the developing embryo.

**D** Allantois The embryo's nitrogenous wastes are excreted into the allantois (uh LAN tuh wus), a membranous sac that is associated with the embryo's gut. When a reptile hatches, it leaves behind the allantois with its collected wastes.

**E** Chorion The chorion (kor ee ahn) is a membrane that forms around the yolk, allantois, amnion, and embryo. It and the allantois allow gas exchange for respiration.

**F** Egg tooth A reptile hatches by breaking its shell with the horny tooth on its snout. This egg tooth drops off shortly after hatching.
All reptiles have internal fertilization. In most cases, the eggs are laid after fertilization and embryos develop after eggs are laid. Most reptiles lay their eggs under rocks, bark, grasses, or other surface materials, but a few dig holes or collect materials for a nest. Most reptiles provide no care for hatchlings, but female crocodiles have been observed guarding their nests from predators.

Reptiles are ectotherms

Even though reptiles are different from amphibians in many ways, they are similar in one way. Both amphibians and reptiles are ectotherms. They depend on an external heat source and behavior to maintain their body temperature within the range needed to perform life functions, such as digestion. In the cool morning, a turtle might pull itself out of the pond or swamp and bask on a log in the sunlight until noon. Then, when the temperature gets a little too warm, the turtle may slip back into the cool water. Figure 31.4 shows other examples of behavioral adjustment of body temperature in reptiles.

Because reptiles are dependent on heat from the environment, they do not inhabit extremely cold regions. Reptiles are common in temperate and tropical regions, where climates are warm, and in hot desert climates. Many species of reptiles become dormant during cold periods in moderately cold environments such as in the northern United States.

How reptiles obtain food

Like other animals, reptiles have adaptations that enable them to find food and to sense the world around them. Most turtles and tortoises are too slow to be effective predators, but that doesn’t mean they go hungry. Most are herbivores, and those that are predators prey on worms and mollusks. Snapping turtles, however, are extremely aggressive, attacking fishes and amphibians, and even pulling ducklings under water.

Lizards primarily eat insects. The marine iguana of the Galápagos Islands is one of the few herbivorous lizards, feeding on marine algae. The Komodo dragon, the largest lizard, is found on several islands in Indonesia, north of Australia. It is an efficient predator, sometimes even of humans. Although lizards such as the Komodo dragon may look slow, they are capable of bursts of speed, which they use to catch their prey.
Snakes are also effective predators. Some, like the rattlesnake, have poison fangs that they use to subdue or kill their prey. A constrictor wraps its body around its prey, tightening its grip each time the prey animal exhales. Two predatory reptiles are shown in Figure 31.5.

How reptiles use their sense organs

Reptiles have a variety of sense organs that help them detect danger or potential prey. How does a rattlesnake know that you are nearby? The heads of some snakes, as shown in Figure 31.6A, have heat-sensitive organs or pits that enable them to detect tiny variations in air temperature brought about by the presence of warm-blooded animals.

Snakes and lizards are equipped with a keen sense of smell. Have you ever seen a snake flick out its tongue? The tongue is picking up molecules in the air. The snake draws its tongue back into its mouth and moves it past or inserts it into a pitlike structure called Jacobson's organ, described in Figure 31.6B.

The Komodo dragon is a predator that can kill animals as large as a deer or even a water buffalo. Adult Komodo dragons can reach a length of more than 3 m. The snapping turtle is common in North America. It has strong claws and a hooked beak that is sharp enough to bite through a person's fingers.

Figure 31.5
Many reptiles are skillful predators that obtain prey in a variety of ways.

Figure 31.6
Snakes have sense organs that enable them to detect prey or identify substances in their environment.

A A pair of heat-sensitive pits below their eyes enable rattlesnakes to detect prey in total darkness.

B The long, flexible tongues of snakes and lizards pick up molecules in the air and transfer them to the Jacobson's organ in the roof of the animal's mouth where special cells identify them.
Diversity of Reptiles

Gracefully gliding snakes and quickly darting lizards are grouped together in the order Squamata. Turtles, slowly plodding and carrying heavy shells, belong to the order Chelonia. Basking crocodiles and alligators, classified in the order Crocodylia, may look clumsy but are surprisingly quick hunters. Tuataras are lizardlike reptiles. They make up the fourth order of reptiles, Rhynchocephalia.

Turtles have shells

Turtles are the only reptiles protected by a shell made up of two parts. The dorsal part of the shell is the carapace, and the ventral part of the shell is the plastron. The vertebrae and expanded ribs of turtles are fused to the inside of the carapace. Most turtles have a two-layer shell—a hard, bony inner layer and an outer layer of horny keratin. In a few species, the shell is a covering made of tough, leathery skin. Most turtles can draw their limbs, tail, and head into their shells for protection against predators. Although turtles have no teeth, they do have powerful jaws with a beaklike structure that is used to crush food.

Some turtles are aquatic, and some live on land. Turtles that live on land are called tortoises. Tortoises forage for fruit, berries, and insects. The largest tortoises in the world, shown in Figure 31.7, are found on the Galápagos Islands off the coast of Ecuador.

Some adult marine turtles swim enormously long distances to lay their eggs. Like salmon, these turtles return from their feeding grounds to the place where they hatched. For example, green turtles travel from the coast of Brazil to Ascension Island in the Atlantic Ocean, a distance of more than 4000 km.

Crocodiles include the largest living reptiles

In contrast to marine turtles, crocodiles don’t migrate to reproduce. They may spend their days alternately basking in the sun on a riverbank and floating like motionless logs. Only their eyes and nostrils remain above water. Crocodiles can be identified by their long, slender snouts, whereas alligators have short, broad snouts. Both animals have powerful jaws with sharp teeth that...
can drag prey underwater and hold it there until it drowns. Another feature that makes these animals efficient predators is that, unlike other reptiles, they can continue to breathe air with their mouths full of food and water. The American alligator is found throughout many of the freshwater habitats of the southeastern United States. The American crocodile can be found only in salt water and estuarine habitats in southern Florida. The American alligator can reach a length of 5 m. Other crocodilians, such as the Nile crocodile of Africa, can grow even longer.

Both alligators and crocodiles lay eggs in nests on the ground. Unlike other reptiles, these animals stay close to their nests and guard them from predators. Several crocodilian species have been observed holding their newly hatched offspring gently in their mouths as they carried them to the safety of the water.

**Reading Check** Explain how crocodiles and alligators reproduce.

**Snakes and lizards have diverse forms**

Lizards, like the ones shown in Figure 31.8, are found in many types of habitats throughout the world. Some live on the ground; some burrow; some live in trees; and some are aquatic. Many are adapted to hot, dry climates. Although a few species of lizards are limbless, most lizards have four legs.

Snakes, in contrast to most vertebrates, have no limbs and lack the bones to support limbs. Exceptions are pythons and boas, which retain bones of the pelvis. The many vertebrae of snakes permit fast undulations through grass and over rough terrain. Some snakes even swim and climb trees.

Snakes usually kill their prey in one of three ways. Remember that constrictors wrap themselves around their prey. Common constrictors include boas, pythons, and anacondas.

Venomous snakes use poison to paralyze or kill their prey. These include rattlesnakes, cobras, and vipers, which inject poison from venom glands.
Most snakes are neither constrictors nor poisonous. They get food by grabbing it with their mouths and swallowing it whole. Snakes eat rodents, amphibians, insects, fishes, eggs, and other reptiles, as shown in Figure 31.9.

The fourth order of reptiles, Rhynchocephalia, is represented by two living species of tuatara, one of which is shown in Figure 31.10. Tuataras are the only survivors of a primitive group of reptiles, most of which died out 100 million years ago.

Figure 31.9
Many poisonous snakes have hollow fangs for injecting venom. Venom can either paralyze or kill prey immediately.

Figure 31.10
Tuataras are found only in New Zealand. They have ancestral features, including teeth fused to the edge of the jaws, and a skull structure similar to that of early Permian reptiles.

Origins of Reptiles
You may have marveled at dinosaurs ever since you were very young. These animals were the most numerous land vertebrates during the Mesozoic Era. Some were the size of chickens, and others were the largest land dwellers that ever lived. Learn more about dinosaurs on pages 1084–1085 in the Focus On.

The ancestors of snakes and lizards are traced to a group of early reptiles, called scaly reptiles, that branched off from the ancient stem reptiles. The name “scaly reptiles” may be misleading because it implies that other reptiles lacked scales—which is not true. Although the evolutionary history of turtles is incomplete, scientists have suggested that they may also be descendants of stem reptiles. Dinosaurs and crocodiles are the third group to descend from stem reptiles, as you can see in Figure 31.11.

Although scientists used to think that birds arose as a separate group from this third branch, there is now much fossil evidence that leads biologists to suggest that birds are the living descendants of the dinosaurs.
Figure 31.11
The radiation of orders of reptiles shows their relationships.

Species numbers are approximate and subject to change pending discoveries or extinctions.

Understanding Main Ideas
1. Explain how the adaptations of early reptiles enabled these animals to live on land.
2. Describe two ways in which turtles protect themselves.
3. Describe how snakes use the Jacobson’s organ for finding food.
4. Analyze the relationship between modern reptiles and dinosaurs.

Thinking Critically
5. Analyze how having a four-chambered heart benefits crocodiles and alligators on a daily basis.

6. Classify Set up a classification key that allows you to identify a reptile as a snake, lizard, turtle, or crocodile. For more help, refer to Classify in the Skill Handbook.

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**Fascinating Feathers**

**Using Prior Knowledge**

Scientists use both physiological and structural characteristics to divide organisms into different groups. You already know how fishes, amphibians, and reptiles differ from each other. Just by looking at a bird, you can see that there are obvious differences between birds and reptiles.

**Infer** What characteristics do birds have that make them different from reptiles?

### What is a bird?

After conquering the sea and land, vertebrates took to the air, where there was a huge source of insect food and a refuge from land-dwelling predators. The existence of more than 8600 species of modern birds, class Aves, shows that flight was a successful adaptation for survival. Birds inhabit a variety of environments around the world, including Antarctica, deserts, and tropical rain forests.

Biologists sometimes refer to birds as feathered dinosaurs. Fossil evidence seems to indicate that birds have evolved from small, two-legged dinosaurs called theropods, illustrated in Figure 31.12. Like reptiles, birds have clawed toes and protein scales on their feet. Fertilization is internal and shelled amniotic eggs are produced in both groups. Although some birds are flightless, all birds have feathers and wings.

**Birds have feathers**

A feather, shown in Figure 31.13, is a lightweight, modified protein scale that provides insulation and enables flight. You may have seen a bird running its bill or beak through...
its feathers while sitting on a tree branch or on the shore of a pond. This process, called preening, keeps the feathers in good condition for flight. During preening, a bird also uses its bill or beak to rub oil from a gland near the tail onto the feathers. This conditions feathers and helps them last longer. You can compare types of bird feathers in the MiniLab on this page.

Even with good care, feathers wear out and must be replaced. The shedding of old feathers and the growth of new ones is called molting. Most birds molt in late summer. However, most do not lose their feathers all at once and are able to fly while they are molting. Wing and tail feathers are usually lost in pairs so that the bird can maintain its balance in flight.

**Birds have wings**

A second adaptation for flight in birds is the modification of the front limbs into wings. Powerful flight muscles are attached to a large breastbone called the sternum and to the upper bone of each wing. The sternum looks like the keel of a sailing boat and is important because it supports the enormous thrust and power produced by the muscles as they move to generate the lift needed for flight.

**Flight requires energy**

Flight requires high levels of energy. Several factors are involved in maintaining these high energy levels. First, a bird’s four-chambered, rapidly beating heart moves oxygenated blood quickly throughout the body. While sleeping, a chickadee’s heart, for example, beats 500 times a minute. Compare this to an average human heart, which beats 70 times a minute. This efficient circulation supplies cells with the oxygen needed to produce energy.

**MiniLab 31.1**

**Compare and Contrast**

**Comparing Feathers** Birds have different kinds of feathers. Contour feathers used for flight are found on a bird’s body, wings, and tail. Down feathers lie under the contour feathers and insulate the body.

**Procedure**

1. Examine a contour feather with a hand lens, and make a sketch of how the feather filaments are hooked together.
2. Examine a down feather with a hand lens. Draw a diagram of the filaments of the down feather.
3. Fan your face with each feather separately. Note how much air is moved past your face by each type of feather.

**CAUTION:** Wash your hands with soap and water after handling animal material.

**Analysis**

1. **Explain** How does the structure of a contour feather help a bird fly?
2. **Explain** How does the structure of a down feather keep a bird warm?
3. **Infer** What accounts for the differences you felt when fanning with each feather?

**Figure 31.13**

A feather’s structure relates to its function.

A. Fluffy down feathers have no hooks to hold the filaments together. Down feathers act as insulators to keep a bird warm.

B. A large bird can have 25,000 or more contour feathers with a million tiny hooks that interlock and make the feathers hold together, making the bird’s body streamlined for flight.
Second, a bird’s respiratory system supplies oxygenated air to the lungs when it inhales as well as when it exhales. A bird’s respiratory system consists of lungs and anterior and posterior air sacs. You can see the path air follows in a bird’s respiratory system in Figure 31.14. During inhalation, oxygenated air passes through the trachea and into the lungs, where gas exchange occurs. Most of the air, however, passes directly into the posterior air sacs. When a bird exhales deoxygenated air from the lungs, oxygenated air returns to the lungs from the posterior air sacs. At the next inhalation, deoxygenated air in the lungs passes into the anterior air sacs. Finally, at the next exhalation, air passes from the anterior air sacs out of the trachea. Thus, air follows a one-way path in a bird. Find out more about bird flight in Figure 31.15.

Birds are endotherms

Birds are able to maintain the high energy levels needed for flight because they are endotherms. An endotherm is an animal that maintains a nearly constant body temperature that is not dependent on the environmental temperature.

Birds have a variety of ways to save or give off their body heat in order to maintain a nearly constant body temperature. Feathers reduce heat loss in cold temperatures. The feathers fluff up and trap a layer of air that limits the amount of heat lost. Responses to high temperatures include flattening the feathers and holding the wings away from the body. Birds also pant to increase respiratory heat loss.

A major advantage of being endothermic is that birds can live in all environments, from the hot tropics to the frigid Antarctic. However, birds and other endotherms must eat large amounts of food to sustain these higher levels of energy. Find out what kinds of food birds in your area prefer by doing the MiniLab on page 830.

Reproduction in birds

Birds, like reptiles, reproduce by internal fertilization and lay amniotic eggs usually inside a nest. Bird eggs are encased in a hard shell, unlike the leathery shell of a reptile. Bird nests may be made out of bits of straw and twigs, may consist of a depression scratched into the sand, or may be elaborate structures that are added to yearly. Whatever the type of nest, birds do not leave the eggs to hatch on their own. Instead, birds incubate or sit on their eggs to keep them warm. The eggs are turned periodically so that they develop properly.
Flight

Figure 31.15
Humans have always dreamed of being able to fly. The popularity of hang gliding and parachute jumping may reflect these dreams. For birds, the ability to fly is the result of complex selective pressures that led to the evolution of many adaptations. Critical Thinking: Although flying is the main form of locomotion for most birds, not all birds fly all the time. Some birds do not fly at all. What other forms of locomotion do birds use? Give specific examples.

A. Wings
Birds have a variety of wing shapes and sizes. Some birds have longer, narrower wings adapted for soaring on updrafts, whereas others have shorter, broader wings adapted for quick, short flights among forest trees.

B. Hollow bones
The hollow bones of birds are strengthened by bony crosspieces. The sternum is the large breastbone to which powerful flight muscles are attached.

C. Beaks
Birds have beaks, sometimes called bills, covered by a protein called keratin, but they do not have teeth.

D. Legs
The legs of birds are made up of mostly skin, bone, and tendons. The feet are adapted to swimming, perching, walking, or catching prey.

E. Digestion
The digestive system of a bird is adapted for dealing with large quantities of food that must be eaten to maintain the level of energy necessary for flight. Because birds have no teeth, many swallow small stones that help to grind up food in the gizzard.

F. Air sacs
About 75 percent of the air inhaled by a bird passes directly into the air sacs rather than into the lungs. When a bird exhales, oxygenated air in the air sacs passes into the lungs. Birds receive oxygenated air when they breathe in and when they breathe out.
In some species of birds, both parents take turns incubating eggs; in others, only one parent does so. Bird eggs are distinctive, and often the species of bird can be identified just by the color, size, and shape of an egg. You can find out more about the adaptive value of bird egg shape in the BioLab at the end of this chapter.

Diversity of Birds

Unlike reptiles, which take on a wide variety of forms from legless snakes to shelled turtles, birds are all very much alike in their basic form and structure. You have no difficulty recognizing a bird.

In spite of the basic uniformity of birds, they do exhibit specific adaptations, depending on the environment in which they live and the food they eat. As shown in Figure 31.16, ptarmigans have feathered legs and feet that serve as snowshoes in the winter, making it easier for the birds to walk in the snow. Penguins are flightless birds with wings and feet modified for swimming and a body surrounded with a thick layer of insulating fat. Large eyes, an acute sense of

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**MiniLab 31.2**

**Compare and Contrast**

**Feeding the Birds** In the winter, it may be difficult for some birds to find food, especially if they live in an environment often blanketed with snow. Making a bird feeder and watching birds feed can be an enjoyable activity for you that may save some birds from starvation. If you do begin feeding birds in the winter, continue to feed them until natural food becomes available in the spring.

**Procedure**

1. Obtain several large, plastic milk bottles. Cut holes, about 10 cm in diameter, 5 cm from the base on opposite sides of each bottle.
2. Place small drainage holes in the bottom of each bottle. Hang the bottles from wires strung through small holes in the neck of each one.
3. Place a different kind of seed (sunflower seeds, hulled oats, cracked corn, wheat, thistle, millet) in different bottles. Add new seed when needed. **CAUTION:** Always wash your hands with soap and water immediately after refilling the feeders.
4. Use a bird guide to make a list of numbers and kinds of birds that frequent each feeder. Note the type of food offered.

**Analysis**

1. **Observe** What type of seed attracted the largest variety of bird types?
2. **Observe** Did any birds visit more than one feeder?
3. **Infer** What do you think an ideal bird food would be?

**Figure 31.16**

Examine these birds and infer where they live and how they are adapted to their environments.

Ptarmigan

Screech owls

Adélie penguins
The shape of a bird’s beak or bill gives clues to the kind of food the bird eats. Hummingbirds, for example, have long beaks that are used for obtaining nectar from flowers. Hawks, like the one shown in Figure 31.17, have curved beaks that are adapted for tearing apart their prey. Pelicans have huge bills with pouches that they use as nets for capturing fish. The short, stout beak of a cardinal is adapted to cracking seeds.

Many bird species are now threatened with extinction due to changes in their habitats. Read the Problem-Solving Lab to learn where birds are endangered. Then read the Biology and Society at the end of this chapter to learn how illegal trade in wildlife threatens birds and other animals.

**Analyze Information**

Where are the most endangered bird species? More than 100 bird species have become extinct in the last 400 years.

**Solve the Problem**

Examine the world map. The key at the bottom right shows the number of bird species that are currently threatened with extinction. The numbers appearing on the map indicate the actual number of threatened bird species in specific countries.

**Thinking Critically**

1. **Use Numbers** If 50 species are threatened, what is the approximate number of bird species in the United States? (Hint: 2.5 percent of the bird species in the U.S. are threatened.)

2. **Estimate** It is estimated that about 11 percent or 1107 of the world’s bird species are threatened. About how many bird species are there in the world?

3. **Observe** Hawaii, the Philippines, New Zealand, and Madagascar all show the highest percent of threatened species. What common geographical feature do these areas share?

4. **Infer** Use the map to support the fact that many areas have a lower number of threatened species and offer an explanation as to why this is so.
Origins of Birds

Current thoughts about bird evolution are illustrated in Figure 31.18. Scientists hypothesize that today's birds are derived from an evolutionary line of dinosaurs that did not become extinct. Figure 31.19 shows the earliest known bird in the fossil record, Archaeopteryx. At first, scientists thought that Archaeopteryx was a direct ancestor of modern birds; however, some paleontologists now
1. What features of birds enable them to live on land?

2. Describe how a bird’s respiratory system works, and explain how air sacs improve a bird’s ability to obtain the energy necessary for flight.

3. What is an endotherm? How does being an endotherm have adaptive value for birds that live in polar regions?

4. Analyze the relationship between modern birds and dinosaurs.

5. Large, flightless birds once were common in areas that did not have large, carnivorous predators. Many of these birds are now extinct. Form a hypothesis about the evolution and extinction of large, flightless birds.

6. Get the Big Picture Make a table that summarizes the adaptations birds have that enable them to fly. For more help, refer to Get the Big Picture in the Skill Handbook.
Not all bird eggs have the same shape. An ostrich egg is almost totally round. Chicken eggs are almost a perfect oval on one end. Cliff-dwelling birds, such as the common guillemot (Uria aalge), have eggs that come almost to a point on one end. Why the variety of shapes? Is there any adaptive benefit to this variety of shapes? Could egg shape be related to where the bird nests?

**Problem**
What shape would be best for an egg to reduce the distance it could roll if pushed from a nest on the ground or a cliff?

**Hypotheses**
There are several hypotheses that you can test. Your hypothesis might be that egg shape influences the distance an egg rolls, or that shape determines the tightness of circular rolling patterns.

**Objectives**
In this BioLab, you will:
- **Design** an experiment to test your hypotheses.
- **Model** different egg shapes and egg masses.
- **Experiment** to test your hypothesis.
- **Draw conclusions** based on your experimental data.

**Possible Materials**
- clay
- table-tennis ball
- ruler
- golf ball
- string
- balance
- hard-cooked egg
- protractor

**Safety Precautions**
CAUTION: Always wear goggles in the lab. Never eat anything used in the lab.

**Skill Handbook**
If you need help with this lab, refer to the Skill Handbook.

**Plan the Experiment**

1. Form a hypothesis and decide on a way to test your group’s hypothesis. Keep the list of available materials in mind as you plan your procedure.
2. Consider the following questions as you design your experiment: How will you incorporate a control? How many egg shapes will you test? How will you model your egg shapes? How many trials will you perform? How might you keep egg models identical in mass? Where will you start to measure distance rolled?

**Check the Plan**
Discuss the following points with other group members to decide the final procedure for each of your experiments.

1. **What is your independent and dependent variable?**
2. **How will you eliminate all other variables?**
3. **What data will you collect? How many trials will you run?**
4. **Will you need a data table and how might it be organized?**
5. **Make sure your teacher has approved your experimental plan before you proceed further.**
6. **Record your hypothesis and carry out your experiments.**
7. **Cleanup and Disposal** As you clean up after the lab, make wise choices about the disposal and recycling of lab materials.

**ANALYZE AND CONCLUDE**

1. **Interpret Data** Describe your results after testing your hypothesis.
2. **Conclude** Do your data support your hypothesis? Explain using both quantitative and qualitative observations.
3. **Identify Variables** What were your independent and dependent variables?
4. **Conclude** In general, how does mass influence the distance an egg will roll? How does egg shape influence the distance an egg will roll or the pattern taken when it rolls?
5. **Predict** Predict why egg shape or mass may be helpful adaptations when considering the variety of bird habitats.
6. **Error Analysis** Compare your data to that of other student groups. What revisions could be made to your hypothesis or experiment based on these comparisons?

**Apply Your Skill**

- **Knowledge** Find out the chemical and physical nature of bird shells. Find out how and where birds produce a shell.
- **Web Links** To find out more about birds and bird eggs, visit [ca.bdol.glencoe.com/birds](ca.bdol.glencoe.com/birds)
Illegal Wildlife Trade

In May 1998, the U.S. Fish and Wildlife Service with the assistance of several foreign law enforcement agencies, broke up an international smuggling ring. Their three-year investigation—code-named Operation Jungle Trade—ended in the arrest of smugglers operating in a dozen countries. In what illegal products were these criminals trafficking? Not diamonds or drugs, but in animals and rare birds.

Species for sale Some people pay large sums of money for parrots, tropical fishes, monkeys, snakes and lizards to add to their animal collections or to keep as exotic pets whether it is legal or not. Worldwide, millions of illegal wildlife products—from jewelry made from sea turtle shells to snow leopard coats and lizard skin belts—are bought and sold annually on the wildlife black market.

Unintended backing People can unknowingly support the illegal wildlife trade when they buy seashells, coral jewelry, or ivory trinkets that are sold as souvenirs in many countries. Also, buying fashion accessories made from animal skins can help finance illegal wildlife trade.

Many traditional remedies manufactured in certain countries are made with body parts from threatened species. Some users of traditional remedies believe strongly in the power of certain parts of animals or plants to enhance their physical attractiveness or treat health-related conditions. The fact that these parts come from endangered species and are traded on the black market may be unknown to the user.

Government action An international trade agreement called CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) was enacted in July 1975. Its purpose is to ensure that the buying and selling of wild animals and plants do not endanger their survival. CITES regulates the international trade of about 5,000 animal species and 25,000 plant species living or dead, and any part of or products made from them. Currently, 160 governments are members of CITES. Despite this global agreement, the illegal wildlife trade is a multibillion-dollar-a-year business.

Perspectives The illegal wildlife trade is contributing to the near extinction of many species, and with every new extinction, Earth’s biodiversity is decreased. Once a species is gone, illegal wildlife traders turn to a different species to fulfill the demands of the market. Education, stricter laws regulating all trade not just international trade, and better enforcement of current laws are needed in order to curtail the booming illegal wildlife trade.

Confiscated products from endangered species and a jaguar skin (inset)

Analyse the issue Research one example of an endangered species that is traded illegally. How has this practice altered the equilibrium of the ecosystem in that area? What, if anything, is being done to further prevent illegal trading of the organism? Present your findings to your class as a multimedia presentation.

To find out more about the illegal wildlife trade, visit ca.bdol.glencoe.com/biology_society
Section 31.1

Reptiles

Key Concepts

- Reptiles are ectotherms that have dry, scaly skins; legs under the body; internal fertilization; and amniotic eggs. Most reptiles have three-chambered hearts. Some reptiles have four-chambered hearts.

- Present-day reptiles belong to one of four groups. Turtles have shells and no teeth. Crocodiles and alligators have streamlined bodies and powerful, toothed jaws. Lizards have a variety of adaptations, including long bodies, tails, and short limbs. Snakes have no limbs. Tautaras are lizardlike reptiles with some primitive characteristics.

- The ancestors of present-day reptiles arose from ancient stem reptiles, which were also the ancestors of the dinosaurs.

Section 31.2

Birds

Key Concepts

- Birds have adaptations for flight including feathers; a keel-shaped sternum; a four-chambered heart; endothermy; reinforced, hollow bones; a beak; and air sacs.

- Birds may be derived from a line of dinosaurs that did not become extinct.

- Female birds lay hard-shelled, amniotic eggs usually in a nest. Each bird species has unique eggs.

- Adaptations, such as beak shape and modified feet and wings, ensure the survival of birds in their specific habitats.

Characteristics of Class Reptilia and Class Aves

<table>
<thead>
<tr>
<th>Class</th>
<th>Organisms</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reptilia</td>
<td>Snakes, lizards, crocodiles, alligators, tautaras</td>
<td>Dry, scaly skin; ectothermic; four limbs (some limbless); three- or four-chambered heart; internal fertilization; leathery-shelled, amniotic egg</td>
</tr>
<tr>
<td>Aves</td>
<td>Cardinals, penguins, ostriches, owls</td>
<td>Feathers; wings; sternum; flight (most); endothermic; four-chambered heart; internal fertilization; hard-shelled, amniotic egg</td>
</tr>
</tbody>
</table>

To help you review reptiles, use the Organizational Study Fold on page 817.
Vocabulary Review

Review the Chapter 31 vocabulary words listed in the Study Guide on page 837. Determine if each statement is true or false. If false, replace the underlined word with the correct vocabulary word.

1. Jacobson’s organ is a sense organ in snakes that picks up and analyzes airborne chemicals.
2. A feather is a large breastbone that provides a site for muscle attachment.
3. A sternum is a lightweight, modified scale that provides insulation and enables flight.
4. An endotherm provides nourishment to the embryo and contains membranes that protect it while it develops in a terrestrial environment.

5. What function does the amnion perform in an amniotic egg?
   A. collects the nitrogenous wastes of the embryo
   B. supplies food to the embryo
   C. cushions the embryo and prevents dehydration
   D. allows gas exchange during respiration

6. Which of the following is NOT an example of a reptile?
   A. turtle       C. penguin
   B. snake        D. tuatara

7. Three features that modern-day birds share are ________.
   A. endothermy; a three-chambered heart; dry, scaly skin
   B. endothermy, feathers, a three-chambered heart
   C. internal fertilization, amniotic eggs, feathers
   D. ectothermy, internal fertilization, hard-shelled eggs

8. Three features that modern-day reptiles share are ________.
   A. endothermy; a four-chambered heart; and dry, scaly skin
   B. endothermy, feathers, a three-chambered heart
   C. internal fertilization, an amniotic egg, leathery-shelled eggs
   D. ectothermy, internal fertilization, hard-shelled eggs that hatch inside the female

9. Concept Map Complete the concept map by using the following vocabulary terms: sternum, feathers, endotherms.

   Birds can live in any environment because they are
   and they have adaptations for flight
   such as a keeled two types of
   1. 2. 3.

10. Open Ended Nest temperature determines the gender of a reptile embryo. In alligators and crocodiles, low nest temperatures produce all female offspring. High nest temperatures produce all male offspring. Explain how this phenomenon could affect future populations of species in a particular area.

11. Open Ended Explain how a bird’s circulatory and respiratory system interrelate to allow birds to achieve flight.

12. Open Ended Why are the fossils of Archaeopteryx and Caudipteryx zoui significant in explaining the evolutionary history of birds?

13. Predict Most dinosaurs had their center of mass near the hips, while most modern birds have their center of mass near the wings. Predict where the center of mass of theropod dinosaurs would be.

14. REAL WORLD BIOCHALLENGE Visit ca.bdal.glencoe.com to investigate the reasons for declining numbers of sea turtles. Select one species of sea turtle and design a pamphlet that describes your selected turtle, the reasons for decline, and the efforts that could be made to protect this species.

838 CHAPTER 31 ASSESSMENT
15. **Design an Experiment** Alligator faces are covered with small, pigmented domes. Scientists hypothesize that the domes are extremely sensitive to small disturbances on the water’s surface. Design an experiment that would test this hypothesis.

16. **Infer** Bar-headed geese migrate over the top of Mount Everest where oxygen levels are only one third of what they are at sea level. What parts of bar-headed geese bodies might have adaptations to survive in areas with low levels of oxygen?

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**Part 1** Multiple Choice

Use the graph below to answer question 17.

**Running Speed Versus Leg Length in Anole Lizards**

17. The relationship between running speed and leg length in anole lizards can best be described as which of the following:
   - A. As leg length increases, running speed increases.
   - B. As leg length decreases, running speed increases.
   - C. Leg length and running speed are not related.
   - D. Running speed decreases as leg length increases.

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**Part 2** Constructed Response/Grid In

Record your answers on your answer document.

20. **Open Ended** Describe the relationship between the number of eggs laid and the size of a newly hatched bird for the species described in questions 18 and 19. Explain why this occurs.

21. **Open Ended** Most reptiles lay between one and 200 eggs at a time. Amphibians lay thousands of eggs at a time. Is there an adaptive advantage to laying fewer eggs on land?