Chapter 33

Animal Behavior

What You'll Learn

- You will distinguish between innate and learned behavior.
- You will identify the adaptive value of specific types of behavior.

Why It's Important

Animals have patterns of behavior that help them survive and reproduce. Some of these behavior patterns are inherited and some are learned. You will recognize that humans, like other animals, have both types of behavior, and that these behavior patterns enable you to survive as well.

Understanding the Photo

In a honeybee hive, a single queen lays all the eggs. Worker bees build combs, store pollen and nectar, feed the queen, and keep the hive ventilated and clean. The sole purpose of the drones is to mate with the queen. In this highly organized system, some behaviors are innate, while others are learned.

Gerry Ellis/Minden Pictures

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Section 33.1

Innate Behavior

SECTION PREVIEW

Objectives

Distinguish among the types of innate behavior.

Demonstrate, by example, the adaptive value of innate behavior.

Review Vocabulary

population: group of organisms of one species that interbreed and live in the same place at the same time (p. 38)

New Vocabulary

behavior
innate behavior
reflex
fight-or-flight response
instinct
courtship behavior
territory
aggressive behavior
dominance hierarchy
circadian rhythm
migration
hibernation
estivation

Do you exhibit innate behavior?

Finding Main Ideas Construct an outline about innate behavior. Use the red and blue titles in this section as a guideline. As you read the paragraphs that follow the titles, add important information and vocabulary words to your outline. An example follows.

I. Inherited Behavior

- **A.** Natural selection favors certain behaviors
  - **1.** Individuals with behavior that makes them more successful at surviving and reproducing tend to produce more offspring than individuals without the behavior.
  - **2.** Inherited behavior of animals is called innate behavior.
  - **3.** Innate behaviors include fixed action patterns, automatic responses, and instincts.

Use your outline to help you answer questions in the Section Assessment on page 867. For more help, refer to *Outline* in the **Skill Handbook.**

Cedar waxwings and their nestlings

What is behavior?

A peacock displaying his colorful tail, a whale spending the winter months in the ocean off the coast of southern California, and a lizard seeking shade from the hot desert sun are all examples of animal behavior. **Behavior** is anything an animal does in response to a stimulus. A stimulus is an environmental change that directly influences the activity of an organism. The presence of a peahen stimulates a peacock to open its tail feathers and strut. Environmental cues, such as a change in day length, might be the stimulus that causes the whale to leave its summertime arctic habitat. Heat stimulates the lizard to seek shade. ***Figure 33.1*** shows two examples of stimuli that affect animal behavior.

Figure 33.1
Animals respond to stimuli by exhibiting a variety of behaviors.

A Squirrels collect and store acorns and nuts in response to shorter day length and colder temperatures.

B Spots that resemble the eyes of owls cause predatory birds to stop their pursuit of this insect.

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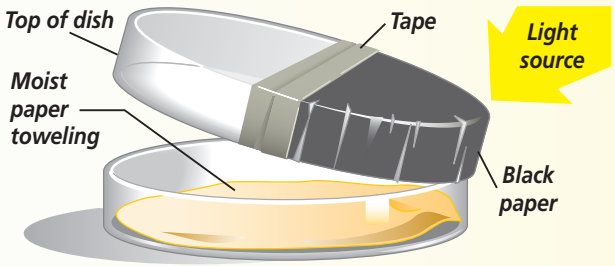
MiniLab 33.1

Experiment

Testing an Isopod's Response to Light Isopods, such as pill bugs and sow bugs, are common arthropods on sidewalks or patios. They are actually land crustaceans and respire through gill-like organs that must be kept moist at all times.

Procedure

1. Copy the data table.
2. Prepare a plastic dish using the diagram as a guide. Moisten the paper toweling.



3. Place six isopods in the center of the dish and quickly add the cover. Place the dish near a lamp or next to a classroom window with light. Have the light strike the dish as shown in the diagram. **CAUTION:** ***Treat isopods gently.***
4. Wait five minutes and observe the dish. Count and record in your data table the number of isopods on the dark or light side. This is your "five minute observation."
5. Repeat step 4 three more times, waiting five minutes before each observation.

Data Table

Observation in Minutes	Number of Isopods Present	
	Light Side	Dark Side
5		
10		
15		
20		
25		

Analysis

1. **Analyze** Do isopods tend to move toward light or dark areas? Support your answer with specific numbers from your data.
2. **Infer** Is the behavior of isopods toward light or darkness innate or learned? Explain your answer.
3. **Think Critically** What might be the adaptive advantage for the observed isopod behavior? Explain how natural selection may have influenced this isopod behavior.
4. **Make and Use Graphs** Prepare a bar graph that depicts your data.

Animals carry on many activities—such as getting food, avoiding predators, caring for young, finding shelter, and attracting mates—that enable them to survive and reproduce. These behavior patterns, therefore, have adaptive value. For example, a parent gull that is not incubating eggs or caring for chicks joins a noisy flock of gulls to dive for fishes. If the parent cannot catch a lot of fishes, not only will it die, but its chicks will not survive either. Therefore, this feeding behavior has adaptive value for the gull.

Inherited Behavior

Inheritance plays an important role in the ways animals behave. You don't expect a hummingbird to tunnel underground or a mouse to fly. Yet, why does a mouse run away when a cat appears? Why does a hummingbird fly south for the winter? These behavior patterns are genetically programmed. An animal's genetic makeup determines how that animal reacts to certain stimuli.

Natural selection favors certain behaviors

Often, a behavior exhibited by an animal species is the result of natural selection. The variability of behavior among individuals affects their ability to survive and reproduce. Individuals with behavior that makes them more successful at surviving and reproducing tend to produce more offspring than individuals without the behavior. These offspring will inherit the genetic basis for the successful behavior. You can observe the behavior of isopods in the *MiniLab* on this page.

Reading Check **Explain** how animal activities that enable them to survive and reproduce are a result of natural selection.

Inherited behavior of animals is called **innate** (ih NAYT) **behavior.** A toad captures prey by flipping out its sticky tongue. To capture prey, a toad must first be able to detect and follow its movement. Toads have "insect detector" cells in the retinas of their eyes. As an insect moves across a toad's line of sight, the "insect detector" cells signal the brain of the prey's changing position, thus initiating an innate response; the toad's tongue flips out. ***Figure 33.2*** shows a toad that captured its prey using an innate behavior known as a fixed-action pattern. A fixed-action pattern is an unchangeable behavior pattern that, once initiated, continues until completed.

Genes form the basis of innate behavior

Through experiments, scientists have found that an animal's hormonal balance and its nervous system—especially the sense organs responsible for sight, touch, sound, or odor identification—affect how sensitive the individual is to certain stimuli. In fire ant colonies, a single gene influences the acceptance or rejection of the ant queen, thereby controlling the colony's social structure. Innate behavior includes fixed-action patterns, automatic responses, and instincts. You can observe the response of animals to certain stimuli in the *BioLab* at the end of this chapter.

Figure 33.2
A toad can starve even though it is surrounded by dead insects because it cannot recognize non-moving animals as prey.

Automatic Responses

What happens if something quickly passes in front of your eyes or if something is thrown at your face? Your first reaction is to blink and jerk back your head. Even if a protective clear shield is placed in front of you, you can't stop yourself from behaving this way when the object is thrown. This reaction is an example of the simplest form of innate behavior, called a reflex. A **reflex** (REE fleks) is a simple, automatic response to a stimulus that involves no conscious control. ***Figure 33.3*** shows an example of a reflex.

The adaptive value of another automatic response is obvious. Think about a time when you were suddenly scared. Immediately, your heart began to beat faster. Your skin got cold and clammy, your respiration increased, and maybe you trembled. You were having a fight-or-flight response. A **fight-or-flight response** mobilizes the body for greater activity. Your body is being prepared to either fight or run from the danger. A fight-or-flight response is automatic and controlled by hormones and the nervous system.

Figure 33.3
Reflexes have survival value for animals. When you accidentally touch a hot stove, you jerk your hand away from the hot surface. The movement saves your body from serious injury.

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Instinctive Behavior

Compare the fixed-action pattern of a toad capturing prey with a fight-or-flight response. Both are quick, automatic responses to stimuli. But some behaviors take a longer time because they involve more complex actions. An **instinct** (IHN stingt) is a complex pattern of innate behavior. Instinctive behavior begins when the animal recognizes a stimulus and continues until all parts of the behavior have been performed.

Word Origin

instinct from the Latin word *instinctus,* meaning "impulse"; An instinct is a complex pattern of innate behavior.

As shown in ***Figure 33.4***, greylag geese instinctively retrieve eggs that have rolled from the nest. They will go through the motions of egg retrieval even if the eggs roll or are taken away until they are comfortably back on their nest. If they see the egg has not been retrieved they begin the process again.

Courtship behavior ensures reproduction

Much of an animal's courtship behavior is instinctive. **Courtship behavior** is the behavior that males and females of a species carry out before mating. Like other instinctive behaviors, courtship has evolved through natural selection. Imagine what would happen to the survival of a species if members were unable to recognize other members of that same species. Individuals often can recognize one another by the behavior patterns each performs. In courtship, behavior ensures that members of the same species find each other and mate. Obviously, such behavior has an adaptive value for the species. Different species of fireflies, for example, can be seen at dusk flashing distinct light patterns. However, female fireflies of one species respond only to those males exhibiting the species-correct flashing pattern.

Some courtship behaviors help prevent females from killing males before they have had the opportunity to mate. For example, in some spiders, the male is smaller than the female and risks the chance of being eaten if he approaches her. Before mating, the male in some species presents the female with an object, such as an insect wrapped in a silk web. While the female is unwrapping and eating the insect, the male is able to mate with her without being attacked. After mating, however, the male may be eaten by the female anyway.

In some species, such objects play an important role in allowing the female to exercise a choice as to which male to choose for a mating partner. The hanging fly, shown in ***Figure 33.5***, is such a species.

Reading Check **Explain** the results of natural selection in the courtship behavior of fireflies.

Figure 33.4
The female greylag goose instinctively retrieves an egg that she sees has rolled out of the nest. She does this by arching her neck around the stray egg and moving it like a hockey player advancing a puck. The female goose will retrieve many objects outside the nest, including baseballs and tin cans. **Explain** ***Why is this behavior considered a fixed-action pattern?***

Territoriality reduces competition

You may have seen a chipmunk chase another chipmunk away from seeds on the ground under a bird feeder. The chipmunk was defending its territory. A **territory** is a physical space an animal defends against other members of its species. It may contain the animal's breeding area, feeding area, and potential mates, or all three.

Animals that have territories will defend their space by driving away other individuals of the same species. For example, a male sea lion patrols the area of beach where his harem of female sea lions rests. He does not bother a neighboring male that has a harem of his own because both have marked their territories, and each respects the common boundaries. But if an unattached, young male tries to enter the sea lion's territory, the owner of the territory will attack and drive the intruder away from his harem.

Although it may not appear so, setting up territories actually reduces conflicts, controls population growth, and provides for efficient use of environmental resources. When animals space themselves out, they don't compete for the same resources within a limited space. This behavior improves the chances of survival of the young, and, therefore, survival of the species. If the male has selected an appropriate site and the young survive, they may inherit his ability to select an appropriate territory. Therefore, territorial behavior has survival value, not only for individuals, but also for the species. The male stickleback shown in ***Figure 33.6*** is another animal that exhibits territoriality, especially during breeding season.

Recall that pheromones are chemicals that communicate information among individuals of the same species. Many animals produce pheromones to mark territorial boundaries. For example, wolf urine contains pheromones that warn other wolves to stay away. The male pronghorn antelope uses a pheromone secreted from facial glands. One advantage of using pheromones is that they work both day and night, and whether or not the animal that made the mark is present.

Figure 33.5
Female hanging flies instinctively favor the male that supplies the largest object—in this case, a moth. The amount of sperm the female will accept from the male is determined by the size of the object.

Figure 33.6
The male three-spined stickleback displays a red belly to other breeding males near his territory. The male instinctively responds to other red-bellied males by attacking and driving them away.

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Aggressive behavior threatens other animals

Animals occasionally engage in aggression. **Aggressive behavior** is used to intimidate another animal of the same species. Animals fight or threaten one another in order to defend their young, their territory, or a resource such as food. Aggressive behaviors, such as bird calling, teeth baring, or growling, deliver the message to keep away.

When a male bighorn sheep is threatened by another male moving into his territory, for example, he does not kill the invader. Animals of the same species rarely fight to the death. The fights are usually symbolic, as shown in ***Figure 33.7.*** Male bighorn sheep do not usually even injure one another. Why does aggressive behavior rarely result in serious injury? One answer is that the defeated individual shows signs of submission to the victor. These signs inhibit further aggression by the victor. Continued fighting might result in serious injury for the victor; thus, its best interests are served by stopping the fight.

Submission leads to dominance hierarchies

Do you have an older or younger sibling? Who wins when you argue? In animals, usually the oldest or strongest wins the argument. But what happens when several individuals are involved in the argument? Sometimes, aggressive behavior among several individuals results in a grouping in which there are different levels of dominant and submissive animals. A **dominance hierarchy** (DAH muh nunts • HI rar kee) is a form of social ranking within a group in which some individuals are more subordinate than others. Usually, one animal is the top-ranking, dominant individual. This animal might lead others to food, water, and shelter. A dominant male often sires most or all of the offspring. There might be several levels in the hierarchy, with individuals in each level subordinate to the one above. The ability to form a dominance hierarchy is innate, but the position each animal assumes may be learned.

Figure 33.7
In many species, such as bighorn sheep, individuals fight in relatively harmless ways among themselves.

John Winnie, Jr./DRK Photo

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Figure 33.8
A variety of animals respond to the urge to migrate.

A Canadian and Alaskan caribou migrate from their winter homes in the taiga forests to the tundra for the summer.

B Both the freshwater eel and all species of salmon migrate to their spawning grounds.

C Adult monarch butterflies fly southward where they roost. In the spring, their young fly back north.

The term *pecking order* comes from a dominance hierarchy that is formed by chickens. The top-ranking chicken can peck any other chicken. The chicken lowest in the hierarchy is pecked at by all the other chickens in the group.

Behavior resulting from internal and external cues

Some instinctive behavior is exhibited in animals in response to internal, biological rhythms. Behavior based on a 24-hour day/night cycle is one example. Many animals, humans included, sleep at night and are awake during the day. Other animals, such as owls, reverse this pattern and are awake at night. A 24-hour, light-regulated, sleep/wake cycle of behavior is called a **circadian** (sur KAY dee uhn) **rhythm.** Circadian rhythms keep you alert during the day and help you relax at night. They may even wake you if you forget to set your alarm clock or on days that you could sleep in. Circadian rhythms are controlled by genes, yet are also influenced by factors such as jet lag and shift work.

Rhythms also can occur on a yearly or seasonal cycle. Migration, for example, occurs on a seasonal cycle. **Migration** is the instinctive, seasonal movement of animals, shown in ***Figure 33.8.*** In North America, about two-thirds of bird species fly south in the fall to areas such as South America, where food is available during the winter. The birds fly north in the spring to areas where they breed during the summer. Whales migrate seasonally, as well. Change in day length is thought to stimulate the onset of migration in the same way that it controls the flowering of plants. You can find out how migrating turtles are tracked in the *Biotechnology* at the end of this chapter.

Reading Check **Infer** why some animals migrate.

Migration calls for remarkable strength and endurance. The arctic tern migrates between the arctic circle and the Antarctic, a one-way flight of almost 18 000 km.

Animals navigate in a variety of ways. Some use the positions of the sun and stars to navigate. They may use geographic clues, such as mountain ranges. Some bird species seem to be guided by Earth's magnetic field. You might think of this as being guided by an internal compass.

Animals that migrate might be responding to colder temperatures and shorter days, as well as to hormones. Young animals may learn when and where to migrate by following their parents. You can easily see why animals migrate from a cold place to a warmer place, yet most animals do not migrate. How many animals cope with winter is another example of instinctive behavior.

You know that many animals store food in burrows and nests. But other animals survive the winter by undergoing physiological changes that reduce their need for energy. Some mammals, such as bats and chipmunks, and a few other types of animals go into a deep sleep during parts of the cold winter months. This period of inactivity is called hibernation. **Hibernation** (hi bur NAY shun) is a state in which the body temperature drops substantially, oxygen consumption decreases, and breathing rates decline to a few breaths per minute. Hibernation conserves energy. Animals that hibernate typically eat vast amounts of food to build up body fat before entering hibernation. This fat fuels the animal's body while it is in this state. The golden-mantled ground squirrel shown in ***Figure 33.9*** is an example of an animal that hibernates. You can find out more about hibernation in the *Problem-Solving Lab* on the next page.

What happens to animals that live year-round in hot environments? Some of these animals respond in a way that is similar to hibernation. **Estivation** (es tuh VAY shun) is a state of reduced metabolism that occurs in animals living in conditions of intense heat. Desert animals appear to estivate sometimes in response to lack of food or periods of drought.

Figure 33.9
The golden-mantled ground squirrel has a normal body temperature of around 37°C. When the day length shortens in the fall, the ground squirrel's temperature drops to 5°C, and it goes into hibernation.

Stephen J. Krasemann/DRK Photo

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Figure 33.10
Australian long-necked turtles are among the reptiles and amphibians that respond to hot and dry summer conditions by estivating.

Australian long-necked turtles, shown in ***Figure 33.10***, will estivate even when they are kept in a laboratory with constant food and water. Clearly, estivation is an innate behavior that depends on both internal and external cues.

Problem-Solving Lab 33.1

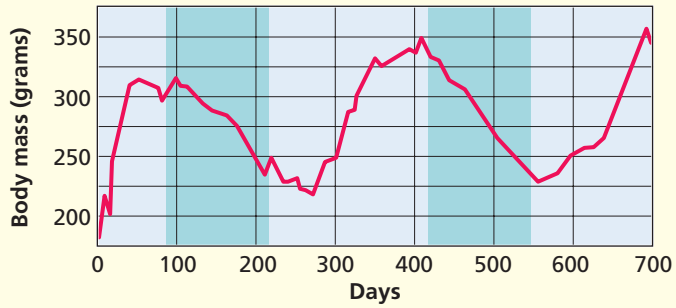
Design an Experiment

Is hibernation an innate or learned behavior? Circadian rhythms occur on an almost 24-hour cycle in certain organisms. The word *circadian* comes from Latin: *circa* ("about") and *dies* ("day").

Solve the Problem

Ground squirrels were placed in a room free from all outside stimuli. The room contained food and water, was kept at a temperature of 22°C, and a light remained on for 12 hours each day. Body mass was measured and recorded weekly. The graph shows the results of the experiment. The dark bands correspond to times when the squirrels were in hibernation.

Body Mass of Golden-Mantled Ground Squirrels



Thinking Critically

1. **Sequence** Describe the squirrels' cyclic pattern of activity.
2. **Lab Techniques** Why did scientists keep temperature, food and water, and light constant?
3. **Use Variables, Constants, and Controls** Why is it appropriate experimental procedure to repeat the experiment using different temperatures?
4. **Experiment** Suggest an experiment that supports the conclusion that this pattern of hibernation is genetic.

Section Assessment

Understanding Main Ideas

1. How is a reflex different from an instinct?
2. Explain by example two types of innate behavior.
3. Explain behaviors that reduce competition.

Thinking Critically

4. How is innate behavior an advantage to a species in which the young normally hatch after the mother has left?

Skill Review

5. **Experiment** Earthworms live in deep, long, and narrow burrows in moist soil. They leave their burrows at night and when it rains, because it is easier for them to move on a wet surface. Design an experiment to determine what stimulus causes an earthworm to return to its burrow. For more help, refer to *Experiment* in the **Skill Handbook.**

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Belinda Wright/DRK Photo

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Section 33.2

Learned Behavior

SECTION PREVIEW

Objectives

Distinguish among types of learned behavior.

Demonstrate, by example, types of learned behavior.

Review Vocabulary

pheromones: chemical signals given off by animals that signal animals to engage in specific behaviors (p. 745)

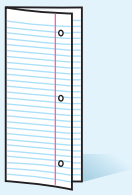
New Vocabulary

habituation
imprinting
trial-and-error learning
motivation
classical conditioning
insight
communication
language

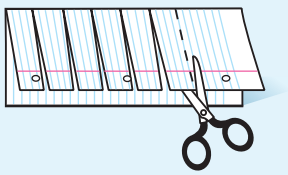
FOLDABLES Study Organizer

Learned Behavior Make the following Foldable to help you understand the vocabulary terms in this chapter.

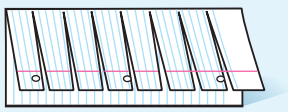
STEP 1 **Fold** a vertical sheet of notebook paper from side to side.



STEP 2 **Cut** along every third line of only the top layer to form tabs.



STEP 3 **Label** each tab.



Build Vocabulary As you read Section 33.2, list the vocabulary words about learned behavior on the tabs. As you learn the definitions, write them under the appropriate tab.

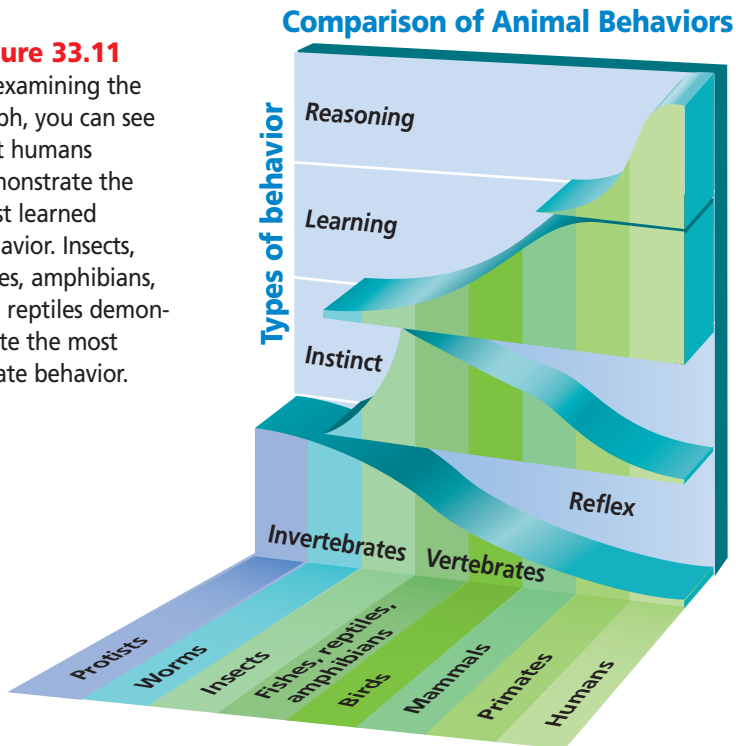


Figure 33.11 By examining the graph, you can see that humans demonstrate the most learned behavior. Insects, fishes, amphibians, and reptiles demonstrate the most innate behavior.

What is learned behavior?

Learning, or learned behavior, takes place when behavior changes through practice or experience. The more complex an animal's brain, the more elaborate the patterns of its learned behavior. As you can see in ***Figure 33.11***, innate behaviors are more common in invertebrates, and learned behaviors are more common in vertebrates. In humans, many behaviors are learned.

Learning has survival value for all animals in changing environments because it permits behavior to change in response to varied conditions. Learning allows an animal to adapt to change, an ability that is especially important for animals with long life spans. The longer that an animal lives, the greater the chance that its environment will change.

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Kinds of Learned Behavior

Just as there are several types of innate behavior, there are several types of learned behavior. Some learned behavior is simple and some is complex. Which group of animals do you think carries out the most complex type of learned behavior?

Habituation: A simple form of learning

Horses normally shy away from an object that suddenly appears from the trees or bushes, yet after a while they disregard noisy cars that speed by the pasture honking their horns. This lack of response is called habituation. **Habituation** (huh bit choo AY shun) illustrated in ***Figure 33.12***, occurs when an animal is repeatedly given a stimulus that is not associated with any punishment or reward. An animal has become habituated to a stimulus when it finally ceases to respond to the stimulus.

Imprinting: A permanent attachment

Have you ever seen young ducklings following their mother? This behavior is the result of imprinting. **Imprinting** is a form of learning in which an animal, at a specific critical time of its life, forms a social attachment to another object. Many kinds of birds and mammals do not innately know how to recognize members of their own species. Instead, they learn to make this distinction early in life. Imprinting takes place only during a specific period of time in the animal's life and is usually irreversible. For example, birds that leave the nest immediately after hatching, such as geese, imprint on their mother. They learn to recognize and follow her within a day of hatching.

In birds such as ducks, imprinting takes place during the first day or two after hatching. A duckling rapidly learns to recognize and follow the first conspicuous moving object it sees. Normally, that object is the duckling's mother. Learning to recognize their mother and follow her ensures that food and protection will always be nearby.

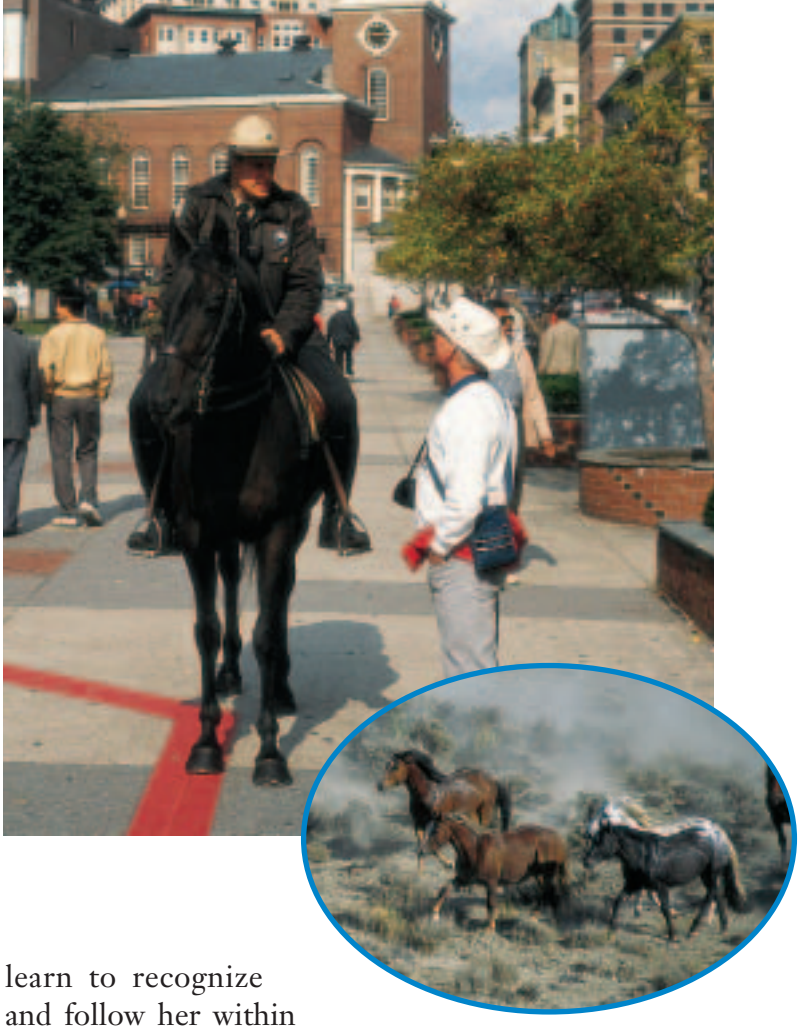

Figure 33.12
Habituation is a loss of sensitivity to certain stimuli. Young horses often are afraid of cars and noisy streets. Gradually, they become habituated to the city and ignore normal sights and sounds.

Learning by trial and error

Do you remember when you first learned how to ride a bicycle? You probably tried many times before being able to successfully complete the task. Nest building, like riding a bicycle, may be a learning experience. The first time a jackdaw builds a nest, it uses grass, bits of glass, stones, empty cans, old lightbulbs, and anything else it can find.

MiniLab 33.2

Experiment

Solving a Puzzle You are given a bunch of keys and asked to open a door. How do you go about finding the right key? Several attempts are needed, and then finally, the door opens. The next time you are asked to perform the same task, can you go directly to the correct key? Chances are, you can. You have learned how to solve this problem.

Procedure

1. Copy the data table below.
2. Obtain a paper puzzle from your teacher.
3. Time how long it takes you to assemble the puzzle pieces into a perfect square.
4. Record the time it took and call this Trial 1.
5. Disassemble the square and mix the pieces.
6. Repeat step 3 for four more trials.

Data Table

Trial	Time Needed to Complete Square Puzzle
1	
2	
3	
4	
5	

Analysis

1. **Interpret data** Explain how the time needed to complete the puzzle changed from Trial 1 to Trial 5.
2. **Infer** Was the final completion of the puzzle an example of innate or learned behavior? Explain your answer.
3. **Analyze** When solving the puzzle, what role might imprinting, trial and error, conditioning, and insight have played in improving your trial times?

With experience, the bird finds that grasses and twigs make a better nest than do lightbulbs. The jackdaw has used **trial-and-error learning** in which an animal receives a reward for making a particular response. When an animal tries one solution and then another in the course of obtaining a reward, in this case a suitable nest, it is learning by trial and error. Find out for yourself how trial and error learning works in the *MiniLab* on this page.

Learning happens more quickly if there is a reason to learn or be successful. **Motivation** is an internal need that causes an animal to act, and it is necessary for learning to take place. In most animals, motivation often involves satisfying a physical need, such as hunger or thirst. If an animal isn't motivated, it won't learn. Animals that aren't hungry won't respond to a food reward. Mice living in a barn, shown in ***Figure 33.13***, discover that they can eat all the grain they like if they first chew through the container in which the grain is stored.

Figure 33.13
Mice soon learn where grain is stored in a barn and are motivated by hunger to chew through the storage containers.

Michael Durham/ENP Images

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Figure 33.14
In the early 1900s, Ivan Pavlov, a Russian biologist, first demonstrated classical conditioning in dogs.

A Pavlov noted that dogs salivate when they smell food. Responding to the smell of food is a reflex, an example of innate behavior.

B By ringing a bell each time he presented food to a dog, Pavlov established an association between the food and the ringing bell.

C Eventually, the dog salivated at the sound of the bell alone. The dog had been conditioned to respond to a stimulus that it did not normally associate with food.

Classical conditioning: Learning by association

Suppose that when you first got a new kitten, it would meow as soon as it smelled the aroma of cat food in the can you were opening. After a few weeks, the sound of the can opener alone attracted your kitten, causing it to meow. Your kitten had become conditioned to respond to a stimulus other than the smell of food. **Classical conditioning** is learning by association. A well-known example of an early experiment in classical conditioning is illustrated in ***Figure 33.14.***

Insight: The most complex type of learning

In a classic study of animal behavior, a chimpanzee was given two bamboo poles, neither of which was long enough to reach some fruit placed outside its cage. By connecting the two tapering short pieces to make one longer pole, the chimpanzee learned to solve the problem of how to reach the fruit. This type of learning is called insight. **Insight** is learning in which an animal uses previous experience to respond to a new situation.

Much of human learning is based on insight. When you were a baby, you learned a great deal by trial and error. As you grew older, you relied more on insight. Solving math problems is a daily instance of using insight. Probably your first experience with mathematics was when you learned to count. Based on your concept of numbers, you then learned to add, subtract, multiply, and divide. Years later, you continue to solve problems in mathematics based on your past experiences. When you encounter a problem you have never experienced before, you solve the problem through insight.

Problem-Solving Lab 33.2

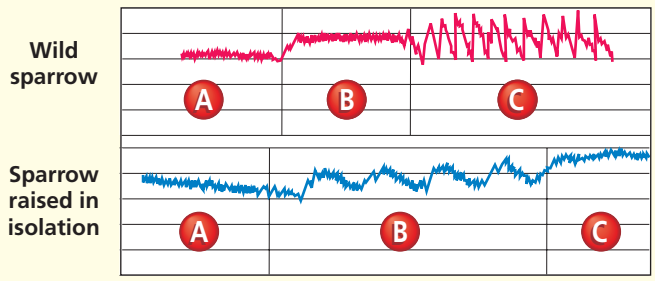
Interpret Data

Do birds learn how to sing? Do birds learn how to sing, or is this innate behavior? Most experimental evidence points to the fact that singing may be a combination of the two types of behavior, but in certain species, learning is critical in order to sing the species song correctly.

Solve the Problem

Bird sound spectrograms allow scientists to record and visually study the song patterns of birds. Using this tool, they recorded spectrograms for white-crowned sparrows. The top spectrogram is that of a wild white-crowned sparrow. The bottom spectrogram is that of a white-crowned sparrow hatched and raised in total isolation from all other birds. Segments of the song have been identified with the letters A–C.

Birds' Songs



Thinking Critically

1. **Compare and Contrast** In general, how do the two spectrograms compare?
2. **Read Graphs** Which segment of the sparrow's song may be innate? Learned? Explain your answers.
3. **Interpret Graphs** Does it appear that the majority of the sparrow's song is learned or innate? Explain your answer.
4. **Predict** In a different experiment, a recording of a white-crowned sparrow song was repeatedly played for a young bird raised in isolation. If a bird's song is mainly learned, predict the outcome of the experiment.

The Role of Communication

When you think about interactions among animals as a result of their behavior, you realize that some sort of communication has taken place. **Communication** is an exchange of information that results in a change of behavior. Black-headed gulls visually communicate their availability for mating with instinctive courtship behavior. The pat on the head from a dog's owner after the dog retrieves a stick signals a job well done.

Reading Check **Define** the term *communication.*

Most animals communicate

Animals have several channels of communication open to them. They signal each other by sounds, sights, touches, or smells. Sounds vibrate in all directions and can be heard a long way from their sources. Sounds such as songs, roars, and calls communicate a lot of information quickly. For example, the song of a male cricket tells his sex, his location, his social status, and, because communication by sound is usually species specific, his species.

Signals that involve odors may be broadcast widely and carry a general message. Ants, shown in ***Figure 33.15***, leave odor trails that are followed by other members of their nest. These odors are species specific. As you know, pheromones, such as those of moths, may be used to attract mates. Because only small amounts of pheromones are needed, other animals, especially predators, may be unable to detect the odor.

Figure 33.15
Ants follow chemical trails left by other ants to find food resources.

Jacana/Photo Researchers

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Using both innate and learned behavior

Some communication is a combination of both innate and learned behavior. In some species of songbirds, such as the one shown in ***Figure 33.16***, males automatically sing when they reach sexual maturity. Their songs are specific to their species, and singing is innate behavior. Yet members of the same species that live in different regions learn different variations of the song. They learn to sing with a regional dialect. In other species, birds raised in isolation never learn to sing their species song. Find out more about the songs birds sing in the *Problem-Solving Lab* on the previous page.

Figure 33.16
The Indigo bunting sings a high-pitched series of notes that descend the scale, then ascend again at the end of the song.

Some animals use language

Language, the use of symbols to represent ideas, is present primarily in animals with complex nervous systems, memory, and insight. Humans, with the help of spoken and written language, can benefit from what other people and cultures have learned and don't have to experience everything for themselves. People can use the accumulated knowledge in the books shown in ***Figure 33.17*** to build new knowledge.

Figure 33.17
English and other languages are made up of words that have specific meanings. An amazing number of meanings can be communicated using words of any human language.

Section Assessment

Understanding Main Ideas

1. How is imprinting different from other types of learned behavior?
2. Compare and contrast trial-and-error learning and insight. Give an example of each.
3. Explain by example the difference between trial-and-error learning and classical conditioning.
4. What is the difference between communication and language?
5. How does an animal become habituated to a stimulus?

Thinking Critically

6. How does learning have survival value in a changing environment? Explain your answer by using an example from your daily life.

Skill Review

7. **Observe and Infer** Two dog trainers teach dogs to do tricks. One trainer gives her dog a food treat whenever the dog correctly performs the trick. The other trainer does not use treats. Which trainer will be more successful at dog training? Why? For more help, refer to *Observe and Infer* in the **Skill Handbook.**

bdol.glencoe.com/self_check_quiz

INVESTIGATE

BioLab

Behavior of a Snail

Before You Begin

Land snails are members of the mollusk class Gastropoda. Land snails live on or near the ground, feed on decaying organic matter, and breathe with gills or, in some cases, with a simple lung. Land snails sense their environment with a pair of antennae and eyes. Snails are excellent organisms for behavioral studies because they show a variety of consistent responses to certain stimuli.

Preparation

Problem

How can you test the behavior of snails to touch stimuli?

Objectives

In this BioLab, you will:

- **Test** the response of snails to touch.
- **Measure** the time needed for habituation to occur after repeated touch stimuli.

Materials

snails
dropper
scissors
probe constructed from tape, rubber band, and pencil
spring water
small dish
dissecting microscope

Safety Precautions

CAUTION: ***Always wear goggles in the lab. Wash your hands with soap and water both before and after handling any animals. Use caution when working with live animals. Be careful not to harm the snails.***

Skill Handbook

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

Procedure

1. Copy the data table.
2. Prepare a stimulator probe by taping a small piece of a cut rubber band to the tip of a pencil.
3. Cover the bottom of a small dish with spring water.
4. Obtain a snail from your teacher and place it in the dish.
5. Use a dissecting microscope to examine and locate its head. Its head has two antennae that it can extend and retract.
6. Place the dish on your desk.

A land snail

Alvin E. Staffan

7. Lightly touch the snail's anterior end using the end of the probe. Note if it responds (yes or no), and record any movement. Conduct a total of five trials.
8. Repeat step 7, touching the snail's posterior end.
9. Repeat step 7, touching the middle of the snail's body.
10. Test the snail's ability to become habituated.
    a. Continue to touch the snail's anterior end with the probe every 10 seconds until habituation occurs. Continue testing for a reasonable length of time if habituation does not occur.
    b. Count and record the number of stimulations needed for habituation.
11. **CLEANUP AND DISPOSAL** Return your snail to the area designated by your teacher. Clean all equipment and return everything to its proper place for reuse. Wash your hands thoroughly with soap and water.

Data Table

Body Area	Response to Touch		
Trial	Anterior	Posterior	Middle
1			
2			
3			
4			
5			
Habituation Studies			
Rate of Stimulation	Number of Stimulations Needed to Reach Habituation		

ANALYZE AND CONCLUDE

1. **Hypothesize** Are the responses to touch shown by snails learned or innate? Explain your answer.
2. **Observe** Describe the direction that a snail moves when its anterior and posterior ends are stimulated. Does one end appear to be more sensitive than the other? Is the middle sensitive to touch? Is the speed of response slow or rapid?
3. **Explain** How is the behavior of responding to touch an adaptation for survival?
4. **Experiment** Why did you perform several trials for each experiment involving stimulation of the anterior, posterior, and middle of the snail?
5. **Define Operationally** Define the term *habituation*.
6. **ERROR ANALYSIS** Suppose you hypothesized that snails are quickly habituated to touch. Is this hypothesis supported by your data? Explain.

Apply Your Skill

Experiment Form a hypothesis regarding snail behavior when given a choice between light and dark conditions. Design and carry out an experiment to test your hypothesis.

Web Links To find out more about animal behavior, visit bdol.glencoe.com/animal_behavior

BIO TECHNOLOGY

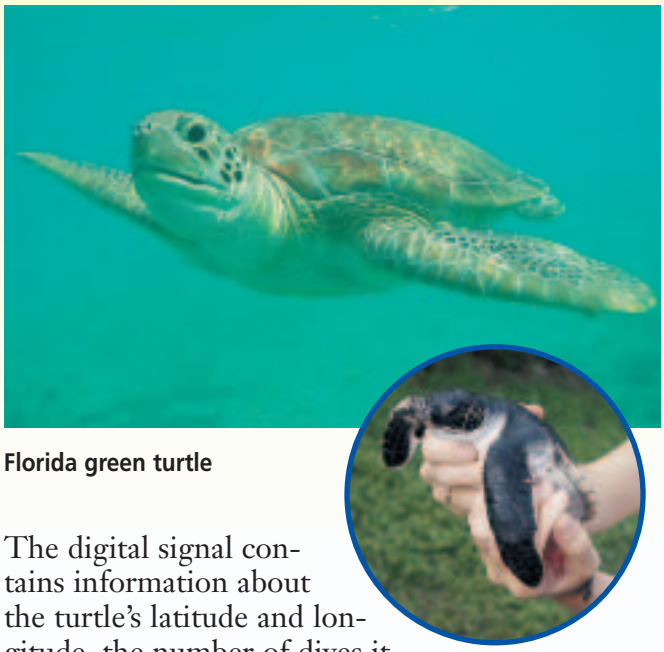
Tracking Sea Turtles

The Florida green turtle *(Chelonia mydas mydas)* is an endangered species that nests on sandy beaches. It is found in temperate and tropical waters, including the southeastern coast of the United States. Like other sea turtles, the Florida green turtle spends virtually all of its life at sea; however, adult females visit beaches several times a year to lay their eggs.

Studying sea turtles presents a challenge because they spend so little time on land. Research is most easily conducted on the beach, where the nesting behavior of the females can be directly observed. These observations have provided important information about how to protect the nesting sites from human disturbance or predation. But more information about the Florida green turtle is needed because protecting an endangered species requires knowing what environmental factors are crucial to its survival.

Tagging To study these animals, researchers affix a small plastic or metal tag onto the flipper of a captured turtle. The tag is etched with an identification number. If the animal is captured again, the date and location are shared with other turtle researchers. But even when a tagged turtle is recaptured, the route the animal took to move from one location to another remains unknown.

Satellite tracking Recent improvements in satellite telemetry are making it possible for researchers to keep much better track of individual turtles as they swim from place to place. A transmitter the size of a small, portable cassette player is attached to the shell behind the turtle's neck. The battery-powered transmitter will work for six to ten months before it falls off. When the turtle comes to the surface to breathe, the transmitter broadcasts data in the form of a digital signal to an orbiting communications satellite. The satellite transmits the data to a receiving station on Earth.



Florida green turtle

The digital signal contains information about the turtle's latitude and longitude, the number of dives it made in the past 24 hours, the length of its most recent dive, and the temperature of the water. By plotting the location of data transmissions on a map, researchers can track the direction and speed in which the animal is moving.

Problems with satellite tracking Sometimes a transmitter stops working after just a few weeks, and there are problems with the data itself. Increasingly accurate information will become available as the technology improves and as more turtles are included in satellite tracking efforts.

Applying Biotechnology

Think Critically Telemetry data from a Florida green turtle indicate the animal has spent the past several days in an offshore location characterized by coral reefs and seagrass meadows. Past telemetry data from other green turtles indicate that these animals periodically interrupt their travels to stop at this location and at other coral reefs and seagrass meadows. Form a hypothesis that could explain this behavior. How could you test your hypothesis?

To find out more about sea turtle migration, visit bdol.glencoe.com/biotechnology

CONTENTS

Chapter 33 Assessment

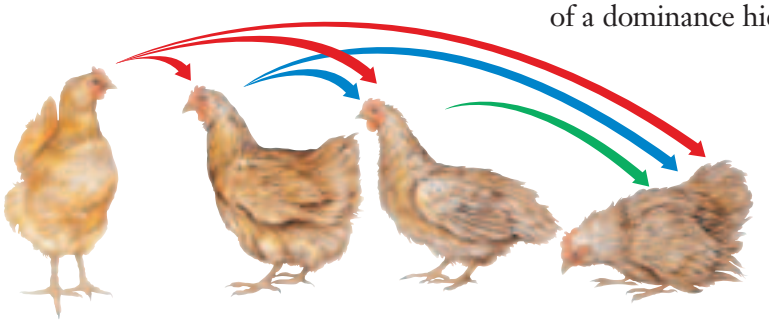
Study Guide

Section 33.1

Innate Behavior

Key Concepts

- Behavior is anything an animal does in response to a stimulus.
- Many behaviors have adaptive value and are shaped by natural selection.
- Innate behavior is inherited. Innate behaviors include fixed-action patterns, automatic responses and instincts.
- Automatic responses include reflexes and fight-or-flight responses.
- An instinct is a complex pattern of innate behaviors.
- Behaviors such as courtship rituals, displays of aggressive behavior, territoriality, dominance hierarchies, hibernation, and migration are all forms of instinctive behavior.
  - Pecking order is an example of a dominance hierarchy.



Vocabulary

aggressive behavior (p. 864)
behavior (p. 859)
circadian rhythm (p. 865)
courtship behavior (p. 862)
dominance hierarchy (p. 864)
estivation (p. 866)
fight-or-flight response (p. 861)
hibernation (p. 866)
innate behavior (p. 861)
instinct (p. 862)
migration (p. 865)
reflex (p. 861)
territory (p. 863)

Section 33.2

Learned Behavior

Key Concepts

- Learning takes place when behavior changes through practice or experience.
- Learned behavior has adaptive value.
- Learning includes habituation, imprinting, trial and error, and classical conditioning.
- The most complex type of learning is learning by insight.
- Some animals use language, whereas most communicate by either visual, auditory, or chemical signals.

Vocabulary

communication (p. 872)
classical conditioning (p. 871)
habituation (p. 869)
imprinting (p. 869)
insight (p. 871)
language (p. 873)
motivation (p. 870)
trial-and-error learning (p. 870)

FOLDABLES Study Organizer

To help you review animal behavior, use the Organizational Study Fold on page 868.

bdol.glencoe.com/vocabulary_puzzlemaker

Jacana/Photo Researchers

Chapter 33 Assessment

Vocabulary Review

Review the Chapter 33 vocabulary words listed in the Study Guide on page 877. Match the words with the definitions below.

1. innate behavior by which animals form a social ranking within a group in which some individuals are more subordinate than others; usually has one top-ranking individual
2. learned behavior in which an animal, at a specific critical time of its life, forms a social attachment to another object
3. complex innate behavior pattern that begins when an animal recognizes a stimulus and performs an action until all parts of the behavior have been formed
4. type of learning in which an animal uses previous experiences to respond to a new situation
5. physical space an animal defends against other members of its species; may contain an animal's breeding area, feeding area, potential mates, or all three

Understanding Key Concepts

6. Your adult dog is chewing on a bone when a puppy approaches. Your dog growls at the puppy. What type of behavior is your dog exhibiting?
   A. conditioning **C.** habituation
   B. aggressive behavior **D.** fighting
7. Animals with behavior that makes them more successful at surviving and reproducing tend to produce more _____.
   A. offspring **C.** territory
   B. aggression **D.** eggs
8. When a toad flips out its tongue to catch an insect flying past, it is exhibiting _____.
   A. learned behavior **C.** territoriality
   B. courtship behavior **D.** innate behavior
9. Caribou are _____ when they move from their winter homes in the forests to the tundra for the summer.
   A. hibernating **C.** migrating
   B. imprinting **D.** learning
10. Establishing _____ reduces the need for aggressive behavior among members of the same species.
    A. reflexes **C.** territories
    B. conditioning **D.** habituation
11. Your cat exhibits _____ when it runs for its food dish upon hearing the can opener.
    A. insight **C.** habituation
    B. conditioning **D.** imprinting

Constructed Response

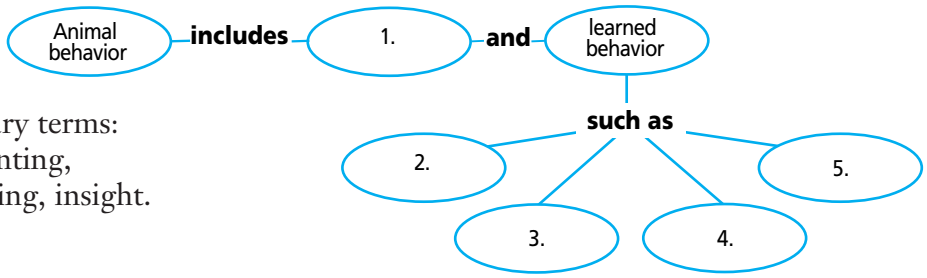
12. **Open Ended** Explain the result of natural selection in animal behavior.
13. **Open Ended** Explain how Ivan Pavlov used scientific methods to study classical conditioning.
14. **Recognize Cause and Effect** When Charles Darwin visited the Galápagos Islands in 1835, he was amazed that the animals would allow him to touch them. Hypothesize why they were not afraid.

Thinking Critically

15. **Compare and Contrast** Ducklings display an alarm reaction when a model of a hawk is flown over their heads and no alarm reaction when a model of a goose is flown over their heads. After several days, neither model causes any reaction. Compare the effects of the two models during the first two days with the effects of the same models two weeks later.
16. **REAL WORLD BIOCHALLENGE** Visit bdol.glencoe.com to investigate bee behavior and communication. Include historic discoveries about how bees communicate with other members of the hive as to where a new food source is. Also include the results of the most recent research about how bees measure the distance to a food source. Present the results of your research to your class in the form of a poster or multimedia presentation.

Chapter 33 Assessment

17. Concept Map Complete the concept map by using the following vocabulary terms: innate behavior, imprinting, habituation, conditioning, insight.

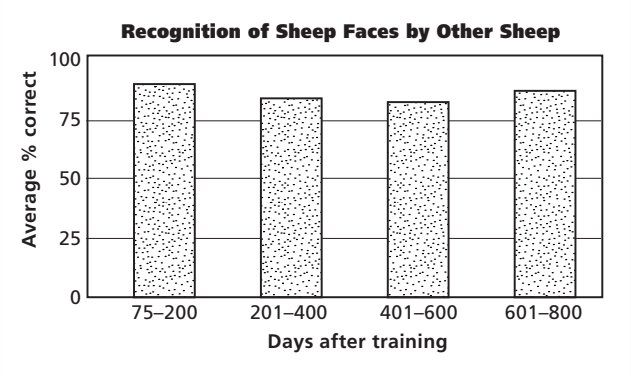


Standardized Test Practice

All questions aligned and verified by The Princeton Review

Part 1 Multiple Choice

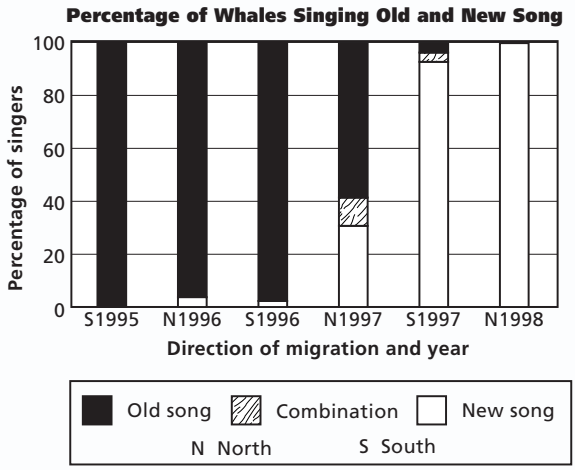
Study the graph and answer questions 18–19.



18. The recognition of sheep faces by other sheep can be described as _____.
- **A.** more than 75% correct even after 800 days
- **B.** less than 50% correct after 400 days
- **C.** remembering 80 sheep after 800 days
- **D.** remembering 800 sheep after 80 days

19. The ability of sheep to recognize faces may be an adaptation to _____.
- **A.** escaping predators
- **B.** living in a herd
- **C.** finding food
- **D.** cold climate

On the east coast of Australia, humpback whales sing the same song while they migrate north and south. Use the graph to answer questions 20–21.



20. In 1996, _____.
- **A.** all whales sang the old song
- **B.** all whales sang the new song
- **C.** one or two whales sang a new song
- **D.** no migration occurred

21. By 1998, all whales sang _____.
- **A.** the new song
- **B.** the old song
- **C.** the old and new songs
- **D.** the intermediate song

Part 2 Constructed Response/Grid In

Record your answers on your answer document.

22. Open Ended Some bird species give differing calls depending on the source of alarm. Other birds of the same species either scan the ground or the sky in response to the calls. Infer what the birds may be communicating.

23. Open Ended What would be the advantage of a dominance hierarchy in members of a species that are not defending a territory?

Vertebrates

Like all chordates, vertebrates have a notochord, pharyngeal pouches, a dorsal hollow nerve cord, and postanal tail. However, in vertebrates the notochord is replaced during development by a backbone. All vertebrates are bilaterally symmetrical coelomate animals that have an endoskeleton, a closed circulatory system, an efficient respiratory system, and a complex brain and nervous system.

Fishes

All fishes are ectotherms, animals with body temperatures dependent upon an external heat source. Fishes have two-chambered hearts and breathe through gills. Fishes are grouped into four different classes.

Two Classes of Jawless Fishes

Lampreys and hagfishes make up the two classes of jawless fishes. Jawless fishes have endoskeletons made of cartilage, like sharks and rays, but they do not have jaws.

Cartilaginous Fishes

Sharks, skates, and rays are cartilaginous fishes. Fossil evidence shows that jaws first evolved in these fishes. Cartilaginous fishes have endoskeletons made of cartilage, paired fins, and a lateral line system that enables them to detect movement and vibrations in water.

Cartilaginous fishes such as this whitetip reef shark have internal fertilization. In some species of cartilaginous fishes, development of fertilized eggs is external; other species give live birth to well-developed young.

Bony Fishes

Most fish species belong to the bony fishes. All bony fishes have a bony skeleton, gills, paired fins, flattened bony scales, and a lateral line system. Bony fishes breathe by drawing water into their mouths, then passing it over gills where gas exchange occurs. They adjust their depth in the water by regulating the amount of gas that diffuses out of their blood into a swim bladder. Most bony fishes fertilize their eggs externally and leave the survival of the offspring to chance.

Vital Statistics

Fishes

Size ranges: Largest: Whale shark, length, 15 m; smallest: Dwarf goby, length, 1 cm
Distribution: Freshwater, saltwater, and estuarine habitats worldwide
Unusual adaptations: Electric eels can deliver an electrical charge of 650 volts, which stuns or kills their prey. Some deep-sea fishes have their own bioluminescent lures to help capture prey.
Longest-lived: Lake sturgeon, 80 years
Numbers of species:
Class Myxini—hagfishes, 43 species
Class Cephalaspidomorphi—lampreys, 17 species
Class Chondrichthyes—cartilaginous fishes, 850 species
Class Osteichthyes—bony fishes, 20 000 species

CONTENTS

Amphibians

Amphibians are ectothermic vertebrates with three-chambered hearts, lungs, and thin, moist skin. Although they have lungs, most gas exchange in amphibians is carried out through the skin. As adults, the majority of amphibians live on land, however, many of these species rely on water for reproduction. Most amphibians go through metamorphosis, in which the young hatch into tadpoles, which gradually lose their tails and gills as they develop legs, lungs, and other adult structures.

Amphibian Classification

Amphibians are classified into three orders: Anura, frogs and toads; Caudata, salamanders and newts; and Apoda, legless caecilians. Frogs and toads have vocal cords that can produce a wide range of sounds. Frogs have thin, smooth, moist skin and toads have thick, bumpy skin with poison glands. Salamanders have long, slender bodies with a neck and tail. Caecilians are amphibians with long, wormlike bodies and no legs.

Like other amphibians, salamanders have smooth, moist skin and lack true claws on their toes. Salamanders are carnivorous, feeding on insects, worms, and small mollusks.

Caecilians are long, limbless amphibians adapted for burrowing and living underground.

Vital Statistics

Amphibians

Size ranges: Largest: Goliath frog, length, 30 cm; Chinese giant salamander, length, 1.8 m; Smallest frog: *Psyllophryne didactyla,* length, 9.8 mm

Distribution: Tropical and temperate regions worldwide

Numbers of species:

Class Amphibia
- Order Anura—frogs and toads, 3700 species
- Order Caudata—salamanders and newts, 369 species
- Order Apoda—legless caecilians, 168 species

The tympanic membrane, or eardrum, is located behind and below the frog's eye. It transmits vibrations from the air or water to the frog's inner ear.

CONTENTS

Reptiles

Reptiles are ectotherms with dry, scaly skin and clawed toes. They include snakes, lizards, turtles, crocodiles, and alligators. With the exception of snakes, all reptiles have four legs that are positioned somewhat underneath their bodies. Most reptiles have a three-chambered heart, but crocodilians have a four-chambered heart in which oxygenated blood is kept entirely separate from blood without oxygen. The scaly skin of reptiles reduces the loss of body moisture on land, but scales also prevent the skin from absorbing or releasing gases to the air. Reptiles are entirely dependent upon lungs for this essential gas exchange.

Constrictors, such as this emerald tree boa, hold prey with their mouths, then wrap coils around the prey's body. The snake tightens its coils, preventing inhalation, and the prey suffocates.

All crocodilians have a strong, muscular jaw and teeth that are in sockets. Crocodiles generally have a narrower snout in comparison with alligators.

Focus on Adaptations

The Amniotic Egg

Nile crocodile hatchling

Reptiles were the first group of vertebrates to live entirely on land. They evolved a thick, scaly skin that prevented water loss from body tissues. They evolved strong skeletons, with limbs positioned somewhat underneath their bodies. These limbs enabled them to move quickly on land, avoiding or seeking the sun as their body temperatures demanded. But perhaps their most important adaptation to life on land was the development of the amniotic egg.

Protecting the embryo An amniotic egg encloses the embryo in amniotic fluid; provides the yolk, a source of food for the embryo; and surrounds both the embryo and yolk with membranes and a tough, leathery shell. These structures in the egg help prevent

All turtles, including this olive ridley, a marine species, lay eggs in nests they dig in the ground. After the eggs are laid, the female turtle covers them and leaves.

The shell of a turtle consists of bony plates covered with horny shields. A turtle can pull its head and legs into the shell to protect itself against predators.

Internal Fertilization

All reptiles have internal fertilization and most species lay eggs. The development of the amniotic egg enabled reptiles to move away from a dependence upon water for reproduction. The amniotic egg provides nourishment to the embryo and protects it from drying out as it develops.

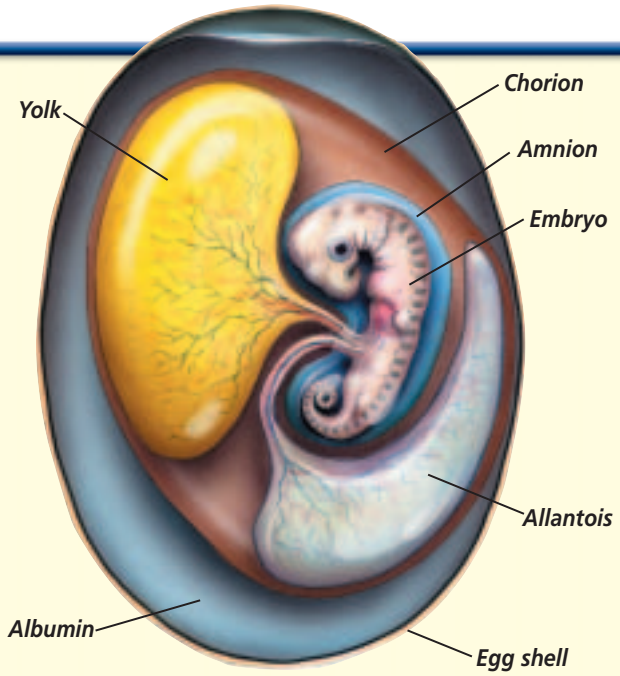
Vital Statistics

Reptiles

Size ranges: Largest: Anaconda snake, length, 9 m; Leatherback turtle, mass, 680 kg; smallest: Thread snake, length, 1.3 cm
Distribution: Temperate and tropical forests, deserts, and grasslands, and freshwater, salt-water, and estuarine habitats worldwide
Reptile that causes most human death: King cobra, 7500 deaths per year
Numbers of species:
Class Reptilia
- Order Squamata—snakes and lizards, 6800 species
- Order Chelonia—turtles, 250 species
- Order Crocodilia—crocodiles and alligators, 25 species
- Order Rhynchocephalia—tuataras, 2 species

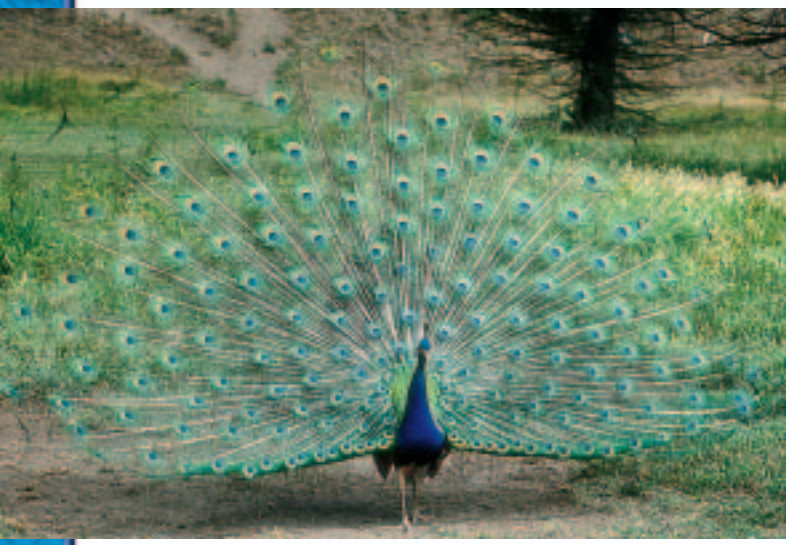
dehydration and injury to the embryo as it develops on land. Most reptiles lay their eggs in protected places beneath sand, soil, gravel, or bark.

Membranes inside the egg Membranes found inside the amniotic egg include the amnion, the chorion, and the allantois. The amnion is a membrane filled with fluid that surrounds the developing embryo. The embryo's nitrogenous wastes are excreted into a membranous sac called the allantois. The chorion surrounds the yolk, allantois, amnion, and embryo. With this egg, reptiles do not need water for reproduction. The evolution of the amniotic egg completed the move of tetrapods from water to land.



Birds

Birds are the only class of animals with feathers. Feathers, which are lightweight, modified scales, help insulate birds and enable them to fly. Birds have forelimbs that are modified into wings. Like reptiles, birds have scales on their feet and clawed toes; unlike reptiles, they are endotherms, animals that maintain a constant body temperature. Endotherms must eat frequently to provide the energy needed for producing body heat.



The male peacock displays its tail feathers to attract the female peahen. Feathers keep birds warm, streamline them for flight, and are often important in courtship or camouflage.

Penguins are flightless birds with wings and feet modified for swimming. A thick layer of insulating fat helps keep these penguins warm in the cold antarctic climate in which they live. This young emperor penguin may reach a height of 1 m and weigh nearly 34 kg.

Bird Flight

Birds have bones with cross braces that provide support for strong flight muscles. Birds also have a four-chambered heart and a unique respiratory system in which oxygen is available during both inhalation and exhalation.

Focus on Adaptations

Bird Flight

Peregrine falcon

What selection pressure may have resulted in bird flight? Maybe an early bird's need to escape from a predator caused it to run so fast its feet left the ground. Whatever caused birds to evolve an ability to fly, there must first have been adaptations that made flight possible. What are some of these adaptations? A bird that flies has a body that is lighter than that of an animal of equal size because it has little fat and air sacs throughout its body. It also has a beak instead of a heavy jaw with teeth, and its legs are made mostly of skin, bone, and tendons.

Efficient respiration Birds receive oxygenated air when they breathe in as well as when they breathe out. Air sacs enable birds to get more oxygen because 75 percent of the air inhaled by a

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Nest Builders

Like reptiles, birds lay amniotic eggs. Unlike reptiles, birds incubate their eggs in nests, keeping eggs warm until the young birds hatch.

Vital Statistics

Birds

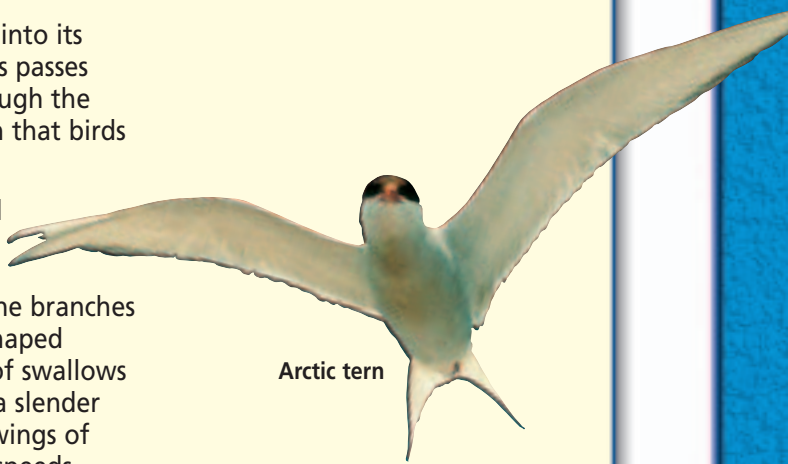
Size ranges: Largest: Ostrich, height, 2.4 m, mass, 156 kg; smallest: Bee hummingbird, length, 57 mm, mass, 1.5 g
Distribution: Worldwide in all habitats.
Widest wingspan: Wandering albatross, 3.7 m
Fastest flyer: White-throated spinetail swift, 171 kph
Largest egg: Ostrich, length, 13.5 cm, mass, 1.5 kg
Longest yearly migration: Arctic tern, 40 000 km
Numbers of species:
Class Aves—8600 species in 27 present-day orders:
- Order Passeriformes—perching song birds, 5200 species
- Order Ciconiiformes—herons, bitterns, ibises, 114 species
- Order Anseriformes—swans, ducks, geese, 150 species
- Order Falconiformes—eagles, hawks, falcons, 288 species

The cedar waxwing is found in open woodlands, orchards, and backyards across the United States. They spend most of the year in flocks, descending upon orchards and eating until the fruit is gone.

Although some birds lay their eggs on the ground or rocks, most birds do construct some type of nest into which eggs are laid. Bald eagles build the largest nests, some of which are 2 m across and 2 tons in mass.

bird passes directly into posterior air sacs rather than into its lungs. When a bird exhales, oxygenated air in the sacs passes into its lungs, then into anterior air sacs and out through the trachea. This one-way flow of air provides the oxygen that birds need to power flight muscles.

Wings adapted for flight Flight is also supported by feathers that streamline a bird's body and shape the wings. Wing shape and size determine the type of flight a bird is capable of. Birds that fly through the branches of trees in a forest, such as finches, have elliptically shaped wings adapted to quick changes of direction. Wings of swallows and terns have shapes that sweep back and taper to a slender tip, promoting high speed in open areas. The broad wings of hawks, eagles, and owls provide strong lift and slow speeds. These birds are predators that carry prey while in flight.



Arctic tern

Mammals

Mammals are endotherms that are named for their mammary glands, which produce milk to feed their young. Most mammals have hair that helps insulate their bodies and sweat glands that help keep them cool. Mammals need a high level of energy for maintaining body temperature and high speeds of locomotion. An efficient four-chambered heart and the muscular diaphragm beneath the lungs help to deliver the necessary oxygen for these activities.

Mammal Diversity

All mammals have internal fertilization, and the young begin development inside the mother's uterus. But from that point, developmental patterns in mammals diverge. Mammals are classified into three groups. Monotremes are mammals that lay eggs. Marsupials are mammals in which the young complete a second stage of development after birth in a pouch made of skin and hair on the outside of the mother's body. Placental mammals carry their young inside the uterus until development is nearly complete.

Female mammals, such as this moose, feed their young milk secreted from mammary glands. Mammals often care for their young until they become adults.

Focus on Adaptations

Endothermy

Polar bear

Both birds and mammals are endotherms. Endotherms have internal processes that maintain a constant body temperature. Just as a thermostat controls the temperature of your home, internal processes cool endotherms if they are too warm, and warm them if they are too cool, thus maintaining homeostasis.

Adaptations A variety of adaptations enables mammals to maintain body temperature. Hair helps many mammals conserve heat. The thick coat of a polar bear is an adaptation to living in a cold climate. Small ears and an accumulation of body fat under the skin also help prevent heat loss. Small ears have less surface area than large ears from which body heat can escape.

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Mammal Teeth

Mammals can be classified by the number and type of teeth they have. All mammals have diversified teeth used for different purposes. Incisors are used to cut food. Canines—long, pointed teeth—are used to stab or hold food. Molars and premolars have flat surfaces with ridges and are used to grind and chew food. By examining an animal's teeth, scientists can hypothesize what type of consumer it is.

Carnivores, such as wolves, have canine teeth that pierce food. Humans, who are omnivores, have incisors, canines, premolars, and molars in order to process many different kinds of food.

Grazing animals, such as this horse, rely on incisors to cut grasses and molars to grind and crush their food. Horses, like many other herbivores, lack canine teeth.

Vital Statistics

Mammals

Size ranges: Largest: Blue whale, length, 30 m, mass, 190 metric tons; smallest: Etruscan shrew, length, 6 cm, mass, 1.5 g
Distribution: Worldwide in all habitats
Fastest: Cheetah, 110 kph
Longest-lived: Asiatic elephant, 80 years; humans, up to 120 years
Numbers of species:
Class Mammalia
- Order Monotremata—egg-laying mammals, 3 species
- Order Marsupialia—pouched mammals, 280 species
- Orders of Placental Mammals—4418 species

Fennec fox

Hibernation Many rodents hibernate during periods of extreme cold. During hibernation, the body temperature lowers. For example, when the surrounding temperature drops to about 0°C, a ground squirrel's temperature drops to 2°C, and it goes into hibernation, which conserves the animal's energy.

Estivation In hot desert environments, where water is limited, some small rodents survive without drinking. They obtain enough water from the foods they eat. Other desert mammals, such as the fennec fox, have large ears that aid in heat loss. During periods of intense heat, some desert mammals go into a state of reduced metabolism called estivation. As a result, the animal's body temperature is lowered and energy is conserved.

Standardized Test Practice

TEST-TAKING TIP

If it Looks Too Good To Be True . . .

Beware of answer choices that seem obvious. Remember that only one answer choice of the several that you're offered for each question is correct. Check each answer carefully before finally selecting it.

Part 1 Multiple Choice

Use the information in the table to answer questions 1 and 2.

Behavior of Male Stickleback Fish	
Model Description	**Frequency of Attack**
Fish-shaped with no red belly	Low
Fish-shaped with a red belly	High
Lump of wax with red stripe at bottom	High

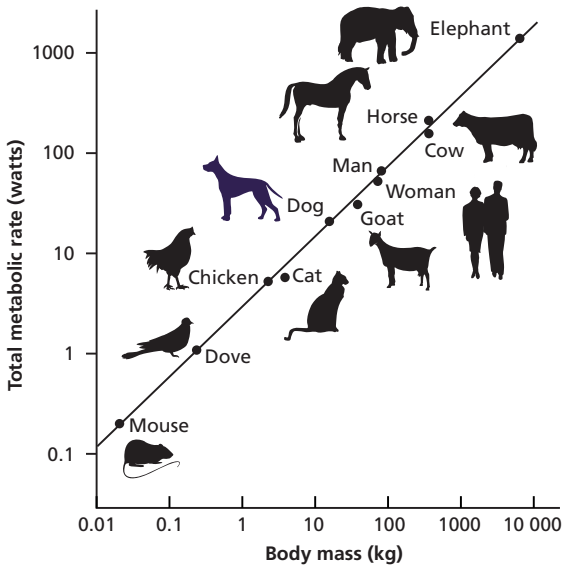
1. The bellies of male stickleback fish turn bright red during breeding season. In an experiment to test for triggers of aggressive behavior, several models were presented to live fish. Based on the results presented in the table, what can you conclude about the triggers for aggressive behavior in these fish?

- **A.** Aggressive behavior is exhibited when the fish recognizes another fish.
- **B.** Aggressive behavior is exhibited when the fish sees any type of foreign object.
- **C.** Aggressive behavior is exhibited when the fish recognizes the red belly.
- **D.** There is no pattern for aggressive behavior.

2. What is the independent variable in this experiment?

- **A.** the live fish used in the experiment
- **B.** the frequency of attacks
- **C.** the models of fish used in the experiment
- **D.** There is no independent variable.

Use the information below and your knowledge of science to answer questions 3 and 4.



3. The best description of the relationship between body mass and total metabolic rate in animals is _____.

- **A.** as body mass increases, total metabolic rate decreases
- **B.** as body mass increases, total metabolic rate stays the same
- **C.** as total metabolic rate decreases, body mass decreases
- **D.** as body mass increases, total metabolic rate increases

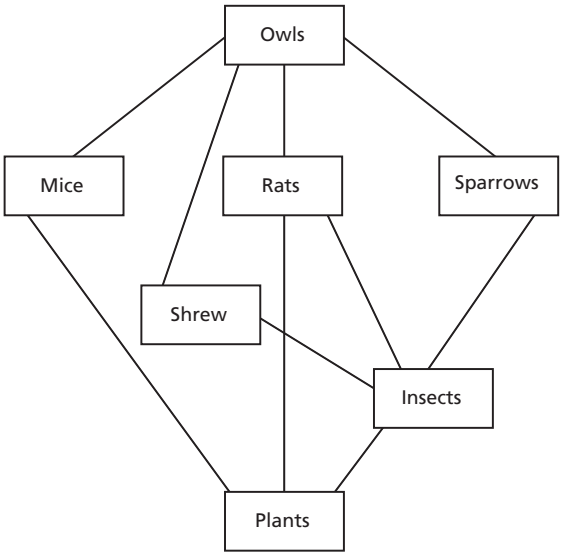
4. Which title is appropriate for this graph?

- **A.** The Relationship Between Metabolic Rate and Body Size
- **B.** The Effect of Metabolic Rate on Body Size
- **C.** The Relationship Between Metabolic Rate and Life Span
- **D.** The Effect of Body Size on Metabolic Rate

5. The arctic fox lives further north than any other terrestrial mammal. The polar climate that occurs above the arctic circle is primarily due to which of the following?

- **A.** frequent El Niño events
- **B.** intensity of solar radiation at Earth's surface decreases as latitude increases
- **C.** ocean currents flow from north to south
- **D.** ocean currents flow from south to north

Use the diagram below to answer questions 6 and 7.



6. What effects could a drastic decline in the insect population have?

A. The numbers of shrew and sparrows will increase.
B. The owls will eat more mice.
C. The numbers of shrew and sparrows will remain the same.
D. The number of rats will increase.

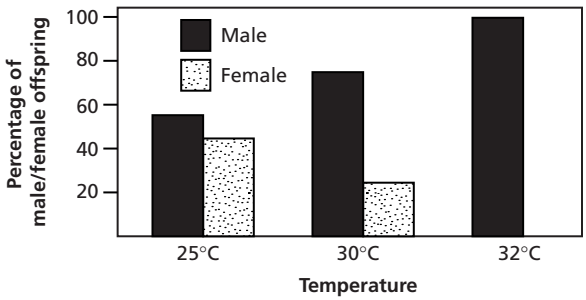
7. Which organism would be considered the top predator in this food web?

A. shrew
B. insect
C. mouse
D. owl

8. Fossil evidence has led scientists to believe that modern birds evolved directly from _____.

A. early reptiles
B. therapod dinosaurs
C. amphibians
D. mammals

Use the graph to answer questions 9–11.



The graph shows the percentage of each gender in offspring of live-bearing lizards kept at different temperatures during gestation.

9. Which temperature(s) yielded the closest ratio of male and female offspring?

A. 25°C
B. 30°C
C. 32°C
D. all of the above

10. If a lizard had been kept at 28°C, predict what percentage of the offspring would be female.

A. 100
B. 70
C. 50
D. 35

Part 2 Constructed Response/Grid In

Record your answers or fill in the bubbles on your answer document using the correct place value.

11. Grid In If four lizards were born in the group at 30°C, how many of them would most likely be male?

12. Open Ended The egg case of a certain species of skate looks like a thin, leathery pod about 5 cm long with each of the four corners ending in a small, curved spike. Form a hypothesis that explains the function of these spikes.

13. Open Ended Tiny particles have been found in the hair of a prehistoric woolly mammoth frozen in the permafrost of Siberia. The particles were of mosses, grasses, beetles, and mites. Make an inference about the environment in which this woolly mammoth lived.

14. Open Ended Wild western-lowland gorillas have been observed in the water making spectacular splash displays. Biologists hypothesize that the gorillas are using water to communicate. Infer what the gorillas may be communicating when they splash.

15. Open Ended The skin of a frog secretes mucus when it is injured or infected with microbes. Form a hypothesis about the function of the mucus and design an experiment to test your hypothesis.