Animal Behavior

BIG IDEA
Organisms use instinctive behaviors and learned behaviors to quickly adapt to their environment.

27.1 Adaptive Value of Behavior

27.2 Instinct and Learning

27.3 Evolution of Behavior

27.4 Social Behavior

Data Analysis
CONSTRUCTING BAR GRAPHS

27.5 Animal Cognition

ONLINE LABS
- QuickLab  Human Behavior
- Using an Ethogram to Describe Animal Behavior
- Pill Bug Behavior
- Animal Cognition
- Investigating Behavior
- Virtual Lab  Interpreting Bird Response

Video Lab  Territorial Behavior
**What can be learned from this chimpanzee’s behavior?**

This chimpanzee is using a leaf to drink water. Chimpanzees use a variety of tools. Bunched up leaves might serve as a sponge to sop up water for drinking or for cleaning themselves. Some chimpanzees also use twigs to dig termites out of their mounds and rocks to crack open hard-shelled nuts or fruits. Tool use is considered an example of complex behavior.

#### USING LANGUAGE

**Predictions** You are probably familiar with the phrase “It might rain today.” There are many words that are used to make predictions. In science, words such as rarely, often, and always can offer clues about the likelihood that an event will happen. Analyze the statement “Cats rarely enjoy getting a bath.” The statement tells you that most cats, but maybe not all cats, dislike baths.

#### YOUR TURN

After reading your text, use never, rarely, often, or always to fill in the blank in the following sentences.

1. New male lions _____ kill all the young cubs in the pride.
2. Territorial behavior _____ results in serious injuries.
Adaptive Value of Behavior

KEY CONCEPT  Behavior lets organisms respond rapidly and adaptively to their environment.

MAIN IDEAS
- Behavioral responses to stimuli may be adaptive.
- Internal and external stimuli usually interact to trigger specific behaviors.
- Some behaviors occur in cycles.

Connect to Your World

Animal behavior can be simple, such as a moth flying toward a light, or it can be complex, such as a chimpanzee using a leaf as a tool to drink water from a stream. At its most basic level, however, every animal behavior demonstrates the adaptive advantage of an organism’s ability to detect and respond to stimuli.

Behavioral responses to stimuli may be adaptive.

A houseplant bends its leaves toward a sunny window. A lizard moves into the shade on a hot day. A pufferfish inflates when threatened by a predator, as shown in FIGURE 1.1. Your cat comes running when it hears a can opener. What do these four observations have in common? They are all examples of organisms responding to stimuli in a beneficial way. A plant can only bend toward light by growing in its direction, but organisms such as the lizard, the pufferfish, or your cat have mechanisms that let them gather and actively respond to information. Behavior can be quite complex, especially in animals with complex nervous systems, but the adaptive nature of behavior can be seen in the relationship between a stimulus and a response.

Stimulus and Response

A stimulus (plural, stimuli) is a type of information that has the potential to make an organism change its behavior. Internal stimuli tell an animal what is occurring in its own body. For example,

- Hunger signals a need for more energy and causes an animal to search for food.
- Thirst signals a loss of internal fluid and causes an animal to look for water.
- Pain warns an animal that some part of its body may be subject to injury and causes it to take some action to avoid injury.

External stimuli give an animal information about its surroundings. For example,

- The sound of a predator can cause an animal to hide or run away to avoid being caught.
- The sight of a potential mate can trigger courtship behaviors.
- Changes in day length can trigger reproductive behaviors or migration.
Animals detect sensory information with specialized cells that are sensitive to changes in specific kinds of physical or chemical stimuli. These sensory cells may detect things such as light, sound, or chemicals. They transfer information to an animal’s nervous system. The nervous system, in turn, may activate other systems in the animal’s body that generate a response to the stimulus. For example, a stimulus may cause a gland to increase or decrease its production of a hormone. When you are startled or scared, your adrenal glands release a hormone called epinephrine that causes many other systems in your body to react in what is known as the “fight-or-flight” response. The most obvious organs activated in response to nervous activity are muscles. An animal’s ability to move is what lets it behave in response to stimuli.

**The Function of Behavior**

One way to look at an animal’s behavior is to consider it as a kind of high-level homeostatic mechanism. Recall that homeostasis refers to the maintenance of constant internal conditions. Many animal behaviors are responses to stimuli—both internal and external—that affect an individual’s well-being. For example, temperature receptors cause a lizard to move to a sunnier spot if it is too cold, or to a shadier spot if it becomes too warm. The lizard’s body has an ideal temperature, and when its actual temperature differs from its ideal temperature, the lizard behaves in a way that returns its body to its ideal temperature.

Kinesis and taxis are two simple types of movement-related behaviors that illustrate behavior’s adaptive nature. Both behaviors cause an animal to go from a less desirable location to a more desirable location. **Kinesis** is an increase in random movement that lasts until a favorable environment is reached. For example, when a pill bug begins to dry out, its activity increases until it happens upon a moist area, after which its activity decreases again. **Taxis** is a movement in a specific direction, either toward or away from a stimulus. For example, *Euglena* are light-sensitive and will move toward a light source.

Like any trait, the way an animal behaves can vary from individual to individual. A kudu that waits too long to run may wind up being a lion’s dinner, as shown in **Figure 1.2**. A male mockingbird with a weak repertoire of songs may not attract a mate. Animals with more successful behaviors tend to have more offspring. If the behaviors are heritable, their offspring will likely behave in similar ways. Just like any of an animal’s characteristics, behaviors can evolve by natural selection.

**Analyze** How is taxis or kinesis an example of the adaptive nature of behavior?
Internal and external stimuli usually interact to trigger specific behaviors.

Some behaviors can be triggered by a single stimulus, but most behaviors occur in response to a variety of internal and external stimuli. For example, an external signal, such as a change in day length, might cause an animal to secrete specific hormones. These hormones act as internal signals that cause other physiological changes. These changes, in turn, make the animal more likely to respond to another external stimulus, such as the mating display of an individual of the opposite sex. This kind of interaction can be seen in the reproductive behavior of green anoles.

Green anoles are small lizards that live in the woodlands of the southeastern United States. During most of the year, female anoles ignore males. However, their behavior changes each spring, when males begin to aggressively guard territories and court females. Two external stimuli trigger the females' change in behavior. First, females must be exposed to long days and short nights. Females must also see reproductively active males.

To court females, males that are ready to mate bob their bodies up and down while extending their dewlap. The dewlap, shown in FIGURE 1.3, is a flap of bright red skin under the lizard's chin. Seeing the red dewlap during the spring makes females release sex hormones into their bloodstream. Sex hormones are an internal signal that make females reproductively receptive.

Experiments with female anoles have shown that their reproductive behavior depends on the presence of both external and internal signals. Females that do not have sex hormones do not respond to courtship. And hormones are not released unless females are exposed to both external stimuli.

Connect What might be internal and external stimuli that cause you to wake up in the morning? TEKS 11A

Some behaviors occur in cycles.

Many environmental changes are predictable, especially those that occur on a daily, monthly, or yearly basis. Animals often use cues such as differences in day length to keep track of these changes, triggering adaptive changes in their behavior. For example, in order to be active during the day, your body requires a period of sleep every night. This daily pattern of activity and sleep is an example of a circadian rhythm. A circadian rhythm (suhr-KAY-dee-uhn) is the daily cycle of activity that occurs over a 24-hour period of time.

These activity patterns are controlled by an internal mechanism called a biological clock. Evidence indicates that an organism's biological clock is run by a combination of melatonin secretions by the pineal gland in the brain and proteins in the body that can detect changes in light.
Hibernation
Hibernation is a behavior in which an animal avoids cold winter temperatures by entering into a dormant state. During hibernation, an animal, such as the dormouse shown in Figure 1.4, has a lower body temperature, reduced heartbeat, and a slowed breathing rate. Hibernating animals prepare for the winter by eating large amounts of food and storing it as fat. This layer of fat not only provides a food source for the animal but also provides additional insulation from the cold.

External factors such as light intensity and temperature determine when an animal enters and leaves hibernation. Shorter days and cooler temperatures cause animals to enter hibernation in the fall. In the spring, increasing day length and warmer temperatures cause the secretion of hormones that awaken the animal out of its dormant state.

Migration
Many kinds of animals migrate, but you are probably most familiar with bird migration. If you’ve ever seen—or heard—a flock of geese flying southward during the fall, you’ve seen bird migration in action. Migratory Canada geese typically spend the spring and summer in Canada and the northern United States. They spend the winter in the southern United States and northern portions of Mexico. Like hibernation, migratory behavior allows animals to avoid harsh conditions in their home range for a part of the year.

Migration is set in motion by a variety of internal and external stimuli. A change in day length during the spring and fall stimulates a change in the portion of the bird’s brain that controls hunger. This change causes birds to gain weight. An increase in fat storage is needed to fuel the bird’s long-distance migration.

Infer How might climate change affect animal migration patterns? TEKS 11B

FIGURE 1.4 During hibernation, the dormouse’s blood temperature drops from 36°C (97°F) to just above 0°C (32°F).

27.1 Formative Assessment

**REVIEWING MAIN IDEAS**

1. Why are behavioral responses to stimuli considered to be adaptive?
2. What internal and external stimuli might signal to Alaskan caribou that it is time to migrate? TEKS 11A
3. What is the connection between a circadian rhythm and the biological clock? TEKS 11A

**CRITICAL THINKING**

4. Relate What is the relationship between an animal’s behavior and homeostasis? TEKS 11A
5. Analyze Why is it important for animals to respond to external factors? TEKS 11B

**CONNECT TO**

**SEXUAL SELECTION**

6. A peacock uses its colorful train of feathers to attract a mate. What factors might control how large a peacock’s train of feathers may grow to be?
Both genes and environment affect an animal’s behavior.

Innate behaviors are triggered by specific internal and external stimuli.

Many behaviors have both innate and learned components.

Learning is adaptive.

Connect to Your World

Why are some families filled with good athletes? Is athleticism passed on from parent to child? Or are younger generations repeating behaviors they watched while they were growing up? You may have heard this “nature versus nurture” debate about many human behaviors, including musical ability, addiction, and thrill seeking. But research shows that genetic and environmental factors interact in most behaviors. “Nature versus nurture” is a false division. Most behaviors represent a mixture of both nature and nurture.

Innate behaviors are triggered by specific internal and external stimuli.

Nothing teaches a spider to build a web. It builds it correctly the first time it tries. This kind of complex inborn behavior is called an instinct. Instinctive behavior is characterized as being innate and relatively inflexible. An innate behavior is performed correctly the first time an animal tries it, even when the animal has never been exposed to the stimulus that triggers the behavior. An inflexible behavior is performed in a similar way each time.

Instinctive behaviors are typically found where mistakes can have severe consequences. Baby mammals that do not suckle die of starvation. Newly hatched sea turtles, such as those shown in Figure 2.1, that do not race to the ocean will be eaten by predators. By having set reactions to particular stimuli, animals can automatically respond correctly in a life-or-death situation.

Instinctive behavior is especially important in newborns, who have had no time to learn any behaviors. Performing certain innate behaviors is key to both the animal’s survival and its ability to pass its genes on to future generations. Animals that do not perform a necessary innate behavior will likely die.

Many innate behaviors are triggered by a simple signal. The signal is called a releaser because it makes the animal run through a behavior. Releasers can be any kind of stimulus: a visual sign, a sound, a scent, or a touch. When a releaser signal has been detected, the animal’s nervous system triggers the expression of a specific behavior. Sometimes the triggered behavior is fixed, and the animal runs through a set sequence of movements each time the behavior is performed.

FIGURE 2.1 After hatching from its egg, a leatherback sea turtle hatchling instinctively makes its way to the ocean, where it will remain until maturity.
Dutch zoologist Niko Tinbergen's experiments with herring gulls showed how simple releasers can be. Hungry herring gull chicks will peck at a red spot at the tip of a parent's bill. The parent usually responds by coughing up a bit of half-digested fish for the chick to eat. Very young chicks do not actually recognize their parent when they beg for food. Instead, the behavior is triggered simply by the sight of a long bill with a red dot near its tip. The chicks will beg from any long object with a red dot, including cardboard cutouts of a herring gull head and the end of a painted stick. Other gull species, such as the lesser black-backed gull shown in Figure 2.2, also have red-dotted bills.

Biologists think that innate behaviors are hard-wired into an animal’s nervous system, but they have studied the details for only a few invertebrate species. Innate behaviors are heritable and are strongly affected by gene expression. But they can also be changed by environmental factors. For example, during its lifetime, a honeybee moves through a sequence of innate behaviors that help to maintain the hive. The behaviors are regulated by different sets of genes. As a bee ages, its brain cells express different genes and its behavior changes. But gene expression is also affected by the hive’s social environment. If a hive has few older foragers, some of the younger bees will mature faster. Even the bill-pecking behavior of gulls has been shown to improve with age, as young herring gulls become more accurate in their ability to aim their pecks at the red spot on their parent’s bill.

Apply Why is behavior considered to be a mixture of both nature and nurture?

MAIN IDEA

Many behaviors have both innate and learned components.

Animals often change their behavior as they gain real-world experience. In other words, animals learn. Learning takes many forms, ranging from simple changes in an innate behavior to problem-solving in new situations. In each case, learning involves the strengthening of nerve pathways. Most animal behaviors are not simple reactions to stimuli using preset pathways in the animal’s brain. Instead, they represent a combination of innate tendencies influenced by learning and experience.

Habituation

Garden shops sell plastic owls that are supposed to frighten away birds. But a gardener who doesn’t move the owls every few days may soon see birds sitting on top of them. This is an example of habituation. Habituation occurs when an animal’s behavioral response decreases due to a repeated stimulus, even if it has features that trigger innate behaviors. The habit of seeing owls in the exact same place in the garden every day causes the birds to get used to, and basically ignore, the stimulus.

CONNECT TO

BRAIN CHEMISTRY

Research indicates that during learning, some neurons undergo structural and molecular changes that allow for the easier flow of information. You will learn more about the structure and function of neurons in the chapter Nervous and Endocrine Systems.
Imprinting

Imprinting is a rapid and irreversible learning process that only occurs during a short time in an animal’s life. During this critical period the animal may, for example, learn to identify its parents, its siblings, its offspring, characteristics of its own species, or the place it was born.

Austrian zoologist Konrad Lorenz’s studies with graylag geese are among the most famous studies of imprinting. Newly hatched graylag geese normally imprint on their mother during the first two days after hatching. After this period, the goslings will follow their mother and eventually grow up to mate with other graylag geese. Lorenz divided a clutch of goose eggs in half, leaving some with the mother and raising the rest himself. The goslings that stayed with their mother behaved normally. Their siblings, which stayed with Lorenz during their critical period, did not recognize other geese as members of their own species. They followed Lorenz as goslings, and tried to mate with humans when they matured. This experiment showed that imprinting is an innate and automatic process, even though the behavior’s stimulus is learned.

When working to reintroduce species into the wild, it is important to avoid having the animals imprint on their human handlers. For example, when working with endangered wattled cranes, scientists try to minimize the birds’ contact with humans. When humans need to interact with the cranes, they wear costumes that cover their entire bodies. They use puppets painted to look like adult cranes to feed the young, as shown in FIGURE 2.3.

FIGURE 2.3 To avoid having cranes imprint on their human handlers, biologists use puppets painted to resemble the head of an adult crane to feed young birds raised in captivity.
Imitation

In imitation, animals learn by observing the behaviors of other animals. The initial behavior becomes a model that the other animals try to copy. Young male songbirds learn to sing by listening to adult males and trying to repeat what they hear. By trial and error, over time they begin to sing the species-specific song they heard from adults. Human babies also imitate adults in a number of ways, such as when they learn to speak their native language.

Not all imitative behaviors are passed from adult to younger animals, however. For example, consider the potato washing behavior among Japanese macaques, or snow monkeys, shown in Figure 2.4. A juvenile female monkey, named Imo by researchers, discovered that it was easier to wash sand off a potato by dipping it in water rather than by brushing it off with her hands. At first, only her brothers and sisters imitated the behavior, followed by her mother. Over a period of time, a number of individuals in the troop adopted the potato washing behavior.

Infer What would be the harm of having a captive animal intended for release imprint on its human handlers?

MAIN IDEA

Learning is adaptive.

Animals that are able to learn can modify, or change, their behavior to better adapt to new situations. This ability to learn can give animals an edge in survival and reproduction, allowing them to pass their genes on to future generations.

Associative Learning

In associative learning, an animal learns to associate a specific action with its consequences. For example, an experiment with young blue jays showed that the birds do not identify prey instinctively. Instead, they ate every new insect that was offered to them. Insects that tasted good, such as grasshoppers, they ate again and again. But it only took one experience with a bad-tasting monarch butterfly to make the jays avoid them for the rest of their lives. The jays learned to associate the monarch’s distinctive orange and black markings with its bad taste. Such trial-and-error learning can help animals to survive within their environments.

One type of associative learning studied by animal behavior scientists is conditioning. Conditioning is a way to modify an animal’s behavior in response to certain stimuli. When teaching an animal by conditioning, two stimuli are paired together, and an animal is conditioned to give a specific response to these stimuli. The two main types of conditioning are called classical conditioning and operant conditioning.
Classical Conditioning

Classical conditioning is a process in which an animal learns to associate a previously neutral stimulus with a behavior that was once triggered by a different stimulus. Ivan Pavlov, a Russian physiologist, was studying digestion in dogs when he realized that salivation, or drooling, is an automatic behavior. Pavlov created an experiment to determine if external stimuli are involved in this behavior.

- Normally, the presence of food makes a dog salivate.
- A bell is rung when food is presented to the dog.
- The dog salivates because of the presence of the food.
- After constantly being presented with both food and the ringing bell at the same time, when only the bell is rung, the dog salivates even though the food is not present.

In this experiment, the ringing bell is initially a neutral stimulus. The response in which the dog salivates upon hearing the ringing bell is the conditioned response. Because the dog was given food at the same time the bell rang, the dog has been conditioned to salivate when the bell is rung because it also expects to be given food.

Operant Conditioning

Operant conditioning is a process in which the likelihood of a specific behavior is increased by reinforcement. In positive reinforcement, such as a food reward as shown in Figure 2.5, a reward is given to increase a behavior. Negative reinforcement is the removal of a negative or aversive stimulus to increase a behavior.

B. F. Skinner, an American psychologist, created “Skinner boxes” to study operant conditioning. A Skinner box is a cage that has a bar or pedal on one wall. When an animal such as a rat pushes down on the bar, a food pellet pops out. The rat then associates the behavior of pressing the bar with the food reward, even if not rewarded every time. If the behavior is no longer rewarded, the rat will, over time, stop performing it.

Apply How might you train a dog to do a trick using positive reinforcement?

27.2 Formative Assessment

REVIEWING MAIN IDEAS

1. What is the difference between an **instinct** and a learned behavior?
2. Describe a behavior that you learned by **imitation**.
3. Using either classical or operant **conditioning** as an example, explain how learning can be adaptive.

CRITICAL THINKING

4. **Apply** Ducklings that are shown a paper silhouette of a hawk initially freeze and cower. After repeated exposure to the silhouette they stop responding. What is this lack of response called?
5. **Summarize** What is the connection between neurons in the brain and learning?

CONNECT TO EVOLUTION

6. Monarch butterflies are toxic. Viceroy butterflies, which look like monarch butterflies, are not toxic, but birds avoid them anyway. Explain how the bird behavior described in this section could have influenced the evolution of viceroy.
Evolution of Behavior

**KEY CONCEPT**
Every behavior has costs and benefits.

**MAIN IDEAS**
- Even beneficial behaviors have associated costs.
- Animals perform behaviors whose benefits outweigh their costs.

**Connect to Your World**

The zebra was very thirsty. It flicked his ears to and fro as it walked toward the water hole, listening carefully for any sign of a hungry lioness. Nothing looked out of the ordinary. But as it neared the edge of the water, it saw a crocodile lurking in the shallows. The zebra quickly retreated and trotted back to its herd. It needed water, but the risk to its life was too great.

**MAIN IDEA**
Even beneficial behaviors have associated costs.

Every behavior has benefits and costs. Shorebirds travel thousands of miles during their spring and fall migrations, burning through an enormous amount of energy in the process. But migration increases a bird's chances of survival by escaping from cold seasonal temperatures to warmer locations.

**Benefits of Behavior**
From an evolutionary standpoint, the most important benefits of a behavior include increased survivorship and reproduction rates. Survivorship refers to the number of individuals that survive from one year to the next. Certain behaviors reduce the chance that an animal will die in a given time period. Similarly, some behaviors increase the number of offspring that an animal will have during its lifetime.

Behaviors that increase an individual's survival and reproduction are behaviors that increase its fitness. These behaviors will be favored by natural selection, but they still have associated costs. For instance, when a sea star touches a sea anemone called Stomphia, the anemone stops feeding, wrenches free of the sea bottom, and swims away. Escape behaviors such as this are expensive in terms of energy in the short term. The animal stops eating and uses up stored energy. But dead animals cannot reproduce. The long-term benefit of the behavior is the increase in the animal's survival and reproduction rates.

**Costs of Behavior**
Behavioral costs can be broken down into three basic categories. 

**Energy costs** Every animal behavior, such as running away from a predator, uses up ATP. When an animal uses metabolic energy for one behavior, such as searching for a mate, that energy is not available for other needs, such as searching for food.
Opportunity costs  Every animal behavior takes time. When an animal spends time doing one behavior, it loses the opportunity to do a different behavior. For example, when a songbird defends its territory from rivals, it is using time that could have been spent eating or mating.

Risk costs  Many behaviors expose an individual to possible injury or death. All animals have to look for food, but foraging also increases the chance that an animal will meet a predator. In many species, males risk injury by fighting for access to females during the breeding season.

Some behaviors that seem harmful may have surprising benefits for an animal. For example, while most male spiders go to great lengths to avoid getting eaten by their mates, a male Australian redback spider deliberately flips his abdomen over the female’s mouth, as shown in Figure 3.2. As they mate, she literally eats him alive. His behavior clearly does not increase his survival. But because she lets him fertilize more of her eggs, it has the benefit of increasing his reproductive success.

Analyze  What is the benefit of bird migration? The cost?

MAIN IDEA  TEKS 7D

Animals perform behaviors whose benefits outweigh their costs.

It is difficult to determine if animals make conscious decisions about their actions. Whether behavioral responses are automatic or reflect more complex cognitive processes, they evolve only if they improve the fitness of those individuals that perform them. Territoriality and optimal foraging are just two examples that demonstrate how animal behaviors are expressed if their benefits outweigh their costs.

Territoriality  Territoriality refers to the control of a specific area—or territory—by one or more individuals of an animal species. The benefit of territorial behavior is the ability to control the resources within the animal’s territory, such as food or access to potential mates. The costs associated with territorial behavior include the energy and time that could have been used for feeding or mating. That time is instead spent protecting territory from invasion by other animals.

Consider the territorial behavior of the Hawaiian honeycreeper. This bird feeds on the nectar of flowers, and it defends a territory that has the flowers from which it feeds. The benefit of holding a territory can be measured in the amount of nectar the bird can get from the flowers located in its territory. An individual should only defend a territory if that territory holds enough flowers to provide the food it needs to at least offset the energy cost of defense. Studies of honeycreeper behavior have shown that individuals stop defending territories when the number of flowers falls below a certain minimum or exceeds a certain maximum number. Individuals only defend a territory in which there is a benefit from excluding other individuals, and in which the energy benefit from the nectar outweighs the energy cost of the defensive behavior.
Optimal Foraging

When animals search for food, they must make decisions about what they should eat. The benefits of foraging are measured in the amount of energy gained. The costs of foraging include the energy used to search for, catch, and eat food; the risk of capture by a predator while foraging; and the loss of time to spend on other activities. The theory of **optimal foraging** states that natural selection should favor behaviors that get animals the most, or optimal amount of, calories for the cost.

The foraging methods of oystercatchers, a type of shorebird shown in **FIGURE 3.3**, have been the subject of many studies. As the birds’ name suggests, they eat bivalves such as oysters and mussels. Some birds sneak up on relaxed bivalves and quickly stab out the meat. Others use their chisel-shaped beak to hammer a hole through the shells.

Hammering oystercatchers get a benefit from eating the mollusks, but at the cost of the time and energy it takes to break open their shells. Small mussels are easy to open, but don’t contain much meat. Larger mussels are meatier but harder to open. Scientists first hypothesized that oystercatchers would prefer to eat the largest mussels they could find. These mussels contained the most meat for the time the birds spent opening them.

When the biologists observed oystercatchers in the wild, they found that the birds did not eat the largest mussels they could find. Their experiment showed that there was another cost to eating mussels. Their first model assumed that the birds could open any mussel given enough time. However, their experiment showed them that the birds also faced a “handling cost” when they hunted. Birds that picked very large mussels lost time handling bivalves they could not open. They actually got less meat on average than birds that ate smaller mussels. Oystercatchers that learn to hunt medium-sized mussels get the most food for their efforts. Better-fed birds have higher survivorship so they reproduce more and their chicks, in turn, learn this behavior.

**Apply**  How does optimal foraging improve an individual’s overall fitness?

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**27.3 Formative Assessment**

**REVIEWING MAIN IDEAS**

1. Compare the three categories of behavior costs.
2. Any animal behavior has a cost and a benefit. Explain this statement using **optimal foraging** as an example.

**CRITICAL THINKING**

3. **Infer** What might be a stimulus that triggers a songbird’s territorial behaviors?
4. **Analyze** Some species of cichlid fish hold their fertilized eggs inside their mouths until they hatch. What might be the costs and benefits of this behavior?

**SCIENTIFIC PROCESS**

5. Some spiders build webs that include visible zigzag lines of silk. But more visible webs catch fewer insects than do less visible webs. Hypothesize what benefits the spider gets by building such a visible web.
Insight Into Instincts

WebQuest

Animal Cognition  Explore examples of animal cognition as well as experiments used to test the mental capabilities of animals.

Sharks Vs. Dolphins
Can the brains and speed of dolphins outmatch the size and serrated teeth of sharks? Find out how scientists determine whether dolphins are afraid of sharks.

Animated BIOLOGY

Behavioral Costs and Benefits  Have a hummingbird use optimal foraging and defensive strategies to maximize its limited energy supply.

That’s Amazing! VIDEO INQUIRY

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Social Behavior

KEY CONCEPT  Social behaviors enhance the benefits of living in a group.

MAIN IDEAS
- Living in groups also has benefits and costs.
- Social behaviors are interactions between members of the same or different species.
- Some behaviors benefit other group members at a cost to the individual performing them.
- Eusocial behavior is an example of extreme altruism.

Connect to Your World
Many factors determine if a species lives alone or in a group. Even closely related species have different living patterns. Such is the case with marmots. Woodchucks (*Marmota monax*), found in the eastern United States, live alone. Yellow-bellied marmots (*Marmota flaviventris*), which live out west, live in colonies.

MAIN IDEA
Living in groups also has benefits and costs.

Some species, such as the emperor penguins shown in Figure 4.1, live together in groups. These groups may have a definite social structure or they may have a constantly changing membership. Social behaviors evolve in species in which the benefits of group living outweigh its costs.

Benefits of Social Behavior
Living in a social group provides significant benefits to individuals within the group. Living in a group may lead to improved foraging, as an individual can follow other members of the group to good feeding sites. Immature or non-reproductive members of the group can provide assistance to those who do reproduce by helping to gather food or protecting newborn members. Living in a group increases the chances of reproductive success. Having more eyes and ears in the group helps in detecting predators. Although groups of animals are easier for predators to spot, a predator can usually capture only one member of a group in any attack, letting the others escape.

Costs of Social Behavior
Living in a group also comes at some cost to an individual. Living together in large groups leads to increased visibility. A group of animals cannot hide from predators as easily as an individual can. Group living also leads to increased competition. A limited amount of resources, such as food or mates, can lead to conflicts between group members. Animals that live together in groups also have an increased chance of contracting diseases or passing parasites to each other. As group size increases, so does the risk.

Connect  What is the benefit of doing group work in class? Are there any drawbacks?
Social behaviors are interactions between members of the same or different species.

Social behaviors are behaviors animals use when interacting with members of their own or other species. These behaviors help to make interactions such as mate selection easier, and they often involve specialized signals.

Communication
Animals use communication as a way to keep in contact with one another, raise alarm in the presence of danger, and attract a mate.

Visual
Gestures or postures, such as the submissive posture of a dog with its tail between its legs, may help to identify an animal's status in the group.

Sound
Animals often use calls to identify offspring, such as the specific call shared between a young penguin and its parents. Alarm calls and distress calls alert others to the presence of a threat. Mating calls are also used to advertise an animal's readiness to mate, increasing reproductive success.

Touch
Bees use their antennae, for example, to interpret the waggle dance performed by a scout bee in order to locate a food source outside the hive.

Chemical
Some animals communicate by using pheromones. Pheromones are chemicals released by an animal that affect the behavior of other individuals of the same species. Often, these chemicals announce an animal's readiness to mate. Odors are also used to identify group members and mark territory.

Mate Selection
Courtship displays are behaviors most often used by male members of a species to attract females. Scientists theorize that females use courtship displays to judge the condition of their potential mate or the quality of his genes. By being choosy about a mate, a female can help ensure that her offspring have the best chance of survival. While some behaviors may be simple in nature, such as the leg-waving dance display of the jumping spider, other behaviors are more elaborate. For example, as shown in Figure 4.2, the male satin bowerbird of Australia constructs a nest site, called a bower, that is decorated with brightly colored and shiny objects. Females inspect the bowers when choosing a mate.

Defense
Defensive behaviors include aggressive actions to protect both the individual and the group. For example, when threatened, an elephant herd will form a protective circle surrounding the younger members of the family group.

Another defensive behavior is mobbing by birds. When a predator is spotted, flocks of birds, sometimes of different species, will join together to harass the intruder to force it to leave. Keeping watch is another defense tactic. For example, while foraging, one or more members of a giraffe herd will serve as a lookout for the group. While vigilant individuals forage less, they also benefit themselves and their group by keeping an eye out for predators.

Infer How might the size of a group affect its defense?
Some behaviors benefit other group members at a cost to the individual performing them.

Individuals that live in a social group often help one another. They may share food or warmth or warn others about an approaching predator. But remember that animals typically perform behaviors that aid their own fitness. In some cases, however, social behaviors seem to reduce the fitness of the individuals that perform them. How could such behaviors evolve?

**Types of Helpful Social Behavior**

Most social interactions between animals improve the survival and reproduction of both individuals. The three kinds of helpful social behavior are cooperation, reciprocity, and altruism.

Cooperation involves behaviors that improve the fitness of both individuals. For example, lionesses hunt in a group and share the prey they catch, even though only one member of the pride may have made the kill.

Reciprocity involves behaviors in which individuals help other group members with the expectation that they will be helped in return. For example, vampire bats form feeding relationships with one another. Bats that have fed will regurgitate blood for other bats that are hungry. The cost to the donor bat is small. But there is a large benefit for the hungry bat, because vampire bats starve if they do not eat every few nights. By giving up some food, the donor ensures that it will be fed when it is hungry.

**Altruism** is a kind of behavior in which an animal reduces its own fitness to help other members of its social group. In other words, the animal appears to sacrifice itself for the good of the group. Consider the behavior of Belding’s ground squirrels. A Belding’s ground squirrel, shown in **FIGURE 4.3**, is a small rodent that lives in large colonies on open grasslands such as the alpine grasslands surrounding the Sierra Nevada mountains in California. When ground squirrels are active during the late spring and summer, they are hunted by predators from the air and on the ground. When an individual spots a predator, it may give an alarm call to alert the rest of the colony. But alarm calls are costly. A calling ground squirrel is twice as likely to be killed as a ground squirrel that does not call. Calling benefits other colony members because it gives them time to escape, but it is harmful to the caller.

**Evolution of Altruism**

How can we explain the evolution of altruism if behavior is supposed to increase fitness? British evolutionary biologist William Hamilton addressed this puzzle by asking how alleles involved in altruistic behavior could spread through a population. He realized that alleles can be transmitted and therefore spread in a population two ways, either directly from an individual to its offspring or indirectly by helping close relatives survive.
When an animal reproduces, its offspring gets half of its alleles. But its relatives also share some of the same alleles, in the following proportions:

- Parents and siblings share 50 percent of the animal's alleles.
- Nephews and nieces share 25 percent of its alleles.
- First cousins share 12.5 percent of its alleles.

The total number of genes an animal and its relatives contribute to the next generation is called its **inclusive fitness**. It includes both direct fitness from reproduction and indirect fitness from helping kin survive. When natural selection acts on alleles that favor the survival of close relatives, it is called **kin selection**.

If kin selection explains the squirrels’ altruism, callers should be closely related to others in the group. Ground squirrel colonies are made up of closely related females and unrelated males. Males do not call much. Nor do adult females foraging alone. The ones that risk their lives are adult females foraging near their daughters, siblings, and nieces. They are warning their relatives.

**Infer** Why is altruistic behavior not very common?

### Eusocial behavior is an example of extreme altruism.

Relationships within populations of some social animals are very specialized. **Eusocial** species live in large groups made up of many individuals, most of whom are members of nonreproductive castes such as workers or soldiers. All of the young in the colony are the offspring of one female, called the queen. Other adults look for food, defend the colony, care for the queen, and raise her offspring. Eusocial behaviors likely evolve by kin selection.

#### Social Insects

Many social insects, such as bees, ants, and wasps, are haplodiploid, which means their sex is determined by the number of chromosome sets in an individual. Males are haploid and females are diploid. Female social insects produce daughters through eggs fertilized by sperm. Unfertilized eggs produce sons. In these animals, daughters share half of their mother’s alleles but all of their father’s alleles. Sisters therefore share up to 75 percent of their alleles overall with one another, compared with 50 percent in humans and most other animals. The very close relationship between sisters in a colony may influence the evolution of eusociality in these insects.

As shown in **Figure 4.4**, weaver ants are one example of a eusocial insect species. The three main castes of this species are a queen, major workers, and minor workers. The worker ants work together to weave their nests from leaves that hang from branches throughout one tree or several trees located next to one another. The ants communicate by secreting pheromones. For example, the queen secretes pheromones that induce workers to groom or feed her. If threatened, major worker ants may release pheromones to call in reinforcements to help protect the nest.
What genetic benefit does a worker ant receive by taking care of its siblings?
CONSTRUCTING BAR GRAPHS

An ethogram is a catalogue of the types of behaviors an animal may perform. A time budget shows how much time organisms spend engaged in each type of behavior. Scientists can use these time budgets to compare patterns of behavior between different species, or between different sexes or age groups of the same species.

Table 1 contains data that were recorded through observations of male and female black-shouldered kites, a type of hawk, during the summer.

1. **Graph Data** Construct a time budget that shows the percent of time (per 24-hour period) the hawks spent in each behavior. (Hint: Remember to convert the amount of time to a percent before graphing.)

2. **Analyze** What behavior did the hawks spend the most time engaged in? Why do you think this behavior was most common?

### Other Eusocial Animals

Eusocial termites, snapping shrimp, and naked mole rats are all normal, diploid animals. But their colonies are still made up of closely related animals. These animals often live in areas where it is difficult for individuals to survive on their own. For example, naked mole rats live in colonies of 70 to 80 individuals dominated by a single queen and a few fertile male “kings.” Most of the colony are the queen's siblings or offspring. Nonreproducing adults are either soldiers or workers. Soldiers defend the colony, while workers work together as a chain gang to dig through the soil to find edible tubers. This eusocial behavior may have evolved due to the amount of work needed to find food. If leaving the colony leads to starvation, kin selection may favor staying in the burrow to work together as a group instead.

### APPLY

How are eusocial behavior and a species’ level of relatedness connected?

---

**TABLE 1. KITE BEHAVIOR**

<table>
<thead>
<tr>
<th>Behavior</th>
<th>Time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active perching</td>
<td>162</td>
</tr>
<tr>
<td>Hunting flight</td>
<td>194</td>
</tr>
<tr>
<td>Cruising flight</td>
<td>4</td>
</tr>
<tr>
<td>Other flight</td>
<td>7</td>
</tr>
<tr>
<td>Feeding nestlings</td>
<td>26</td>
</tr>
</tbody>
</table>


---

**27.4 Formative Assessment**

**REVIEWING MAIN IDEAS**

1. Outline the costs and benefits of living in a group. [TEKS 7D]
2. Use an example to explain what social behavior is.
3. What are the three types of helpful behavior?
4. What characteristic makes a social group *eusocial*?

**CRITICAL THINKING**

5. **Connect** Give an example of reciprocal behavior from everyday life.
6. **Analyze** Why might a juvenile scrub jay help its parents raise a new brood of chicks instead of building its own nest?

---

**CONNECT TO GENETICS**

7. How is a haplodiploid species different from a diploid species?
Connect to Your World

No one would deny that humans are intelligent animals. We surround ourselves with invented objects, from the clothes we wear to the buildings in which we live. But from where did human cognition come? And do other animals share aspects of this ability to think about the world?

MAIN IDEA

Animal intelligence is difficult to define.

In the first half of the 20th century, the focus of many animal intelligence studies was determining whether a certain animal was “intelligent” according to human standards. Today, learning how an animal’s level of intelligence compares with a human’s is no longer a focus of research. Instead, as shown in FIGURE 5.1, scientists study an animal’s cognitive abilities. Cognition is the mental process of knowing through perception or reasoning. Cognitive behavior also includes awareness and the ability to judge. Animals with a higher level of cognition can solve more complex problems.

In contrast to intelligence, which is difficult to define and measure, cognitive abilities can be more objectively described and measured. However, even an animal’s cognitive abilities can be difficult to distinguish from other factors that might be affecting an animal’s behavior.

For example, in the early 1900s, a horse in Germany nicknamed Clever Hans seemed to be able to solve math questions by using its hoof to tap out the correct answer. However, upon closer inspection it was found that the horse’s ability to tap out the correct answer had nothing to do with mathematical skills. Instead, it was relying on changes in the posture or facial expressions of its trainer. The horse was able to perceive the increased tension in its trainer when it neared the correct answer, and would stop tapping its hoof. This example illustrates how difficult it can be to determine the cognitive abilities of animals. While the horse was unable to solve mathematical problems, it can be argued that its ability to perceive changes in its trainer’s posture is an example of cognition on a different level.

Analyze Why do scientists focus on an animal’s cognitive abilities rather than its “intelligence” when studying animal behavior?
Some animals can solve problems.

Scientists sometimes study how animals think by giving them problems to solve. If cognition involves the ability to invent new behaviors in new situations, then animals with cognitive abilities should be able to solve problems they have never encountered before. Different species react to new situations with varying amounts of success.

Problem-Solving Behavior

Researchers have observed extremely complex problem-solving behavior in primates, dolphins, and the corvids—a group of birds that includes crows, ravens, and jays. In one classic study, a chimpanzee was placed in a room containing boxes, sticks, and a banana hung out of reach. At first, the chimp sat around and did nothing. But after a while it suddenly piled up the boxes and climbed up to knock down the fruit with a stick. This ability to solve a problem mentally without repeated trial and error is called insight.

Tool Use

Tools are inanimate objects that help an animal accomplish a task, such as collecting hard-to-reach foods. A number of different animals use tools. For example, Australian bottlenose dolphins use pieces of sponge to cover their snouts when foraging. In addition to protecting their noses from stonefish stings, this method also helps to scare up fish from the ocean floor. Some primates and New Caledonian crows have been observed making tools. Chimpanzees trim sticks to make termite probes. As shown in Figure 5.2, brown capuchin monkeys use rocks to crack open palm nuts. In one experiment, crows given straight wires bent the wire to make a hook and then used it to fish food out of a tube. Tool use itself is not a sign of cognitive ability. But making tools suggests that an animal can understand cause and effect, and can make predictions about its own behavior.

Contrast  What is the difference between insight and associative learning?

Cognitive ability may provide an adaptive advantage for living in social groups.

Animals we recognize as the most “intelligent” often have two things in common. They have relatively large brains for their body size, and they live in complex social groups. More neurons may mean more interconnections and greater opportunities for complex behaviors to emerge. But evidence suggests that it is just as important to live in a group with a complex social system.
Animals that live in large groups with a definite social structure, such as the elephants shown in Figure 5.3, are surrounded by politics. Surviving and reproducing depend on remembering and being able to use a vast amount of information to the individual’s advantage. These animals must be able to

- identify other individuals in the group
- remember which individuals are their allies and rivals
- keep track of the constantly changing state of affairs among individuals
- use this information to their own advantage

**Cultural behavior** is behavior that is spread through a population by learning, rather than by selection. The key to cultural behavior is that the behavior is taught to one generation by another. The development of cultural behavior does not require living in complex societies. For example, some scientists would argue that the transmission of birdsong is an example of cultural behavior. However, living close together in social groups may help to enhance the transmission and expression of cultural behaviors.

**Connect** What is an example of cultural behavior from your life?

### Formative Assessment

#### REVIEWING MAIN IDEAS

1. Why is animal intelligence difficult to define?
2. Use an example to explain what solving a problem by using **insight** means.
3. Explain how living in a complex social group might select for increased cognitive abilities.

#### CRITICAL THINKING

4. **Apply** In Section 2, you learned about the potato-washing behavior of snow monkeys. Is this an example of **cultural behavior**? Explain your reasoning.
5. **Analyze** There are three keys on a table. How might you use insight to determine which key opens a nearby door?

#### SCIENTIFIC PROCESS

6. Why are scientists so interested in studying primate behavior? What might scientists learn about human behavior?
27 Summary

KEY CONCEPTS

27.1 Adaptive Value of Behavior
Behavior lets organisms respond rapidly and adaptively to their environment. A stimulus is a type of information that has the potential to make an organism change its behavior. An animal’s behavior can be considered as a way of maintaining homeostasis. Many animal behaviors are responses to stimuli that affect an individual’s well-being. Internal and external stimuli interact to trigger specific behaviors. Some behaviors occur in cycles. Hibernation and migration are two behaviors that are controlled by an animal’s biological clock.

27.2 Instinct and Learning
Both genes and environment affect an animal’s behavior. Innate behaviors are inborn instinctive behaviors. Many behaviors have both innate and learned components. Animals that are able to learn can modify their behavior to adapt to new situations. Classical conditioning and operant conditioning are two examples of associative learning.

27.3 Evolution of Behavior
Every behavior has costs and benefits. Benefits of certain behaviors include increased survivorship and rates of reproduction. Three categories of behavioral costs include energy costs, opportunity costs, and risk costs. Animals perform behaviors for which the benefits outweigh the costs.

27.4 Social Behavior
Social behaviors enhance the benefits of living in a group. Social behaviors are interactions between members of the same species. Altruistic behaviors benefit other group members at the cost of the individual performing them. Eusocial behaviors are an example of extreme altruism.

27.5 Animal Cognition
Some animals other than humans exhibit behaviors requiring complex cognitive abilities. Even though animal intelligence is difficult to define, animal behavior scientists are able to study the cognitive abilities of animals. Characteristics of animal cognition include awareness, perception, reasoning, and judgment. Some animals can solve problems through the use of insight. Cultural behavior is behavior that is spread through a population by learning rather than by selection.

RESEARCH TOOLBOX
SYNTHESIZE YOUR NOTES

Concept Map Use a concept map like the one below to summarize your notes on cyclical behaviors.

- Biological clock controls
- Cyclical behaviors which include migration

Process Diagram Use a process diagram like the one below to summarize your notes on an animal’s response to a stimulus.

- Stimulus occurs
- Sensory cells detect stimulus
-
-
**CHAPTER 27: Review**

**CHAPTER VOCABULARY**

<table>
<thead>
<tr>
<th>27.1 stimulus kinesis taxis circadian rhythm biological clock</th>
<th>27.3 habituation imprinting imitation classical conditioning operant conditioning survivorship territoriality optimal foraging</th>
<th>27.4 pheromone altruism inclusive fitness kin selection eusocial cognition insight cultural behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td>27.2 instinct innate releaser</td>
<td>27.3 habituation imprinting imitation classical conditioning operant conditioning survivorship territoriality optimal foraging</td>
<td>27.5 cognition insight cultural behavior</td>
</tr>
</tbody>
</table>

**Reviewing Vocabulary**

**Compare and Contrast**

Describe one similarity and one difference between the two terms in each of the following pairs.

1. classical conditioning, operant conditioning
2. cultural behavior, imitation
3. territoriality, optimal foraging

**Vocabulary Connections**

The vocabulary terms in this chapter are related to each other in various ways. For each group of words below, write a sentence or two to clearly explain how the terms are connected.

4. stimulus, taxis
5. survivorship, territoriality
6. altruism, eusocial
7. instinct, innate

**Reading Toolbox**

**Greek and Latin Word Origins**

8. The term *stimulus* comes from a Latin word, *stimulare*, which means “to goad, prod, or urge.” Explain how this meaning relates to *stimulus*.
9. The term *habituation* comes from the Latin word *habitus*, which means “condition or habit.” Explain how this meaning relates to *habituation*.
10. The term *pheromone* comes from a combination of the Greek words *pherein*, meaning “to carry,” and *horme*, meaning “impulse.” How do these words relate to the meaning of *pheromone*?
11. The term *altruism* comes from the Latin word *alter*, meaning “other.” How is this meaning related to the definition of an altruistic individual?
12. The term *kinesis* comes from the Greek word *kinein*, meaning “to move.” Explain this connection.

**Reviewing MAIN IDEAS**

13. What is the role of the nervous system in an animal’s response to a stimulus? [TEKS 11A]
14. Identify the internal and external factors that are likely to lead to migration in songbirds. [TEKS 11A, 11B]
15. What are some of the characteristics of innate behaviors?
16. When does habituation occur?
17. How is the ability to adapt behaviors to new situations important for an animal’s survival? [TEKS 7D]
18. Describe the benefits and costs of migratory behavior. [TEKS 7D]
19. The territory of a pack of gray wolves can be more than 3000 square kilometers. The alpha male marks the boundaries of the territory with urine. Explain why this time-consuming behavior is important. [TEKS 7D]
20. Groups of small songbirds will often mob an owl or a hawk. They fly around it and call loudly. What is the cost and benefit of this behavior to the songbirds? Explain your answer. [TEKS 7D]
21. Arctic ground squirrels live in groups and forage for food during daylight. What is the cost of foraging in a group?
22. What information might be provided to potential mates by a courtship display such as the competitive performances of sage grouses?
23. In the meerkat group, one animal always stands guard and sounds an alarm call if a bird of prey is sighted. Why is this an altruistic behavior?
24. What are the characteristics of eusocial behavior?
25. What is the connection between cognitive ability and insight?
**Critical Thinking**

26. **Connect**  Your alarm clock wakes you up, and you get ready for school. You eat breakfast but then eat one more slice of toast. After stepping outside, you go back in to get a lighter jacket. Identify all the stimuli in this scene and whether they are internal or external.  
   **TEKS** 11A, 11B

27. **Apply**  A zookeeper needs to use a scale to measure the weight of an otter. How might she use operant conditioning to get the otter onto the scale?

28. **Analyze**  Gray wolves live in packs with about 6 to 15 members. Young pups remain behind while the older animals hunt for prey as a group. They often seek out old, sick, and slower prey animals. All of the adults regurgitate food for the pups. Suggest two costs and two benefits of gray wolf feeding behavior.

29. **Infer**  The unison call is performed by a pair of whooping cranes. The male and female each have their own notes and perform this call often when they arrive at their nesting area. Suggest some reasons why the birds perform this call.  
   **TEKS** 11B

30. **Apply**  You buy a bag of raisins. There are no directions on how to open it. There is no tab to pull. You do not have scissors to cut the bag open. You examine the bag for a few seconds and then pull the seams of the sealed top apart to open it. What type of problem-solving behavior did you demonstrate? Explain your answer.

**Interpreting Visuals**

Use the photograph to answer the next three questions.

31. **Infer**  Why do you think the baby elephants are traveling between the adults?  
   **TEKS** 11B

32. **Analyze**  For which elephants might there be a benefit for this type of behavior and for which elephants might there be a cost?  
   **TEKS** 11B

33. **Evaluate**  If there is a benefit, does it outweigh the cost? Explain your answer.  
   **TEKS** 7D

**Analyzing Data Construct a Bar Graph**

The graph below shows a time budget for different behaviors exhibited by grizzly bears in a national park in the Yukon Territory, Canada. Use the data to answer the next three questions.

**GRIZZLY BEAR BEHAVIOR**


34. **Analyze**  What behavior did the bears engage in most of the time?

35. **Analyze**  Do the bears interact more often with other bears or with other species in this park?

36. **Infer**  What can you infer about the habitat based on the data for foraging and eating?

**Making Connections**

37. **Write a Fable**  You may remember reading Aesop’s fables as a child. A fable is a story that ends with a moral, or lesson, such as “the early bird gets the worm.” This chapter described reasons for animal behaviors, various types of responses, and the situations in which behaviors might occur. Write a short fable about an animal’s behavior, in which the moral of the story illustrates the adaptive value of the behavior.

38. **Analyze**  Consider again the chimpanzee shown on the chapter opener. Why might scientists be interested in studying tool use in primates such as chimpanzees?
Record your answers on a separate piece of paper.

**MULTIPLE CHOICE**

**TEKS 2D**

1. Students plan an experiment to determine whether fish exhibit different feeding behaviors when presented with food flakes of different colors. The students predict that fish will be able to see brightly colored flakes more easily and will therefore eat more of these flakes. This prediction most closely resembles a scientific —
   A. theory
   B. hypothesis
   C. conclusion
   D. law

**TEKS 12A**

2. A female ground squirrel may send out a call warning her offspring that a predator is near. Often, the mother sacrifices her own life since the predator can more easily locate her from the call. Even though this behavior results in death, it is beneficial to her in that —
   A. half of her alleles are preserved in each offspring
   B. all of her alleles are preserved in each offspring
   C. the predator may be less likely to attack the population again
   D. the alleles that caused her behavior will no longer be in the gene pool

**TEKS 12C**

3. When a frog hunts, it catches its prey with flicks of its long, sticky tongue. Energy obtained from eating the insect that is not used or stored in the body is —
   A. passed on to offspring
   B. recycled within the frog
   C. lost to the environment as heat
   D. available to organisms that eat the frog

**TEKS 11A**

The action illustrated above will most likely result in a response produced by the —
   A. nervous system
   B. respiratory system
   C. endocrine system
   D. immune system

**TEKS 6F**

In a hypothetical rabbit species, fur color and nose color are traits that are each controlled by one gene that can occur in a dominant form or a recessive form. Females of the species prefer to mate with gray males with pink noses over brown males with black noses. A gray female (Ff) with a black nose (nn) mates with a gray male (Ff) with a pink nose (Nn) and produces a litter of eight rabbits. Theoretically, how many of the offspring will have brown fur and black noses?
   A. 0
   B. 1
   C. 2
   D. 4
The Loss of Biodiversity

Extinction is occurring at its fastest rate in the last 100,000 years. As humans develop land for agriculture and other human needs, ecosystems are changed. Each time an acre of land is lost, species that once lived there may be lost as well. Rain forests, for example, are areas with high biodiversity, and wide swaths are being destroyed by humans. Why is biodiversity important? How does its loss affect you?
Biodiversity at Risk

Biologists estimate that there are between 10 and 100 million species living on Earth. At current rates of extinction, over half of these species will be gone by the end of this century. Across the globe, animal species that are threatened with extinction include:

- 12 percent of all birds
- 21 percent of all mammals
- 28 percent of all reptiles
- 30 percent of all amphibians
- 70 percent of all plants

Extinction is a natural process and is always occurring. Using evidence from the fossil record, the background, or normal, extinction rate is calculated to be between 10 and 100 species per year. However, the current rate of extinction greatly exceeds that number; we lose a species every 20 minutes! Hundreds of thousands of species will disappear before we are even aware of their existence.

The Value of Biodiversity

Ecosystems provide human communities with a number of services free of charge, including air and water purification, flood and drought control, pollination of crops and other vegetation, dispersal of seeds, and nutrient cycling. These services have an economic value. If humans had to pay for ecosystem services based on their market value, biologists estimate that the cost would be approximately $33 trillion annually.

In addition, 40 percent of all medicines are derived from plants, animals, and microbes. For example, biologists are developing a painkiller based on an extract from the skin of an Ecuadorian frog. The painkiller is 200 times stronger than morphine, but is not addictive. Every time a plant, animal, or microbe becomes extinct, biologists lose whatever knowledge they might have been able to gain by studying it.

TECHNOLOGY S.T.E.M.

Bioremediation

Microorganisms can be used to clean up wastes that are spilled. Some bacteria can eat substances that would be fatal to humans and most other animals. Using microorganisms to clean up a polluted environment is called bioremediation.

1. Toxic waste, such as crude oil, is spilled on soil or in water.
2. The waste kills most bacteria, but a few survive and adapt.
3. Surviving bacteria feed on the toxins that were spilled and break them down. They may change the toxin to another form that is not dangerous, break the compound into smaller parts, or completely degrade it into inorganic molecules such as carbon dioxide and water.
4. Oxygen and nutrients are added so that more bacteria will survive to help break down the toxins.
5. When the spill has been completely broken down, bacteria die because they have run out of food.

Sometimes the needed microbes do not naturally occur in the contaminated site. When this is the case, the clean-up crew adds the specialized microbes to the site to break down the toxins.

Read More >> at HMDScience.com
Does Biodiversity Really Matter?  

Some people might suggest that biodiversity belongs in a zoo and the rest of the world belongs to humans to develop. Arguments in favor of development include the following:

- The rise and fall of species is part of nature. No species lives forever. New species replace old ones.
- Economic development provides jobs to people who are living in poverty.
- Land set aside as wilderness could be better used as farmland to provide more food for a rapidly increasing human population.

Conservation biologists view the pro-development arguments as shortsighted. Their view is that the Earth must be maintained for future generations, not simply harvested to provide for the needs of its current population. In fact, they argue that biodiversity plays an important part in ecosystem stability.

In general, the more species that live in an ecosystem, the more efficient and stable that ecosystem will be. For example, a rain forest can produce much more oxygen than an orchard full of apple trees. Also, many plants, including 75 percent of the world’s staple crop plants, need animal pollinators such as birds and insects to help them reproduce.

Unanswered Questions

As you have learned, biodiversity is very valuable. Yet questions remain about how best to protect biodiversity. Two of these unanswered questions include

- How can we slow down the current extinction rate?
- Some of the areas with the highest amount of biodiversity are located in developing countries. How can biodiversity be preserved without harming the country’s economic growth?

Conservation Biologist in Action

ANGEL MONTOYA

TITLE Senior Field Biologist, The Peregrine Fund

EDUCATION M.S., Wildlife Science, New Mexico State University

In 1990, Angel Montoya was a student intern working at Laguna Atascosa National Wildlife Refuge in Texas. He became interested in the Aplomado falcon, a bird of prey that disappeared from the southwestern United States during the first half of the 20th century. Montoya decided to go looking for the raptors, and he found a population of Aplomados in Chihuahua, Mexico. His work helped to make it possible for the falcons to be reintroduced to an area near El Paso, Texas.

Restoration of the Aplomado falcon became Montoya’s life work. He has monitored and researched the falcon since 1992. He helps release falcons that have been raised in captivity back into the wild, and monitors falcons that have already been released. It isn’t easy to keep tabs on a falcon, however. “Their first year they are pretty vulnerable because they haven’t had parents,” Montoya says. “Just like juveniles, they’re always getting into trouble. But I think they will do just fine.”