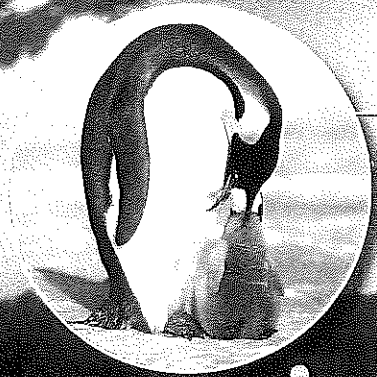


Courtship behavior



Nurturing behavior



Territorial behavior



THEME FOCUS Patterns
Biologists study animals, their behaviors, and their environments to learn about their interactive relationships.

BIG Idea Many animal behaviors are influenced by both genetics and environmental experiences.

Section 1 • Basic Behaviors
Section 2 • Ecological Behaviors

Section 1

Reading Preview

Essential Questions

- How are animal behaviors related to evolution by natural selection?
- What are the differences between innate and learned behaviors?
- What are the different types of animal behavior and what are examples of each?

Review Vocabulary


natural selection: population process by which heritable traits that result in the greatest number of offspring eventually become the most common traits in the population

New Vocabulary

behavior
innate behavior
fixed action pattern
learned behavior
habituation
classical conditioning
operant conditioning
imprinting
cognitive behavior

 Multilingual eGlossary

Basic Behaviors

 **Key Takeaway** Animal behaviors can be innate or learned, and they evolve through natural selection.

Real-World Reading Link Think about what happens when you smell your favorite food as you walk by a restaurant. Whether you are hungry or not, your mouth might start to water and you might start thinking about how good that food tastes. Other animals have similar behaviors.

Behavior

You might have seen a lizard lying on a rock in the sunlight. The lizard is regulating its body temperature through its behavior. In order to raise its body temperature, the lizard absorbs the Sun's heat. If the lizard's body temperature starts to get too high, it will move into the shade. This is an example of behavior. **Behavior** is the way an animal responds to a stimulus. A stimulus (STIHM yuh lus) is an environmental change that directly influences the activity of an organism.

Behavior can occur in response to an internal stimulus, which is a stimulus that comes from inside the body, as in the case of the lizard. Behavior can also be caused by an external stimulus—a stimulus that comes from outside the body. An external stimulus could be the smell of food, someone calling your name, or the sight of a predator.


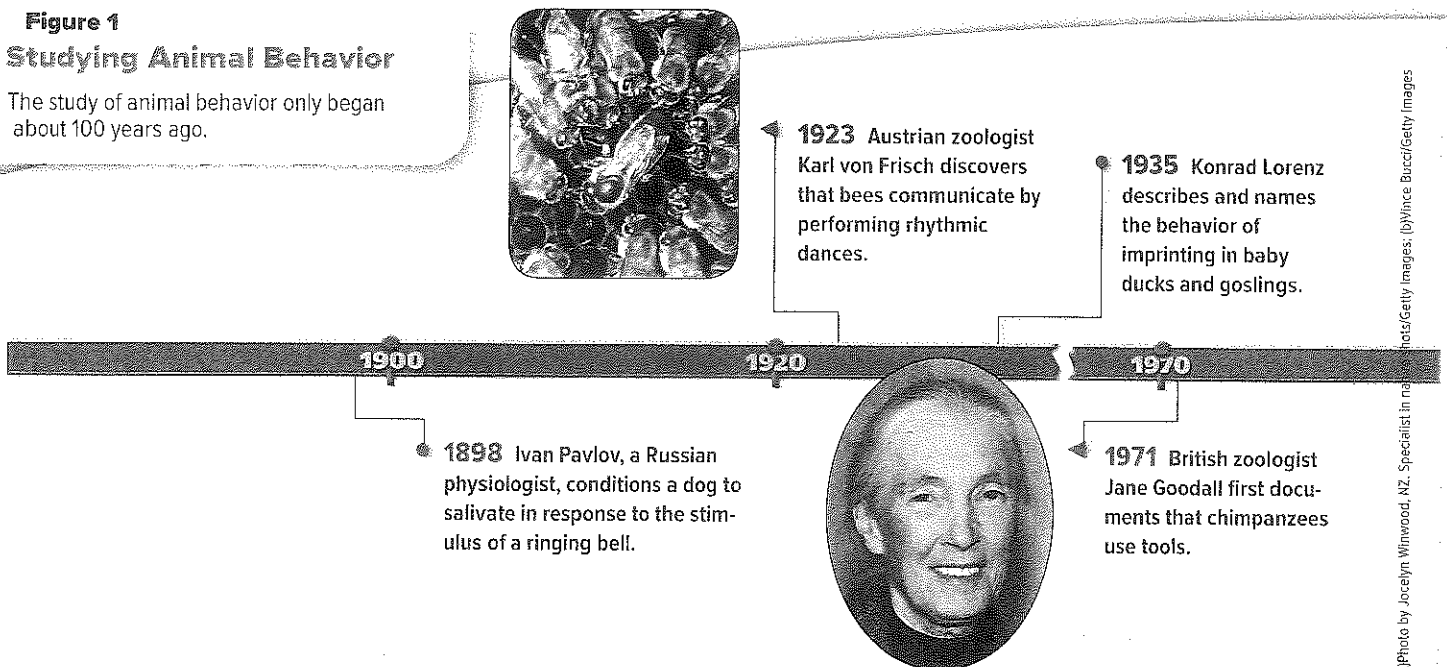
 **Reading Check** Summarize why a lizard might lie on a warm rock in the morning.

Figure 1 Studying Animal Behavior

The study of animal behavior only began about 100 years ago.



(Photo by Jocelyn Winwood, NZ. Specialist in nature photography. ©Vince Bucchi/Getty Images)

What influences behavior? For many years, scientists asked whether behavior was genetically based or a result of experiences. Studies have shown that some behavior is based solely on genetics and is not influenced by experience. Other behaviors, such as a finch learning the song of its species, are known to result from a combination of genetics and environmental influences. Today, many behaviors are considered to be the result of both genes and experience. In many cases, behavior results from the interaction of genetically based behaviors and behaviors based on experience.

Figure 1 shows some important discoveries about animal behavior.

The evolution of behavior Two general questions are asked when studying animal behavior. The first question focuses on what triggers an animal to react to specific stimuli. For example, what triggers a male bird, like the one shown in **Figure 2**, to sing during breeding season? The answer usually is found by studying the internal biology of an animal. Scientists now know that some male birds sing during breeding season in response to the internal stimulus of increased levels of the hormone testosterone.

The second question focuses on what advantages certain behaviors provide animals. The answers to this question are tied to the evolution of behavior through natural selection. What advantage does singing during breeding season provide the male bird? Perhaps the singing helps the male bird keep other male birds away. Perhaps the singing helps the male attract a mate.

You already have learned that animals with traits giving them a competitive advantage over other animals that do not possess those traits are more likely to reproduce and pass their genes on to future generations. In the past, birds that sang tended to have more offspring than birds that did not sing. Over a number of generations, birds that sang became the only birds contributing to the population's gene pool. The behavior has been naturally selected.

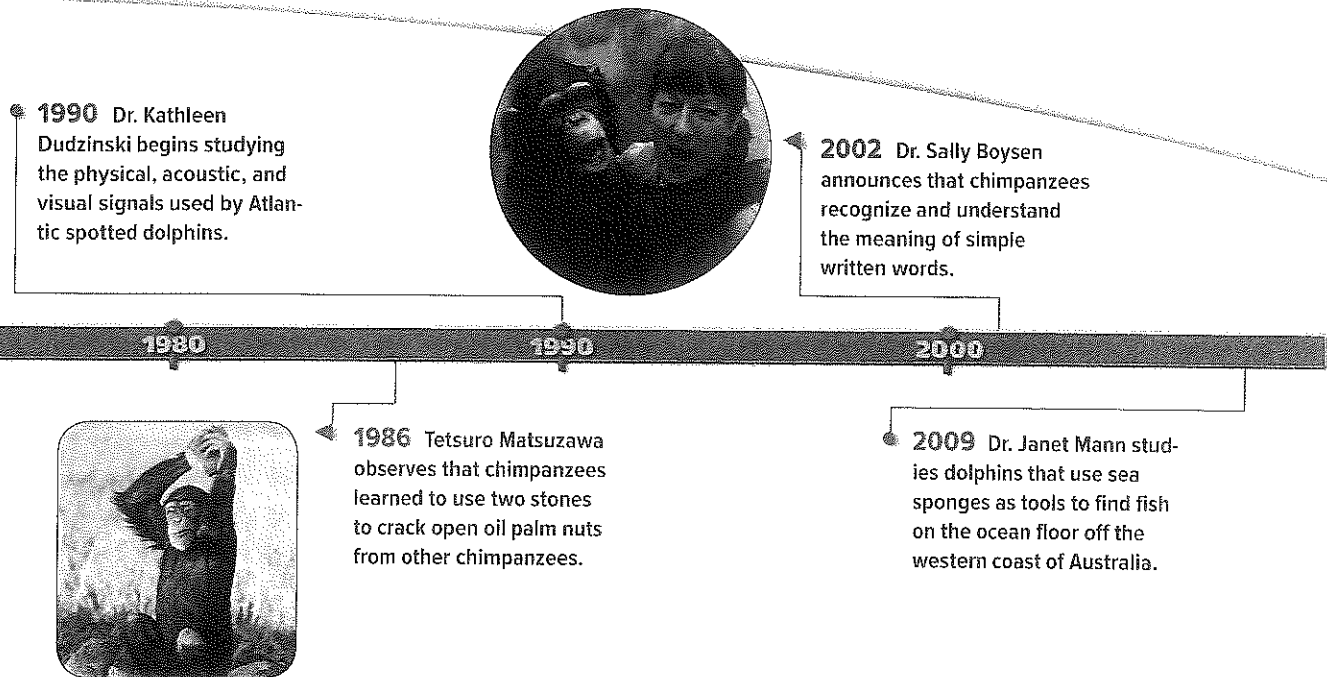


Figure 2 The male zebra finch sings during mating season to attract a female.



Virtual Lab

©Richard F. Wille/Getty Images; (c) Jo McCulloch/Getty Images; (d) University via the Columbus Dispatch/AP Images; (e) Fuse/Getty Images



Animal Behaviorist Scientists that study the causes, development, and evolution of behavior are animal behaviorists. Animal behaviorists might work at zoos, aquariums, or museums, or they might teach or conduct research at a university.

Innate Behavior

Behaviors that are genetically based and not linked to past experiences are called **innate** (ih NAYT) **behaviors**. However, you might say that all animal behaviors occur in and are influenced by the environment. Behaviors are referred to as innate, or instinct, when the same behavior commonly is observed among a large number of individuals within a population, even if the environments are different. For example, in some species, newly hatched birds will make innate chirping sounds while opening their mouths in an upward direction when a parent lands in the nest. As part of an innate response to the chick's open mouth, the parent will feed the chirping bird. In addition, members of a particular group of mammals typically begin to walk at the same age, depending on their species. Therefore, walking is generally considered an innate behavior.

Fixed action patterns The goose in **Figure 3** is exhibiting innate behavior. When an animal carries out a specific set of actions in sequence, in response to a stimulus, it is called **fixed action pattern**. The goose is responding to the stimulus of an egg that is out of the nest. The set of actions carried out is usually the same and usually in the same order. The goose will extend its neck toward the egg and then stand up. It will then roll the egg back to the nest with a side-to-side motion of its neck with the egg held beneath its bill. The stimulus, finding that the egg is out of the nest, triggers the innate behavior, and the entire sequence of actions is carried out. Even if the egg is removed midway through the retrieval process, the goose will continue the behavior without the egg. This is the key to a fixed action pattern. The stimulus triggers an innate response that the animal does not control and is not directly influenced by environmental conditions or past experiences. Another example of a fixed action pattern is shown in **Figure 4**.


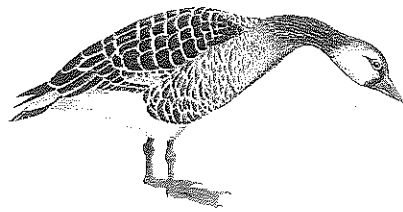
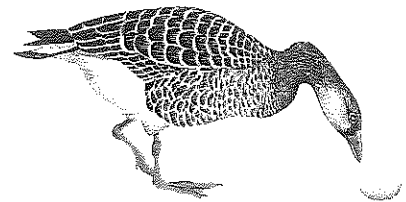
 **Reading Check** Explain why a fixed action pattern is an example of innate behavior.

Figure 3 The goose is carrying out a fixed action pattern.

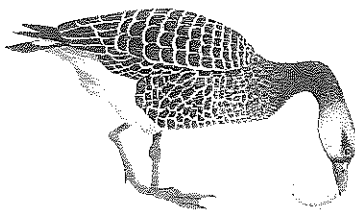
Infer what would happen if the egg were replaced with a similarly shaped object, such as a small rubber ball.



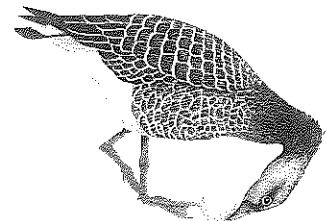
A The goose responds to the stimulus of an egg out of the nest.



B The goose begins to roll the egg.



C The goose rolls the egg back to the nest with the underside of its bill.



D The goose continues to roll the egg until it is in the nest.

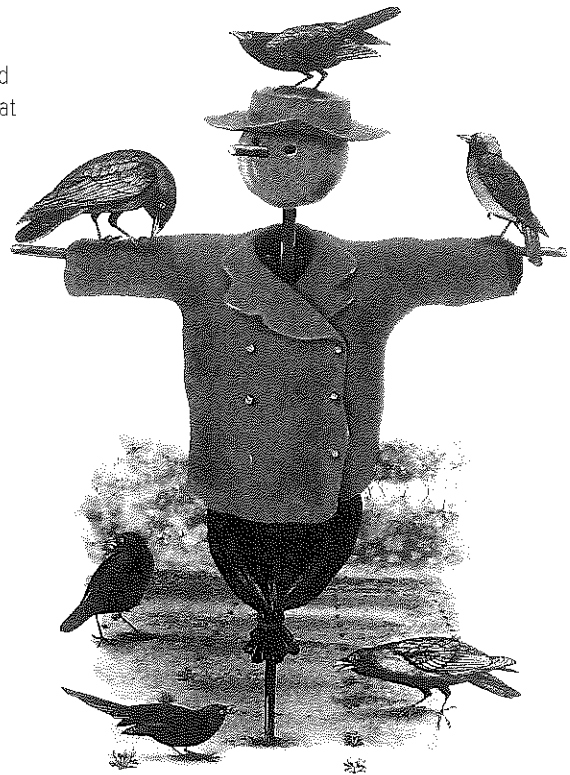
Visualizing Types of Behavior

Figure 4

Animal behavior is either innate or learned. Fixed action pattern behavior is innate because it is genetically based and is not linked to past experience. Habituation and operant conditioning are learned behaviors because each results from situations that the animal experiences.



Fixed Action Pattern This newly hatched cuckoo is carrying out a fixed action pattern. An adult female cuckoo lays her eggs in the nests of other bird species. When the baby cuckoo hatches, it ejects the other eggs from the nest before its eyes are even open. The process of ejection is a fixed action pattern.



Habituation These birds have become habituated to the scarecrow. Although they might have avoided it when it was first placed in the field, they learned that there were no positive or negative effects associated with it.



Operant Conditioning These ducks have learned to associate the presence of humans near the edge of the pond with the reward of food.



Animation



Figure 5 Police horses become habituated to noise from crowds and traffic. Recall a time when you became habituated to a stimulus.

Learned Behavior

Which activities do you enjoy—playing a sport, driving a car, playing video games or a musical instrument? These activities are examples of learned behaviors. **Learned behaviors** result from an interaction between innate behaviors and past experiences within a particular environment. Examples of learned behavior include habituation, conditioning, imprinting, and cognitive behavior.

Habituation Sometimes, animals learn over time that a potentially important stimulus deserves little or no attention. For example, baby birds in a nest see many types of objects moving overhead. At first, they might respond to these stimuli by crouching down and staying still. Some of the objects, such as falling leaves or members of their own species flying by, often are seen and have no positive or negative effects to the birds. Over time, the birds will stop responding to these stimuli. This is referred to as **habituation** (huh bit choo AY shun), which is a decrease in an animal's response after repeatedly being exposed to a stimulus that has no positive or negative effects.

The horses shown in **Figure 5** have become habituated to street and crowd noise. Habituation can be thought of as learning not to respond to a stimulus. Habituation is important to an animal's success because it allows an animal to ignore unimportant stimuli and focus on and respond to important stimuli, such as the presence of food, a mate, or a predator. Another example of habituation is shown in **Figure 4**. Birds often become habituated to a scarecrow because they learn that it has no positive or negative effects.

FOLDABLES

Incorporate information from this section into your Foldable.

Mini Lab 1

Explore Habituation

Does an earthworm habituate to touch? In this lab, you will observe whether an earthworm will learn that a stimulus can be ignored.

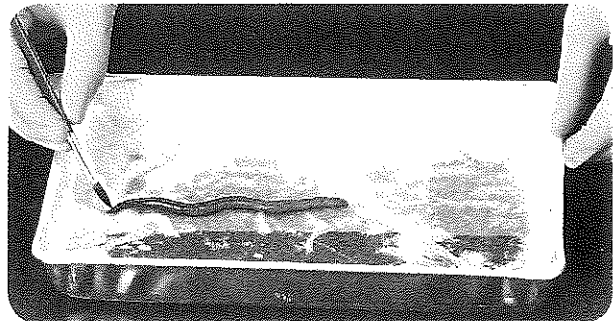
Procedure 

WARNING: *Treat the earthworm in a humane manner at all times.*

1. Read and complete the lab safety form.
2. Line a small narrow tray with a paper towel moistened with aged tap water. Put on a pair of gloves and wet them with aged tap water.
3. Use your gloved hand to pick up an earthworm and gently transfer it to your tray. Allow the worm to rest for 1 min.
4. Determine which is the anterior end (head) of your worm. Lightly touch the anterior of the worm with the bristles of a small paintbrush.
5. After the worm recovers from its withdrawal reflex, touch it lightly again.



MiniLab

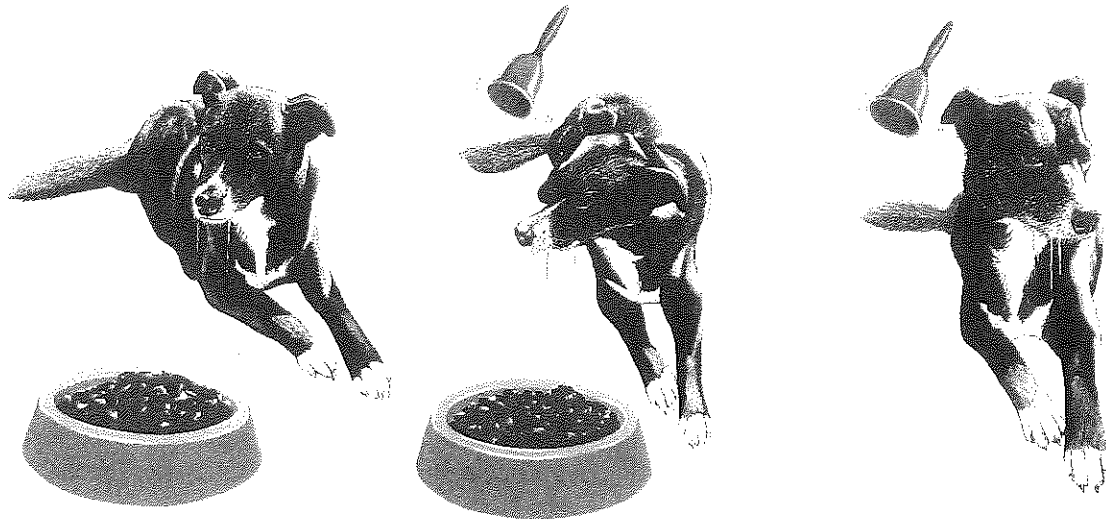


6. Repeat Step 5 five more times and record any changes in the worm's behavior.

Analysis

1. **Explain** Did the earthworm become habituated to the stimulus? How do you know?
2. **Think Critically** Why is the earthworm's withdrawal reflex likely an innate behavior? How does this behavior help the worm survive in its natural environment?





A When a dog is presented with food, it salivates.

B A bell is rung each time a dog is presented with food. The dog forms an association with the ringing bell and food.

C Eventually, the dog will salivate to the sound of the bell alone. It has been conditioned to respond to the ringing bell.

Classical conditioning Ivan Pavlov, a Russian scientist who conducted experiments in the late 1890s and early 1900s, noticed that after he presented meat powder to a dog, the animal produced saliva. Later, Pavlov rang a bell each time he presented the meat powder. After repeated trials, the dog salivated when it heard the bell alone, without smelling or tasting meat powder.

Pavlov concluded that the dog related the sound of the ringing bell with the meat powder. Animal behaviorists refer to this type of learning as classical conditioning, which is illustrated in **Figure 6**.

Classical conditioning occurs when an association is made between two different kinds of stimuli. In Pavlov's experiment, the dog learned to associate the sound of the bell with the unrelated stimulus of meat powder. The sound of the bell could produce the response of salivation.

Reading Check Describe an example of when you were conditioned by unrelated stimuli.

Operant conditioning B.F. Skinner, an American psychologist, carried out experiments on operant conditioning. In **operant conditioning**, an animal learns to associate its response to a stimulus with a reward or a punishment. In Skinner's experiment, a rat was placed in a box. As the rat explored the box, it accidentally would hit a lever, causing a food pellet to be released into the box. At first, the rat ignored the lever. It would eat the pellet and continue to move around the box. Eventually, the rat learned to associate pressing the lever with getting food. The animal was rewarded positively (receiving the food pellet) for its response (pressing the lever) to the stimulus (the lever).

In some cases, animals learn to associate their response with a negative reward. Monarch butterflies, which have a bright orange color pattern, are toxic to many predators. When a young blue jay eats a monarch butterfly for the first time, the bird becomes ill and vomits the butterfly. The bird quickly associates eating the butterfly with illness. In the future, the bird avoids eating monarch butterflies and other butterflies with a similar color pattern.

Figure 6 Through classical conditioning, the dog learns to associate the sound of a ringing bell with food.

VOCABULARY

SCIENCE USAGE & COMMON USAGE

Trial

Science usage: one of a number of repetitions in an experiment
The biologist collected data for 50 trials during her study of behavior.

Common usage: a formal examination of a matter in a civil or criminal court
The defendant was found innocent at the end of the trial.



BrainPOP



VOCABULARY

ACADEMIC VOCABULARY

Migratory

characterized by moving from one location to another

Migratory birds fly south for the winter.

⇒ **Figure 7** The first flock of whooping cranes to be imprinted using the ultralight arrived at their winter destination on December 3, 2001. Each year since then, a new flock has been imprinted, with all the cranes following the ultralight back to Wisconsin in the spring.

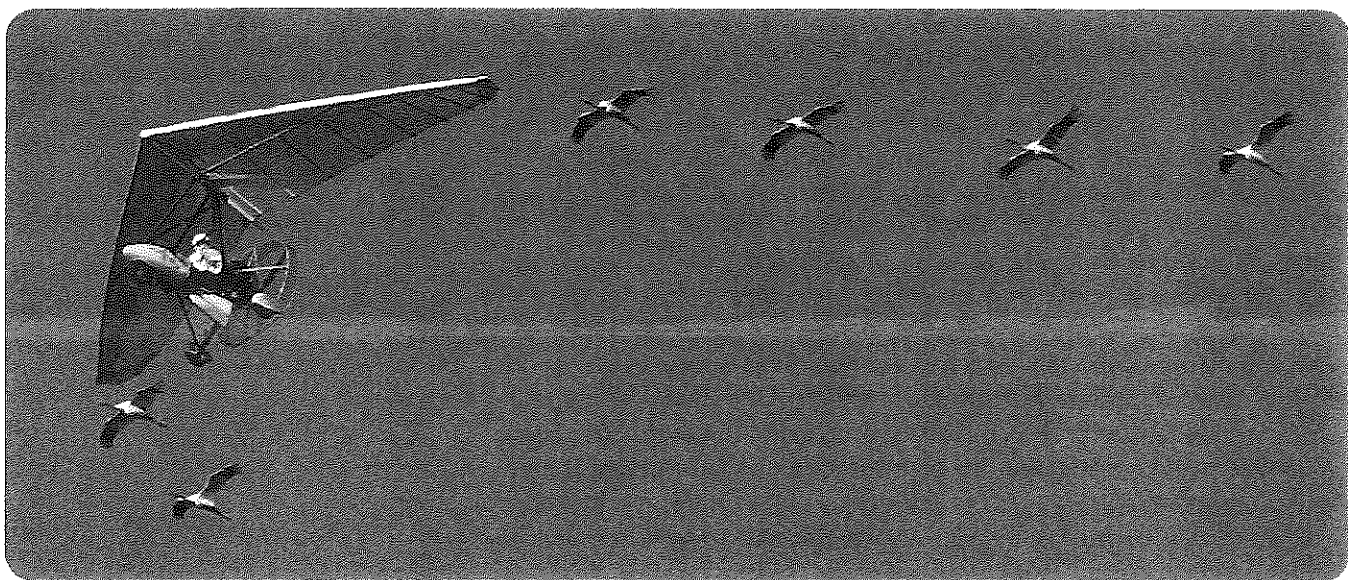
Infer *what would happen if newly hatched cranes imprinted using a crane from the first flock.*

Operant conditioning is a more powerful, long-lasting kind of learning that dominates much of everyday learning of humans and other vertebrates. For example, animals, including humans, learn ways of finding food by exploring a variety of locations. When certain locations prove to be a good source of food, animals are positively reinforced. Research shows that such animals are more likely to seek food the next time in the same location or locations that appear similar.

Imprinting Learning that can only occur within a specific time period in an animal's life and is permanent is called **imprinting**. The time during which an animal imprints is called the *sensitive period*. In some animals, the sensitive period occurs immediately after birth. Newborn offspring can form a strong bond with another animal, such as a parent, during this time. Some animals, such as whooping cranes, form a social attachment to the first object that they see after birth. Other animals, such as salmon, imprint on the chemical composition of the water in which they are hatched. The salmon use this imprint to return to this location when it is time for them to spawn.

Evidence of the influence of genetics on imprinting comes from experiments with newly hatched birds. In nature, the first object the offspring sees most likely will be its parent. This ensures that the offspring will have a higher chance of survival by being nurtured by a parent. Experiments have shown that newly hatched birds will imprint on whatever object they see first, whether it is an animal of a different species, such as a human, or an inanimate object, such as a box.

Connection to Biology In 1999, only one flock of 180 migratory whooping cranes existed naturally. Scientists created a plan to introduce a second migratory flock of cranes to help ensure the species would not become extinct. Crane chicks were hatched in Wisconsin at the northernmost point of their migratory path. The chicks were imprinted using an ultralight plane like the one shown in **Figure 7**. Each year since 2001, a group of newly hatched chicks is imprinted by an ultralight. They follow it to the winter migration site in Florida and back to Wisconsin in the spring. In doing this, a second population of migratory cranes has been established successfully.



Scott Martin/AP Images





Figure 8
The chimpanzee uses a stone to crack open nuts. Some scientists interpret this as cognitive behavior.

Cognitive behavior Thinking, reasoning, and processing information to understand complex concepts and solve problems are **cognitive behaviors**. Humans exhibit cognitive behaviors when they solve problems, make decisions, and plan for the future. Some experimental evidence supports the idea that other animals, such as chimpanzees, exhibit cognitive behavior.

Observations made by scientists of animals in their natural habitats also seem to show examples of cognitive behavior. Chimpanzees, like the one shown in **Figure 8**, have been observed using rocks to break open nuts. This behavior suggests that the chimpanzees are thinking and using tools to solve problems. Experiments are being conducted to find out if some primates purposely deceive, or lie to, other animals in their group, which is another sign of cognitive behavior.



What's BIOLOGY Got To Do With It?

Section 1 Assessment

Section Summary

- Behavior can be influenced by both genes and experience.
- Successful behaviors are those that give individuals an advantage for survival and reproduction.
- Behavior can be innate or learned.
- Learned behavior includes habituation, conditioning, and imprinting.
- Cognitive behavior involves thinking, reasoning, and problem solving.

Understand Main Ideas

1. **MAIN Idea** Explain how behavior could evolve.
2. Explain the difference between an internal stimulus and an external stimulus. Give an example of each.
3. **Compare and contrast** innate and learned behavior.
4. **Illustrate** specific examples of two types of learned behavior.

Think Critically

5. **Infer** A toad eats a bumblebee and receives a painful sting on its tongue. From then on, the toad avoids feeding on bumblebees or any other yellow and black insects. What kind of behavior is the toad exhibiting?

WRITING in Biology

6. Explain how you would train an animal, such as a dog, to do tricks. Use the terms *classical conditioning* and *operant conditioning*.



Online Quiz



Section 2

Reading Preview

Essential Questions

- What are different types of competitive behaviors and what are examples of each?
- What is the importance of foraging, migration, and biological rhythms?
- What are the different types of communication, nurturing, and cooperative behaviors?
- What are the advantages and disadvantages of behavior in terms of survival and reproductive success?

Review Vocabulary

colony: a group of unicellular or multicellular organisms that live together in a close association

New Vocabulary

agonistic behavior
dominance hierarchy
territorial behavior
foraging behavior
migratory behavior
circadian rhythm
language
courting behavior
nurturing behavior
altruistic behavior



Multilingual eGlossary

APPLYING PRACTICES

Evaluate the Evidence Go to the resources tab in ConnectED to find the Applying Practices worksheet *Investigating Group Behavior*.

Figure 9 These bighorn sheep spar until one sheep gives up. The winner will be able to court a mate without interference from the other male.

Explain why this behavior favors natural selection.

Ecological Behaviors

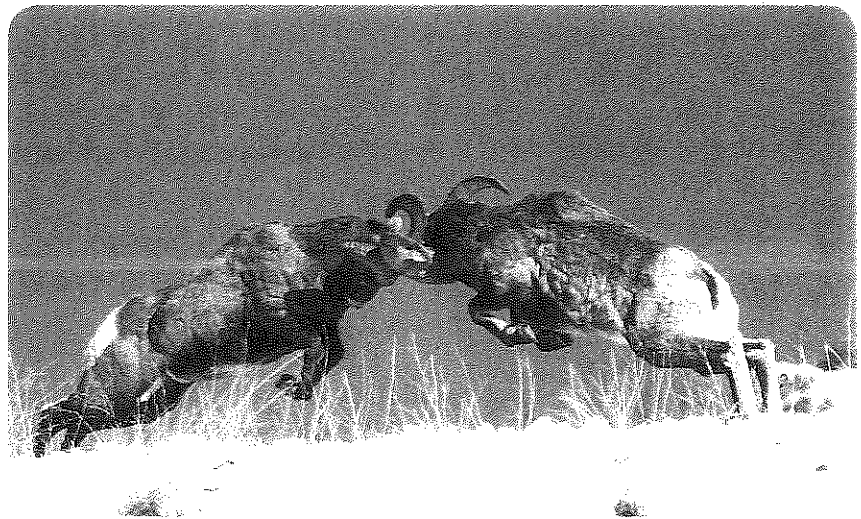
MAIN Idea Animals that engage in complex behaviors might survive and reproduce because they have inherited more favorable behaviors.

Real-World Reading Link Think about the advantages and disadvantages of owning a car. You would be able to drive yourself and your friends around town. However, you would also have to pay for gasoline, car insurance, and repairs. In a similar way, there are advantages and disadvantages to every type of animal behavior.

Types of Behaviors

All animal behaviors are somewhat ecologically based. Ecology is the study of the interactions of living things with each other and with their environment. These interactions can occur between members of the same species or between members of different species. Animals that engage in complex behaviors survive and reproduce because they have inherited genes that allow them to be successful in a particular environment.

Examine **Figure 9**, which shows two bighorn sheep fighting over a mate. Although it looks painful, the thick horns of the sheep protect them from injury when they butt heads. One of the sheep eventually will give up the contest, leaving the other the winner. What are the survival and reproductive advantages and disadvantages of this behavior? The winner is able to court and mate with a female without interference from the other male. The genes of the winner most likely will be passed on to future generations. Genes that provide adaptive advantages will increase in relative frequency according to the principles of evolution by natural selection. Genes that do not help an individual animal survive and produce offspring are likely to decrease in frequency in the gene pool of future generations. As you read about different types of behavior in this section, think about why a particular behavior might have evolved.





• **Figure 10** Polar bears engage in agonistic behavior. They spar until one bear leaves.

Infer some advantages of agonistic behavior.

Competitive behaviors Competition for food, space, mates, and other resources occurs between individuals within a population. Competitive behaviors, like the example shown in **Figure 9**, allow individuals to establish dominance or control of an area or resource. Animals that are successful at competitive behaviors are more likely to obtain resources needed for survival and reproduction. Successful animals are therefore more likely to reproduce and pass their traits to the next generation. Types of competitive behaviors include agonistic behavior, dominance hierarchies, and territorial behavior.

Agonistic behavior The polar bears in **Figure 10** are engaging in behavior in which one bear will be the winner and will have control over resources such as food or potential mates. This type of threatening or combative interaction between two individuals of the same species is called **agonistic** (ag oh NIHS tikk) **behavior**. Although the bears look as though they might hurt each other, agonistic behavior usually does not result in serious injury or death to either individual. The challenge will end when one animal eventually stops participating and leaves.

Dominance hierarchies A hierarchy is a grouping in which objects or individual animals are ranked in order from highest to lowest. Some animals living in groups develop **dominance hierarchies** (DAH muh nunts • HI rar keez) in which a top-ranked animal has access to resources without conflict from other animals in the group. This ranking system helps reduce hostile behaviors among animals. These hostile behaviors would take time and energy away from finding food or a mate, or caring for offspring. Higher-ranked animals are more likely to get what they need to survive and reproduce. Female wolves, baboons, some songbirds, and the chickens shown in **Figure 11**, establish dominance hierarchies.

Study Tip

Flashcards Make flashcards of the vocabulary terms in this section. Use the flashcards to review the terms with a partner or small group.

• **Figure 11** Female chickens, called hens, establish hierarchies in which one hen is dominant over the others. The dominant hen pecks other hens to maintain dominance.





Figure 12 Gannets breed in large colonies. They establish a small area of territory in which to make a nest. Territorial behaviors include fighting, jabbing at each other, and biting each other's necks.

Territorial behaviors Many animals establish a territory. A territory is a specific area that contains resources, such as food or potential mates, that an individual continually defends against other individuals of the same species. The size of territories varies widely, depending on the animal and the particular environment. **Territorial behaviors** are attempts to adopt and control a physical area against the other animals of the same species. Territorial behaviors include verbal signals, such as the singing of birds or chattering of squirrels, as well as chemical signals, such as a male cheetah's urine. Birds, such as the North American gannets shown in **Figure 12**, that gather in large colonies to breed engage in territorial behavior by fighting and jabbing to maintain space in the nesting colony. Territories usually are defended by males in order to increase their chance of obtaining adequate food, mates, and places to rear their offspring.

Foraging behaviors Finding and eating food are examples of **foraging behaviors**. These behaviors have obvious advantages for animals. Foraging successfully means obtaining needed nutrients, while avoiding predators and poisonous foods. Foraging involves a trade-off between a food's energy content and the cost of finding, pursuing, and eating it. Scientists theorize that natural selection favors individual animals whose foraging behaviors use the least amount of energy to obtain the maximum amount of energy possible. These are the animals that will be most able to reproduce successfully and pass genes on to future generations.



Reading Check Identify some of the disadvantages of foraging behaviors.

DATA ANALYSIS LAB 1

Based on Real Data*

Interpret the Data

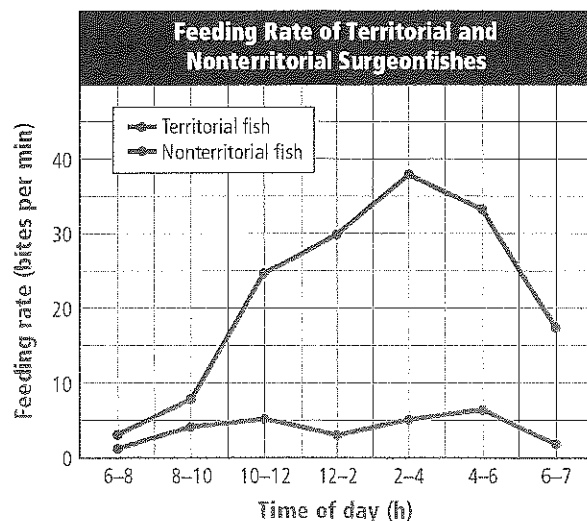
Can the advantages of territorial behavior be observed? Surgeonfish are algae-eating fishes that vigorously defend their territory against other algae-eating fishes. They maintain a territory of about 2–3 m².

Data and Observations

The graph shows the results of a study that compared the feeding rates of territorial surgeonfish to those of nonterritorial surgeonfish.

Think Critically

1. **Interpret** the meaning of each set of graphed data.
2. **Interpret** the advantage of the surgeonfishes' territorial behavior.
3. **Hypothesize** why this behavior has evolved.



*Data obtained from: Craig, P. 1996. Intertidal territoriality and time-budget of the surgeonfish, *Acanthurus lineatus*, in American Samoa. *Environmental Biology* 46: 27–36.



Migratory behaviors Some animals, such as birds and grazing mammals, engage in **migratory behaviors**, moving long distances seasonally to new locations increasing their chances of survival. Land animals, like the wildebeest and zebra in East Africa, migrate almost continuously as different areas receive the rain needed for their food sources to grow. Each fall in North America, about two-thirds of bird species fly south to areas such as South America where food is available during the North American winter. The birds fly north in the spring to areas where they feed and breed during the summer.

How do the snow geese, shown in **Figure 13**, and other birds know which direction to fly? Sometimes migrations cover thousands of kilometers each year, with seemingly little navigational information. Recent studies show that the first migration of some birds is guided innately by both the position of the stars and Earth's magnetic field. Future migrations are influenced by external cues that the bird learns while flying that help it navigate more precisely.

Biological rhythms Many animals, including humans, repeat behaviors in a rhythmic cycle. A **circadian** (sur KAY dee uhn) **rhythm** is a cycle, such as sleeping and waking, that occurs daily. Other biological cycles are seasonal or yearly. These cycles are influenced by environmental factors such as temperature changes, the increase or decrease of daylight hours, and the availability of food and water. These factors act as cues for animals to move into another phase of the cycle.

The daily cycle of sleeping and waking is influenced by external cues in animals. However, experiments have shown that many animals have an internal clock, often referred to as a biological clock, that maintains the daily rhythm of the sleep/wake cycle of about 24 hours. The graphs in **Figure 14** show the results of an experiment in which the activity level of nocturnal squirrels was monitored under two sets of conditions for 23 days—one in which a squirrel was exposed to a light cycle of 12 hours of light followed by 12 hours of darkness, and one in which a squirrel was kept in continual darkness. The biological clock of the squirrel maintained a sleep/wake cycle of 24 hours and 21 minutes in the absence of an external light and dark cycle. Controlled experiments show that the human biological clock has a cycle length of about 24 hours and 11 minutes.

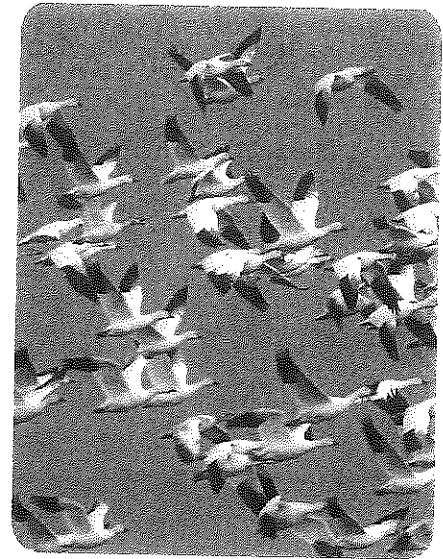


Figure 13 Snow geese are one of the many bird species that migrate to find better weather conditions and food sources as seasons change.

Explain why animals may engage in migratory behaviors.

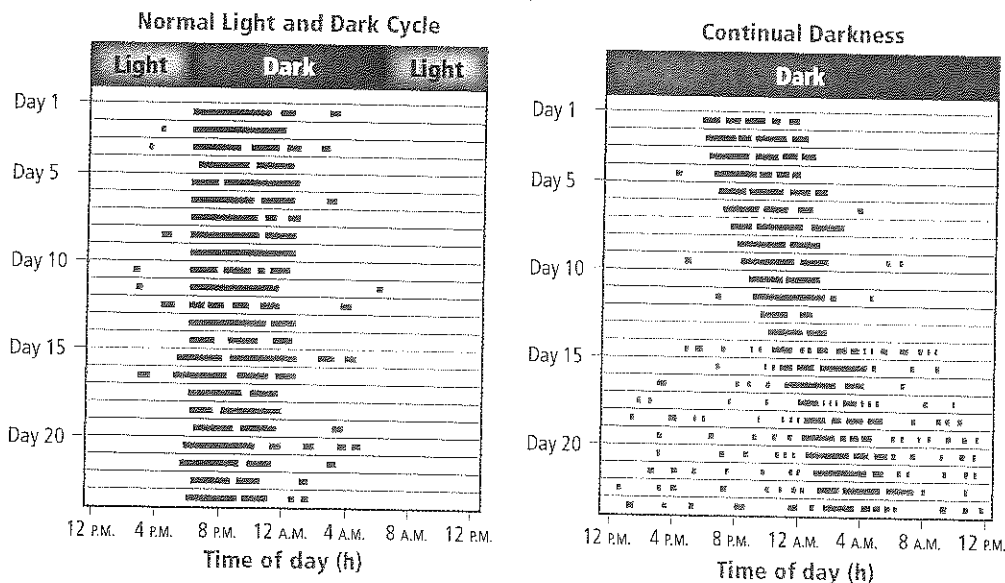


Figure 14 The green bars represent periods of the squirrels' activity, confirming that they have a sleep/wake cycle of about 24 h.

Left: When exposed to a normal cycle of light and dark, the nocturnal squirrel was active when it was dark. It slept while it was light.

Right: When in the dark all of the time, the squirrel maintained a sleep/wake cycle of 24 h 21 min, instead of 24 h.



VOCABULARY

Woop, howl

Auditory

audio- from Latin, meaning relating to sound

-ory suffix; from Latin, meaning producing

Communication Behaviors

Dogs bark, birds chirp, wolves howl, and lions roar. These are all examples of animal communication. Wolves howl to communicate information over long distances, including letting other wolves know their location, attracting mates, and signaling the presence of a predator. Such communication behaviors are critical to the survival and reproductive success of animals. Animals have several types of communication behaviors.

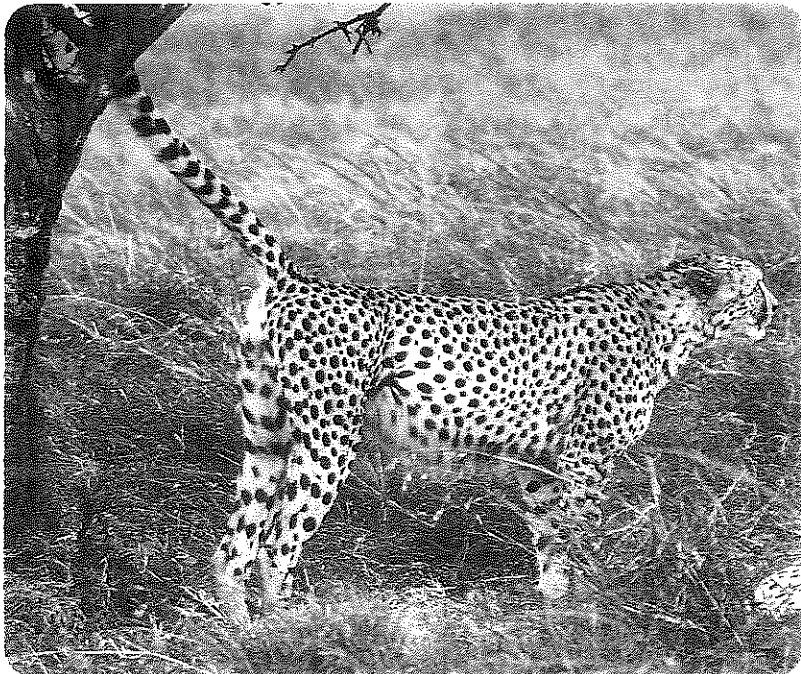
Pheromones Some animals communicate by spreading highly specific chemicals called pheromones. These chemicals are specific to species, ensuring that individuals within a population receive important information. An advantage of species-specific pheromones is that predators cannot detect them, unlike other more noticeable communication behaviors, such as barks or howls. Pheromones often are used to relay messages between males and females about reproduction. For example, female silk moths produce a pheromone that is used to attract male moths for mating. Pheromones also can be used to relay messages of alarm in response to a predator attack. The cheetah in **Figure 15** is leaving its scent to communicate with other cheetahs.

Auditory communication If you ever have spent an evening outside in a park or a forest, you might have heard many animals using auditory communication. Howls, hoots, barks, and chirps are just a few of the sounds you might have heard. Auditory communication permits animals to send and receive sound messages that move faster than chemical messages. Male crickets, frogs, birds, and the howler monkey shown in **Figure 15** communicate information about mating, predators, and territory to others in the population using auditory communication. Humans use language to communicate complex information.

Language is a form of auditory communication in which animals use vocal organs to produce groups of sounds that have shared meanings.

◀ **Figure 15** Some animals, like this cheetah, use pheromones to communicate and mark their territory. Male howler monkeys defend their territories with howls that can be heard over 4 km through dense forest.

Identify which communication behavior sends a message the farthest distance.



Cheetah



Howler monkey

(l)Elliot Neep/Oxford Scientific/Getty Images; (r)Kevin Schafer/Photobry/Getty Images



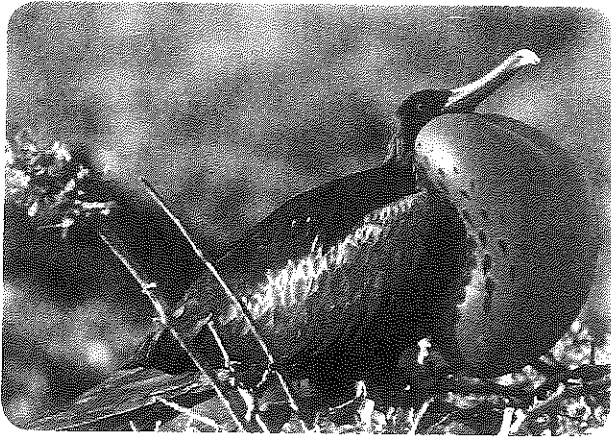


Figure 16 Male frigate birds on the Galapagos Islands inflate and display red throat sacs to attract females during breeding season.

Courting and Nurturing Behaviors

Certain behaviors displayed by animals are directly related to the reproductive success of an individual animal. Attracting a mate and caring for offspring are important aspects of reproductive success.

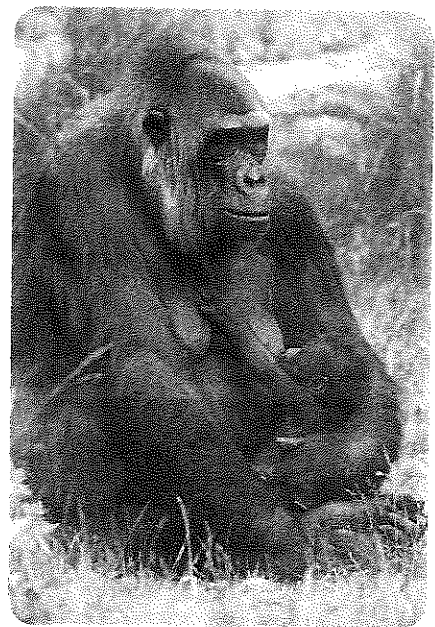
Courting behaviors An animal engages in **courting behaviors** in order to attract a mate. An example of courting behavior is shown in **Figure 16**. The male frigate bird has inflated its bright red throat sac and is displaying it to attract the attention of female frigate birds. Courtship signals, whether they are a display of brightly colored feathers or a series of movements or sounds, are species specific. This is important in ensuring the reproductive success of a species. Courting behavior can last for minutes or months, depending on the species.

Selecting a mate is often the female's role in the courtship process. Females often choose to mate with males that appear relatively larger and healthier than others. Thus, males with desired traits have a competitive advantage over other males and typically have a better chance of mating and successfully producing offspring.

Nurturing behaviors When parents provide care to their offspring in the early stages of development, they are engaging in **nurturing behaviors**. This includes providing food, protection, and skills needed for survival. Nurturing behaviors cost parents energy because of the extra work required to sustain offspring until they can take care of themselves. Animal species that spend time nurturing young often produce fewer offspring than animals that do not nurture.

For example, a female cod can produce as many as nine million eggs during a single reproductive period. Only a small percentage of these eggs will survive. Reproductive energy can be spent producing millions of eggs, with little if any energy spent on nurturing. In contrast to the cod, animals that nurture, such as primates, produce far fewer eggs and offspring. A female gorilla, like the one shown in **Figure 17**, will give birth to one baby that she will nurse for up to three years. The baby will stay with the mother for three to five years. In this case, more energy is spent nurturing young after birth to ensure they successfully reach a reproductive age. Although each reproductive strategy uses energy differently, they both usually result in the survival of at least one mature, reproductive offspring.

Figure 17 Nursing is an example of a nurturing behavior. Describe other examples of nurturing behaviors.



 **Reading Check** Compare and contrast courting and nurturing behaviors.



CAREERS IN BIOLOGY

Evolutionary Psychologist The social behavior of animals, including human social behavior and altruistic behavior, is studied by evolutionary psychologists.



Launch Lab

Review Based on what you have read about animal behavior, how would you now answer the analysis questions?

Cooperative Behaviors

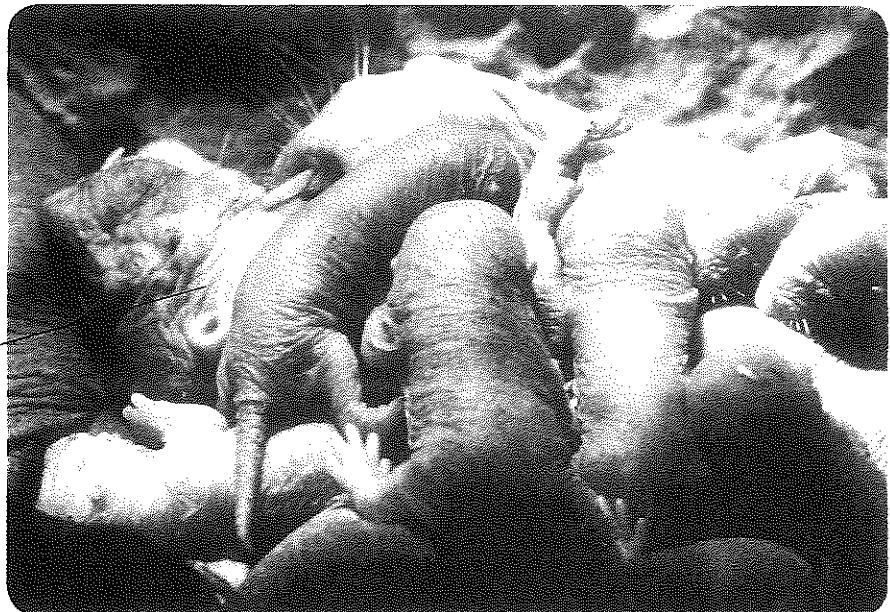
Cooperative behaviors can exist in groups of same-species animals. Cooperative behaviors can benefit all members of the group. However, some examples of cooperative behavior lead to an individual animal performing altruistic (al trew IHS tihk), or self-sacrificing, behaviors.

Altruistic behavior Sometimes an animal will perform an action that benefits another individual at a cost to itself. This type of behavior is called **altruistic behavior**. One example of altruistic behavior occurs in naked mole rats. Naked mole rats live underground in colonies. Each colony consists of one female that reproduces, called the queen, several males with whom the queen mates, called kings, and between 75-250 other males and females that do not reproduce. The nonreproductive members of the colony forage for food and care for and protect the queen, kings, and newborn offspring. **Figure 18** shows the nonreproductive individuals of a colony surrounding a queen and her offspring. By huddling around her, they are helping to keep the offspring warm.

Scientists have wondered what the advantage of altruistic behavior would be to an individual animal. Why should behavior that might hurt the individual animal ever be selected?

Kin selection One theory that has been presented to explain some types of altruistic behavior is kin selection. According to the idea of kin selection, altruistic behavior evolves because it increases the number of copies of a gene that is common to a population. It does not matter which individual passes the gene on to future generations. In the case of the mole rats, scientists have discovered through DNA analysis that all of the individuals in a colony of naked mole rats are closely related. The nonreproductive members of the colony will not pass on their genes. However, genes that are similar, if not identical, to their own will be passed on by the queen. As the nonreproductive members work to protect the queen and bring her food, they are ensuring that genes similar to their own will be passed on to future generations.




Queen



☞ **Figure 18** The nonreproductive members of a colony of naked mole rats exhibit altruistic behavior. They forage for food, protect the queen, and huddle around her to provide warmth while she nurses her offspring.

Table 1**Effects of Behaviors**

Interactive Table

Behavior	Example	Advantage	Disadvantage
Migration		Animals that migrate increase their chance of survival by moving to a location that has better climate conditions and more food.	A large amount of energy is needed to move long distances and there is the possibility of increased predation while moving.
Pheromone communication		Pheromones provide a species-specific form of communication, which works without alerting predators.	Pheromones have a more limited range of communication than auditory or visual cues.
Nurturing		Nurturing increases an offspring's chance of survival. Genes of the parents continue to be present in future generations.	Parents spend increased amounts of energy on caring for offspring, possibly at the cost of the parents' health or safety.

Advantages and Disadvantages

Many behaviors have benefits and disadvantages related to survival and reproductive success. A cost-benefit analysis examines the advantages and disadvantages of a particular behavior in terms of survival and reproductive success. **Table 1** shows the cost-benefit analysis of some types of animal behavior.

Section 2 Assessment

Section Summary

- Behavior evolves when genes from successfully reproductive animals remain in a gene pool.
- Competitive behaviors allow animals to establish dominance without serious injury or death to other individuals.
- Behaviors such as foraging, migrating, and maintaining a biological rhythm are important activities in animals' lives.
- Communication behaviors are critical to the survival and reproductive success of animals.
- Certain behaviors, such as courting and nurturing, are directly related to the reproductive success of an individual animal.

Understand Main Ideas

1. **Write an Idea** Explain how the behavior of an animal relates to its survival and reproductive success.
2. **Define** agonistic behavior. Give one example of this type of behavior.
3. **Analyze** the advantages and disadvantages of nurturing behaviors.
4. **Describe** how animals can communicate using pheromones.
5. **Explain** why migration is advantageous for some animals.

Think Critically

6. **Expand Table 1** by providing examples of the advantages and disadvantages of three other behaviors presented in this section.

MATH in Biology

7. The data in **Figure 14** show that the squirrel kept in continual darkness shifted the time of its activity slightly each day. After 23 days, the squirrel's activity cycle had shifted by eight hours. On average, how much, in minutes, did the activity cycle change each day?



Online Quiz



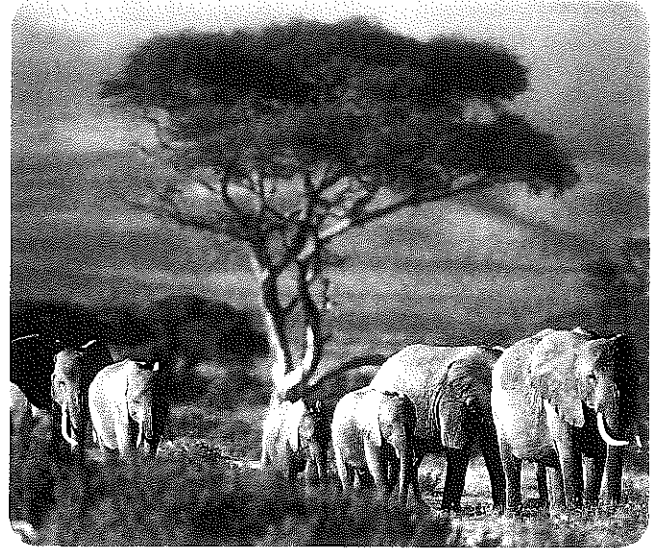
BioDiscoveries

Eavesdropping on Elephants

Elephant ESP? Humans can hear many of an elephant's calls, from the loud, shrill trumpet to low moans and grumbles. However, people used to believe that elephants also used Extra Sensory Perception (ESP) to communicate with each other. ESP might include the ability to read other's minds or know their thoughts. ESP was used to explain how a male elephant, traveling for kilometers, avoids other male elephants but finds a female that is ready to mate, which occurs once every few years.

Solving the mystery Enter Katy Payne, a bioacoustics researcher at Cornell University. In 1984, she was visiting the elephant display at the Washington Park Zoo in Portland, Oregon, when she realized that the air throbbed near the elephants. Was something going on that people could not hear? She recorded "elephant talk" and found that the low rumbles that people could hear were only a small part of an elephant's way of communicating. The elephants were using infrasonic sound waves to communicate. Infrasonic sound is produced by sound waves that are below the range of human hearing. Those deep elephant sounds people could hear actually were the overtones of sounds so low and powerful they could travel without interference over long distances. In fact, these calls can be heard by other elephants and felt as vibrations in the ground many kilometers away.

Copy cat Not only do elephants use infrasonic sound to communicate, they also are capable of vocal learning and mimicry. Scientists hypothesize that vocal imitation is used within complex social groups to enhance bonds between individuals.



Most infrasonic calling occurs within family groups, and females with young tend to be the most vocal.

Just why exactly do elephants need to communicate? And why is it important to biology? The way animals communicate can reveal some evolutionary secrets, such as how "talking" to each other can increase the chances of survival of individuals in a species. The wide variety of communication methods that have evolved demonstrates the importance of communication among all creatures. Future research might enhance our understanding of animal communication, as well as uncover many more methods of communication.

WRITING in Biology

Time Line Research at least four scientists from the past and present who have made discoveries about animal communication. Create a time line with your results. Detail the research that they conducted, including their hypotheses, scientific methods, data, and results.

©Siema Balfour/Gallo Images/Corbis



BIOLAB

Design Your Own

HOW DOES THE EXTERNAL STIMULUS OF LIGHT AFFECT BEHAVIOR?

Background: A response to light can be an important part of an animal's ecological behavior in that it might help make an animal more successful in finding food, escaping predators, or maintaining homeostasis. In this lab, you will design a testing chamber and use it to test how isopods respond to light.

Question: *How do isopods respond to light?*

Materials

clear plastic food wrap	isopods
forceps	scissors
plastic Petri dishes with lids	light source
cardboard boxes or trays	filter paper
small paper plates	paper towels
aged tap water	tape
black paper	graph paper

Safety Precautions



WARNING: *Be careful when working with a light source that can become hot. Treat the isopods in a humane manner at all times.*

Plan and Perform the Experiment

1. Read and complete the lab safety form.
2. Form a hypothesis about how the isopods will respond to light.
3. Plan how you will build a testing chamber, and then design an experiment to test your hypothesis. Keep in mind that isopods need to be kept moist at all times. Make sure your experiment has a control group of isopods. Identify the variables and ensure that your experiment tests only one variable at a time. What will you measure? How will you measure it?
4. Design and construct a data table you can use to record the data you collect concerning the behavior of the isopods in response to light.

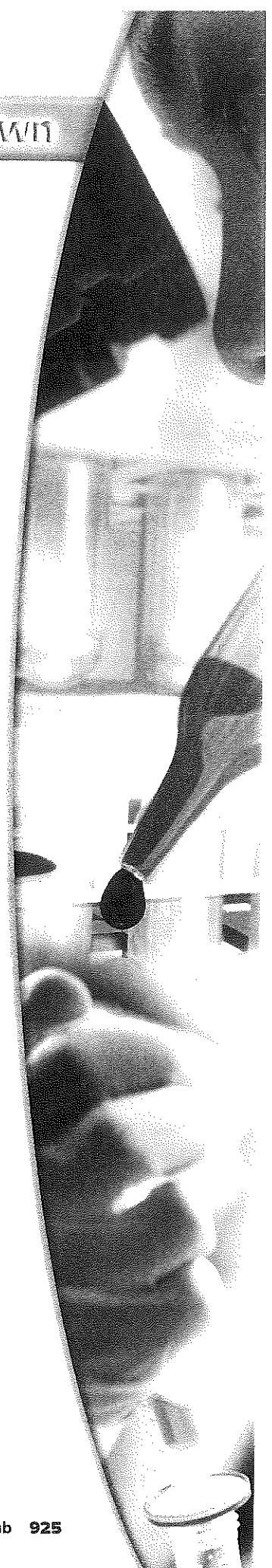
5. Make sure your teacher approves your plan before you proceed.
6. Collect material needed for your experiment and construct your testing chamber. Handle isopods gently and carefully.
7. Carry out your experiment.
8. **Cleanup and Disposal** Return isopods to their classroom habitat. Disassemble any equipment you put together and return any reusable materials to their proper storage area. Be sure to wash your hands thoroughly.

Analyze and Conclude

1. **Organize data** by creating a graph to illustrate your findings.
2. **Explain** what your graph shows about the response of isopods to light.
3. **Draw Conclusions** Did the data you collected from your observations of the control and experimental groups of isopods support your hypothesis?
4. **Use Scientific Explanations** What types of complex ecological behaviors of isopods might involve their response to light?
5. **Think Critically** Isopods also respond to the stimulus of low moisture by crowding together. Predict how this behavior would maximize their fitness and success.
6. **Error Analysis** What variables in your experiment would affect your data if they were not well controlled?

APPLY YOUR SKILL

Field Investigation Look for isopods in their natural habitat. How do the data you collected in this lab help you select places to begin your search? Write a summary describing your observations of isopods in their natural habitat.



Chapter 31 Study Guide

THEME FOCUS Patterns Biologists study animals, their behavior, and their environment to learn about their interactive relationships.

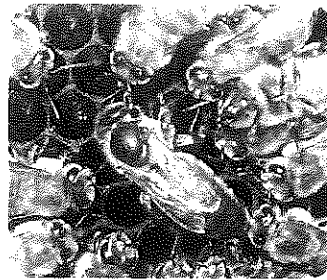
Big Idea Many animal behaviors are influenced by both genetics and environmental experiences.

Section 1 Basic Behaviors

behavior (p. 908)
innate behavior (p. 910)
fixed action pattern (p. 910)
learned behavior (p. 912)
habituation (p. 912)
classical conditioning (p. 913)
operant conditioning (p. 913)
imprinting (p. 914)
cognitive behavior (p. 915)

Big Idea Animal behaviors can be innate or learned, and they evolve through natural selection.

- Behavior can be influenced by both genes and experience.
- Successful behaviors are those that give individuals an advantage for survival and reproduction.
- Behavior can be innate or learned.
- Learned behavior includes habituation, conditioning, and imprinting.
- Cognitive behavior involves thinking, reasoning, and problem solving.



Section 2 Ecological Behaviors

agonistic behavior (p. 917)
dominance hierarchy (p. 917)
territorial behavior (p. 918)
foraging behavior (p. 918)
migratory behavior (p. 919)
circadian rhythm (p. 919)
language (p. 920)
courting behavior (p. 921)
nurturing behavior (p. 921)
altruistic behavior (p. 922)

Big Idea Animals that engage in complex behaviors might survive and reproduce because they have inherited more favorable behaviors.

- Behavior evolves when genes from successfully reproductive animals remain in a gene pool.
- Competitive behaviors allow animals to establish dominance without serious injury or death to other individuals.
- Behaviors such as foraging, migrating, and maintaining a biological rhythm are important activities in animals' lives.
- Communication behaviors are critical to the survival and reproductive success of animals.
- Certain behaviors, such as courting and nurturing, are directly related to the reproductive success of an individual animal.



(Photo by Jocelyn Winwood, NZ. Specialist in nature shots/Getty Images; (b) Lisa Harrison

Section 1

Vocabulary Review

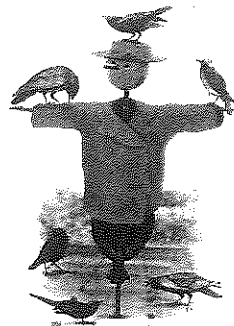
Use what you know about the vocabulary terms found on the Study Guide page to answer the following questions.

1. What type of behavior is carried out in a sequence of specific actions in response to a stimulus?
2. What type of behavior occurs when an association is made between two different kinds of stimuli?
3. What type of learning is permanent and occurs within a specific time period of an animal's life?
4. What type of behavior leads to a decrease in an animal's response after being exposed repeatedly to a stimulus that has no positive or negative consequences?
5. What type of behavior involves an animal associating its response with a reward or punishment?

Understand Main Ideas

6. Which behavior is genetically based and not linked to past experience?
 - A. habituation
 - B. classical conditioning
 - C. fixed action pattern
 - D. operant conditioning
7. Which is an example of imprinting?
 - A. salmon returning to the water in which they hatched to spawn
 - B. a rat learning to press a lever to get food
 - C. a baby lion learning how to hunt
 - D. baby birds getting used to seeing objects above them
8. An animal that solves a problem is engaging in what type of behavior?
 - A. fixed action pattern
 - B. cognitive behavior
 - C. imprinting
 - D. conditioning
9. Seasonal movement is an example of which type of behavior?
 - A. migratory behavior
 - B. classical conditioning
 - C. cognitive behavior
 - D. imprinting

Use the figure below to answer question 10.



10. Which type of behavior is shown above?
 - A. imprinting
 - B. fixed action pattern
 - C. habituation
 - D. operant conditioning
11. What is the time during which an animal imprints?
 - A. nurturing period
 - B. cognitive period
 - C. sensitive period
 - D. learning period

Constructed Response

12. **Short Answer** Compare and contrast classical conditioning and operant conditioning.
13. **Open Ended** What difficulties might scientists have when trying to determine if animals engage in cognitive behaviors?
14. **THINK Idea** Describe how the evolution of animal behaviors is affected by natural selection.

Think Critically

15. **Hypothesize** why a behavior of an animal would cause it not to spend energy and time caring for its offspring.
16. **CAREERS IN BIOLOGY** Animal behaviorists observed that one species of lovebird carries nest-building materials in its beak. Another species of lovebird carries the material under its feathers. Hybrid offspring are produced by breeding these two species. The hybrids repeatedly shift the material between their beaks and their feathers while carrying it. What conclusion can be drawn about the influence of genetics on behavior from the results of this experiment?



Section 2

Vocabulary Review

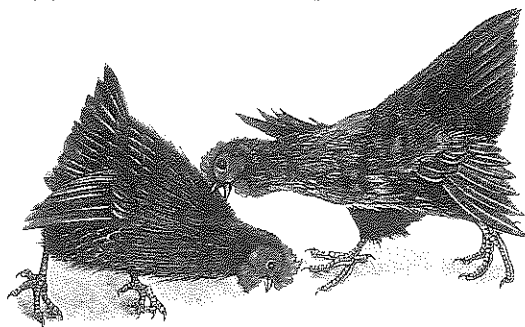
Use the vocabulary terms found on the Study Guide page to answer the following questions.

- What is a form of auditory communication in which animals use vocal organs to produce groups of sounds which have shared meanings?
- In which situation does a top-ranked individual get access to resources without conflict from other individuals in the group?
- What is a specific chemical spread by animals in order to communicate?
- Which type of behavior results in an animal adopting and controlling a physical area against other animals of the same species?
- Which type of behavior results in a threatening or combative interaction between two individuals of the same species?

Understand Main Ideas

- Which behavior usually is concerned with finding and eating food?
 - nurturing
 - courting
 - foraging
 - migration
- Which behavior is directly related to reproductive success within a species?
 - altruism
 - courting
 - foraging
 - migration

Use the figure below to answer question 24.



- What is shown in the figure above?
 - agonistic behavior
 - migration
 - dominance hierarchy
 - nurturing behavior

- What behavior is linked with pheromones?
 - agonistic
 - migration
 - nurturing
 - communication
- Which is an example of a circadian rhythm?
 - migration
 - sleep/wake cycle
 - hibernation
 - reproductive cycle
- Ensuring that offspring have an increased chance of survival is an example of which type of behavior?
 - agonistic
 - migration
 - nurturing
 - territorial

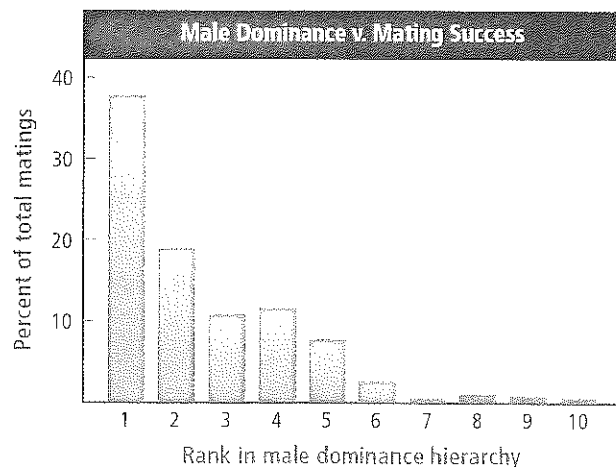
Constructed Response

- Short Answer** Provide an example that illustrates how animal behavior is related to genetic inheritance.
- Short Answer** Distinguish dominance hierarchy from territorial behaviors.
- Open Ended** Hypothesize what would happen if circadian rhythms disappeared.

Think Critically

- Hypothesize** the successful evolutionary advantages of an animal sacrificing itself for its sibling in a competitive battle with a predator.

Use the graph below to answer questions 32 and 33.



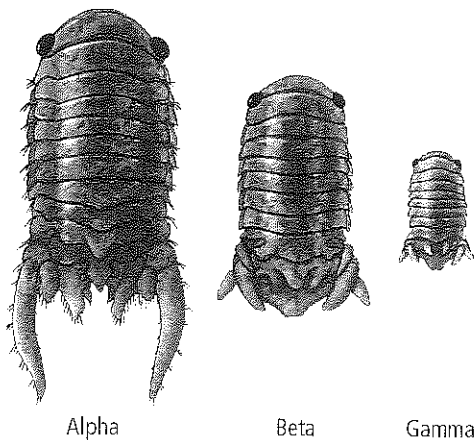
- Draw conclusions** about the relationship between the order of male seals in the dominance hierarchy and their number of matings.
- Hypothesize** a reason for this behavior.



34. **Infer** how an animal might starve if its parents failed to teach it competitive behaviors.
35. **Infer** If an individual animal no longer was able to learn, how might this condition affect its ability to engage in competitive behaviors in the near future?
36. **Compare and contrast** two strategies of spending reproductive energy—producing large numbers of eggs with little or no parental care, and producing a smaller number of eggs and engaging in nurturing behavior. Give an example of animals that use each strategy.
37. **THEME FOCUS Patterns** Of the three animals you have observed in this chapter—emperor penguins, earthworms, and isopods, which has the most complex ecological behavior? Based on what you know about these animals, why do you think this might be?

Use the figure below to answer questions 38 and 39.

A species of marine isopods lives in sponges in intertidal zones. The males of this species exist in three different sizes—alpha, beta, and gamma. Females of this species are similar in size to the beta males. Each size of male has a different strategy for mating.



38. **Identify** which size of male would use the mating strategy that involves avoiding the alpha-sized males and hiding in a sponge to mate with a female. Explain your answer.
39. **Identify** which size of male would use the mating strategy that involves fighting with an alpha-sized male until one isopod wins. What is this type of behavior called?

Summative Assessment

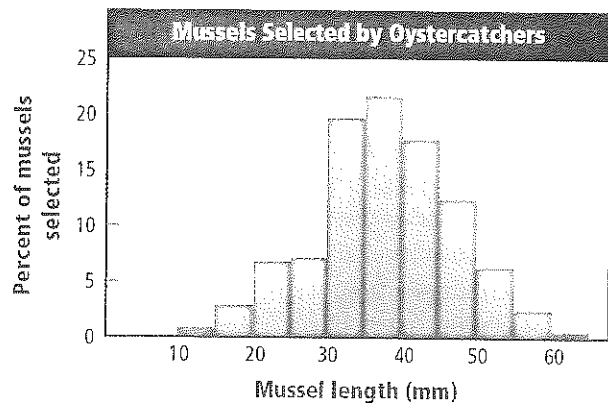
40. **CRITICAL THINKING** Choose an animal and create a graphic organizer showing how genetics and environmental factors have influenced its daily needs and activities.
41. **WRITING** **Biology** Write a persuasive paragraph on why altruistic behavior by an individual animal might result in the animal's genes appearing in future generations.

DB Document-Based Questions

Oystercatchers are small shore birds that eat mussels as one of their primary foods. The birds must spend time and effort to hammer or stab the mussels to open them.

Use this graph to answer the questions below.

Data obtained from: Meire, P.M., and Ervynck, A. 1986. Are oystercatchers (*Haematopus ostralegus*) selecting the most profitable mussels (*Mytilus edulis*)? *Animal Behaviour* 34: 1427-1435.



42. Which mussel size do the oystercatchers prefer?
43. The 10-mm mussels are the most abundant. Hypothesize why oystercatchers often do not forage for them.
44. Larger mussels provide many more calories than smaller mussels. The larger the mussel, the more it tends to be encrusted with barnacles that make it harder to open. Hypothesize why oystercatchers do not forage for the largest, most energy-rich mussels.



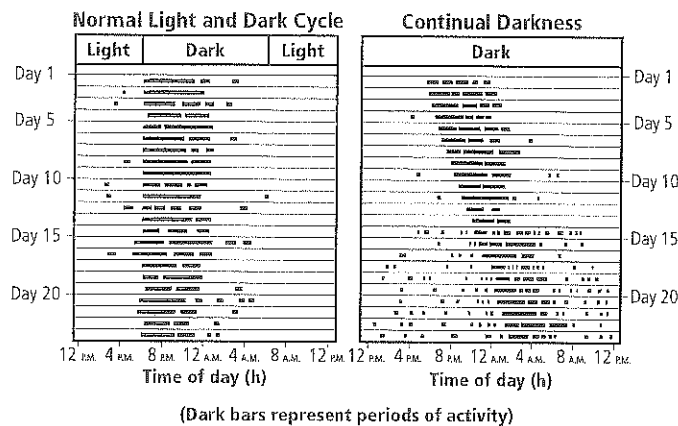
Standardized Test Practice

Cumulative

Multiple Choice

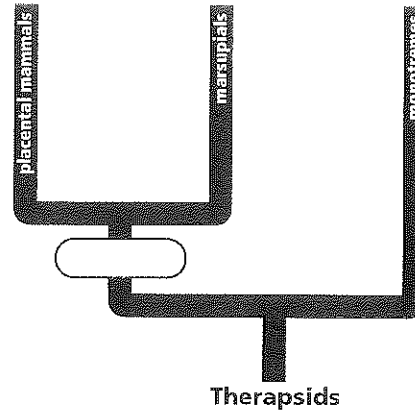
- Which describes a function of feathers?
 - insulation
 - nesting
 - conserving water
 - swimming

Use the diagram below to answer questions 2 and 3.



- The squirrels that were exposed to 12 h of daylight each day displayed which behavior pattern during the 24-h cycles?
 - most activity during hours of darkness
 - most activity during hours of daylight
 - constant sleeping
 - continuous activity
- Squirrels that were exposed to 24 h of darkness displayed which circadian rhythm?
 - cycles of exactly 12 h
 - cycles of less than 12 h
 - cycles of exactly 24 h
 - cycles of more than 24 h
- How did the earliest fishes obtain their food?
 - by grazing on phytoplankton at the water surface
 - by living as parasites inside larger marine animals
 - by sucking up organic matter off the ocean floor
 - by using sharp teeth to break apart mollusks

Use the diagram below to answer question 5.

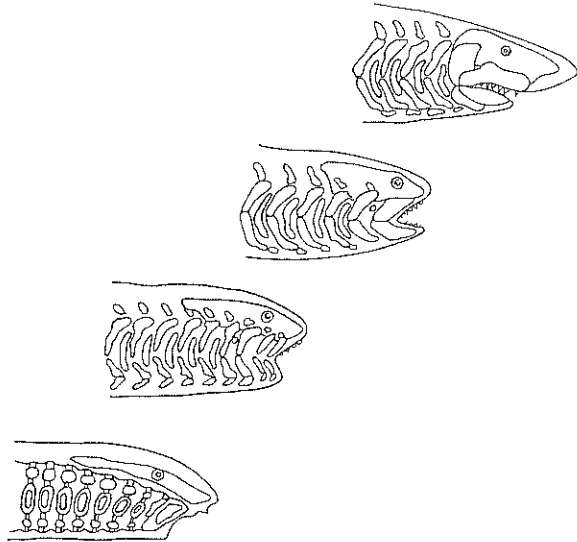


- What information belongs in the bubble in the diagram?
 - Adults give birth to live young.
 - Adults lay eggs.
 - Offspring live in mother's pouch after birth.
 - Offspring receive milk from their mother.
- Which structures are used by fishes to take in oxygen and transport it to body cells?
 - gills and a closed circulatory system
 - gills and an open circulatory system
 - lungs and a closed circulatory system
 - lungs and an open circulatory system
- Echinoderms, such as sea stars, use their tube feet for locomotion and what else?
 - reproduction
 - respiration
 - sensing gravity
 - sensing light
- Which characteristic is used to classify dinosaurs into two groups?
 - structure of the hipbones
 - structure of the skull and jaw
 - whether they are ectotherms or endotherms
 - whether they are herbivores or carnivores



Short Answer

Use the diagram below to answer question 9.



9. Describe the evolution of the jaw. Explain how it was an important advancement for fishes.
10. Hypothesize why some birds migrate thousands of miles each year.
11. Identify three traits of mammals. Explain why they are necessary for endotherms.
12. Compare and contrast an open circulatory system and a closed circulatory system.
13. Compare and contrast organisms in the order Rodentia with those in order Lagomorpha.
14. Hypothesize how an animal would benefit from a dominance hierarchy if it does not defend a territory.

NEED EXTRA HELP?

If You Missed Question . . .	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Review Section . . .	29.2	31.1	31.2	28.2	30.2	28.1	27.1	29.1	28.2	31.2	30.1	25.3	30.2	31.2	21.1	31.2	30.2

Extended Response

15. Suppose a plant with adaptations for survival in a tropical rain forest is transplanted to a tropical desert. What adaptations in the rain forest plant could cause it to have trouble surviving in the new environment?
16. A certain type of insect uses pheromones to attract mates. The insect is most active during the day. Propose the advantages and disadvantages of this type of behavior for attracting mates.

Essay Question

The ring-tailed lemur is an herbivore. It eats a variety of plants and plant materials. Ring-tailed lemurs eat up to three dozen species of vegetation, but one of their favorites is the kily tree.

Groups of ring-tailed lemurs are led by a dominant female. A group usually contains between 15 and 30 lemurs. They can travel over a large area, some days more than 4 km. When the lemurs aren't eating, they often bathe in the Sun, groom each other, or play. Ring-tailed lemurs sleep under large trees. Settling down for the night is usually preceded by a loud whoop-like call from all the lemurs.

Using the information in the paragraph above answer the following question in essay format.

17. The passage above describes the diet and behavior of ring-tailed lemurs. Suppose you want to do a study of lemur behavior. In an organized essay, explain what your research question would be and how you would study the behavior of ring-tailed lemurs.

