Topic 8.1

Responses to the Environment

Learning Objectives

- Know the behavioral and physiological responses in organisms to environmental changes
- Understand the behavioral changes in organisms due to internal and external cues
- Learn about organism communication signals as causes of differential reproductive success
- Understand the role of sensory and molecular signals in animal population health
- Learn about the information response and communication in natural selection and evolution
- Learn about the innate and learned behaviors favored by natural selection
- Understand the importance of cooperative behavior in a population

Topic Questions

- In what ways do organisms respond to their environment? How can these responses change based on the situation?
- In which ways do organisms communicate with one another? How is this communication related to natural selection, evolution, and fitness?

8.1.01 Behavioral and Physiological Responses in Organisms to Environmental Changes

[ENE-3.D.1]

A **behavior** can be defined as an action done by an organism that involves movement or is directed toward the organism's external (ie, outside) environment, or the way an action is performed (eg, its timing). Note that *behavior* can also be used collectively, to show a full or partial set of individual behaviors shown by an organism (eg, dog *behavior*, mating *behavior*). Behaviors include a wide variety of actions, such as how lizards compete for mates, the different sounds a songbird uses to communicate, or the time of day a mouse forages (ie, searches for food).

Environmental factors (eg, weather, climate change, human activity, threats from predators) can affect an organism's behavior and physiology. **Behavioral responses**, directed toward an organism's external environment, and **physiological responses**, directed toward the organism itself, allow organisms to better adapt to their environments.

Behavioral and physiological responses can sometimes overlap (Figure 8.1). For example, plants move toward light through growth (ie, phototropism), amoebae move toward food by changing their shape, and chameleons and octopi control the distribution of skin pigments or crystals to change color. *Note: Although the role of behavior and physiology in the responses of organisms to their environments is important to understand, for this topic there is no need to memorize specific behavioral or physiological responses.*

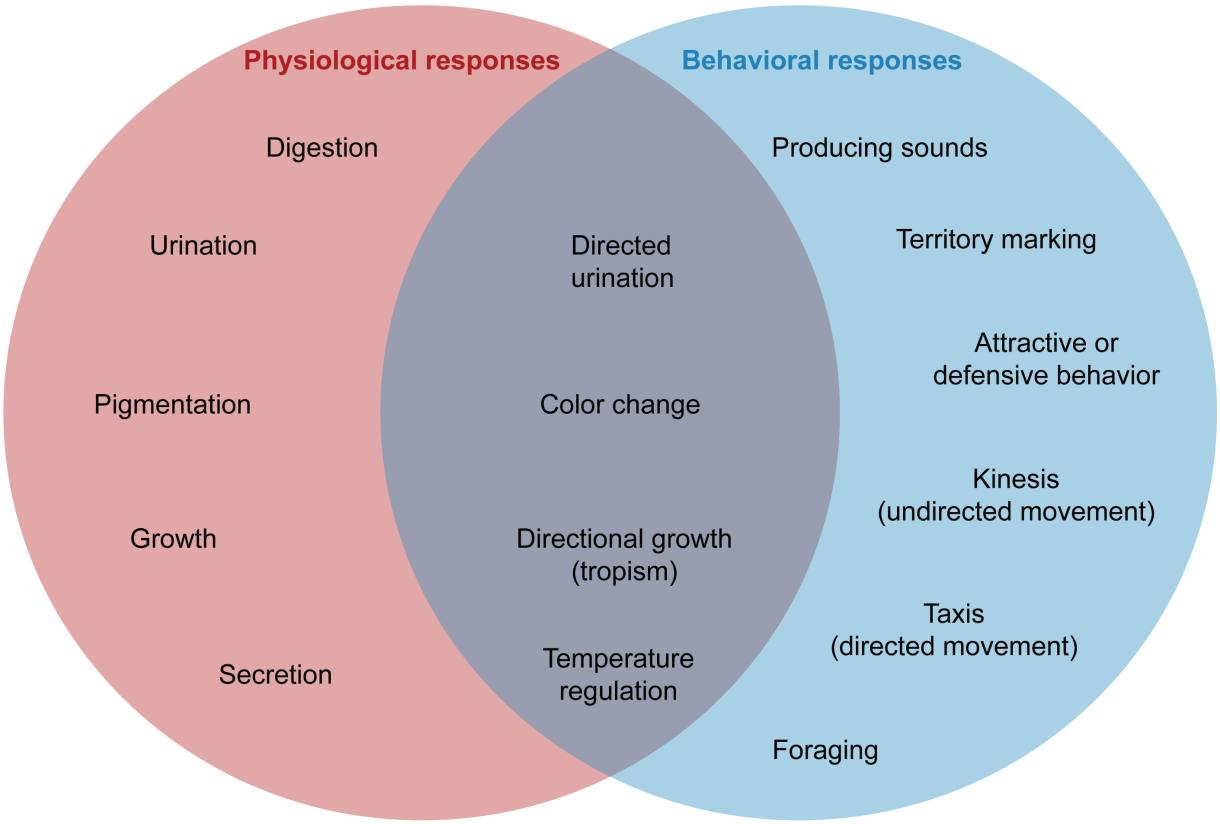


Figure 8.1 Examples of physiological and behavioral activities.

An organism's evolutionary **fitness** can be defined as its ability to pass its genetic material on to the next generation. The physiology and behaviors of an organism strongly influence the organism's fitness, and physiological and behavioral characteristics that increase survival and reproduction increase evolutionary fitness. Examples of these characteristics include those that make an organism more likely to attract a mate, survive a threat from a predator, or acquire enough food.

8.1.02 Behavioral Changes in Organisms Due to Internal and External Cues

[ENE-3.D.2]

Organisms change their behaviors in response to cues (ie, signs), both internal (eg, cell signals) and external (eg, information from other organisms in the environment). Internal or external cues can start one action or a sequence of actions. A sequence of unlearned actions that is instinctual is called a **fixed action pattern**. A fixed action pattern cannot be changed: once activated, it will be fully completed by the organism.

The release of hormones by animal cells is an example of an internal cue that results in behavioral changes. The hormones released during ovulation can trigger mating behaviors, and the hormone epinephrine released in stressful situations triggers fight or flight behavior.

Other behaviors are the result of external environmental cues. Information exchange between animals (ie, **communication**) can change behavior (Table 8.1). For example, many organisms (eg, songbirds) use sounds to communicate threats, attract mates, or drive away competitors. Other communication methods include pheromone release, body position changes, or outward displays (eg, a peacock unfolding distinctive tail feathers). *Note: Although given here for understanding, specific examples of communication do not need to be memorized for the exam.*

Table 8.1 Examples of animal communication.

Animal communication method	Purpose	Examples
Auditory (Sound production)	• Warning • Mating	Rattlesnakes vibrate their tails to warn; birdsongs attract bird mates
Chemical (Scent, pheromones)	• Alarm • Mating • Food location • Territory	Social insects (ants, honeybees) use pheromones to warn if colony is disturbed or to lead others to food source
Tactile (Touch, movement)	• Fighting • Mating • Food location • Bonding	Mammals lick, nuzzle, groom offspring and other group members to bond; social insects can use elaborate dances to communicate food location
Visual (Coloring, movement, expressions)	• Warning • Mating	Insects and amphibians with bright colors warn predators of toxicity; brightly colored bird plumage attracts potential mates

Behaviors that increase organism survival and fitness are more likely to remain in a population (ie, be naturally selected). Over many generations, behavioral responses that continue to increase fitness can become fixed in a species.

8.1.03 Organism Communication Signals as Causes of Differential Reproductive Success

[IST-5.A.1 IST-5.A.2]

Different forms of communication (eg, auditory, chemical, see Sub-Topic 8.1.02) are often the cues that trigger behavior in an individual or group. These communications consist of *signals*, which are actions or sensory information that one organism produces to communicate with another. As shown in Figure 8.2, organism communication can affect organisms from the same or different species. Examples of such communications are an organism calling for a mate (ie, same species) or an organism warning away a predator (ie, different species).

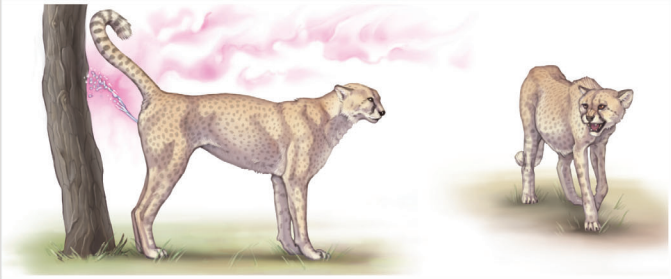
Communication type	Example
Use of flower color by plants to attract pollinators	
Scent marking by animals to discourage others from entering their territory	

Figure 8.2 Examples of communication between organisms of the same or different species.

Signaling behaviors can increase organisms' reproductive success (ie, evolutionary fitness) in various ways, including improved self-defense, increased ability to find food and mates, or the ability to find good environments for reproduction. Behaviors that let organisms increase their survival and reproduction within an ecological community will likely remain in a population as long as the environmental conditions remain similar.

8.1.04 Role of Sensory and Molecular Signals in Animal Population Health

[IST-5.A.2]

Organisms use different mechanisms to communicate information, including visual (eg, colorful displays), auditory (eg, mating calls), tactile (eg, grooming), electrical (eg, electrolocation), and chemical (eg, pheromones) signals. Mechanisms that increase survival and reproduction tend to remain in a population (ie, be naturally selected), and mechanisms that decrease fitness tend to be removed (ie, *selected against*). *Note: Although knowing categories of communication mechanisms is important for the exam, specific examples do not need to be memorized.*

Communication can be used to attract or prevent the entry of other organisms into an area, establishing a territory. For example, some organisms use scent to mark their territory. If this communication results in increased attraction of mates and exclusion of predators, the communication can increase survival rates (ie, a population's fitness). On the other hand, some communication methods can decrease survival (eg, fighting for mates) or attract predators, decreasing reproductive success. Therefore, mutations that prevent or limit communication can also promote population survival.

8.1.05 Information Response and Communication in Natural Selection and Evolution

[IST-5.A.3]

Organisms can produce and respond to different types of signals, which allows for communication. Signaling behaviors (eg, auditory, visual, chemical) can increase evolutionary fitness in different ways. For example, communication can increase an organism's ability to find food, successfully mate, or avoid predators.

The overall effect of a particular type of communication on evolutionary fitness depends on the balance between any positive and negative outcomes. For example, some organisms may give an auditory

warning upon seeing a predator. This may have the effect of making the warning organism more likely to be killed but making other organisms in the environment more likely to survive, as shown in Figure 8.3.

Figure 8.3 The overall effect of communication on evolutionary fitness depends on the balance between positive and negative outcomes on a population.

Natural selection is the process by which physiological or behavioral characteristics associated with increased evolutionary fitness build up in a population. If a particular communication method continues for a long period of time in nature, it is likely favored by natural selection.

8.1.06 Innate and Learned Behaviors Favored by Natural Selection

[IST-5.A.3]

Some animal behaviors are necessary for survival and reproduction. Therefore, behavior is subject to natural selection and can be grouped into two categories (Figure 8.4):

- **Learned behaviors** are gained through experience and usually develop after organisms have seen the behavior performed by other organisms.
- **Innate behaviors** are under genetic control and are performed similarly by all population members without the need for previous experience.

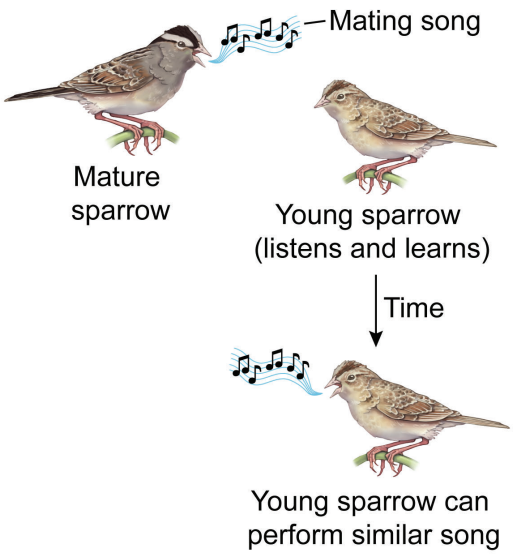
Behavior type	Definition	Example
Learned behavior	Learned by an organism over time through experience	
Innate behavior	Controlled by an organism's genes and can be performed automatically without previous experience	

Figure 8.4 Examples of learned and innate behaviors.

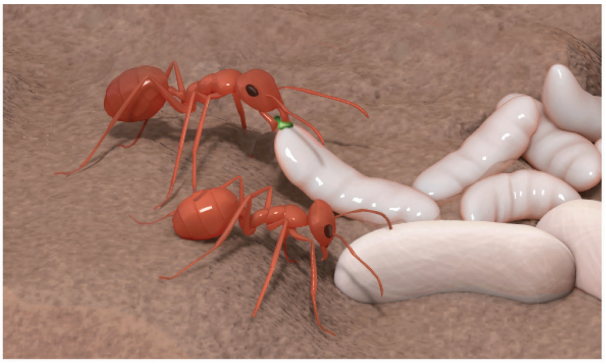
For example, an organism may show a learned hunting behavior that puts the organism at risk of death but has been present in the population over many generations. Because natural selection tends to eliminate traits that decrease survival or reproduction, natural selection most likely favors this hunting behavior. Although the behavior has a risk, the benefit outweighs the risk. Behaviors that continue in a population are likely to have consistently improved evolutionary fitness of the population over many generations. If conditions change in the future, however, previously beneficial behaviors can sometimes continue, even if they have become harmful.

8.1.07 Importance of Cooperative Behavior in a Population

[IST-5.A.3]

Behaviors can have an overall positive or negative effect on survival and reproduction (ie, evolutionary fitness). The evolution of behaviors toward those that increase evolutionary fitness can result from natural selection (ie, the natural continuation of beneficial genes over time in a population).

Some populations show **cooperative behaviors** where organisms work together to improve the fitness of the whole group (Figure 8.5). **Animal societies** are groups of animals that show collective behaviors due to cooperation. Animal societies can be structured in different ways; for example, some societies consist of a single reproductive female and hundreds or thousands of sterile workers, while others are complex groups that include several breeding and non-breeding individuals.



Sterile worker insects care for offspring of fertile individuals, **improving** chances of survival for the entire colony.

Pack hunting improves the chances of acquiring prey, **enhancing** the ability of the group to survive.

Figure 8.5 Examples of cooperative behavior.

Cooperative behaviors can provide many benefits to individuals in the group. A group with multiple animals means that many individuals are available to watch for predators, defend against competitors, or forage for food. Hunting in groups can increase the chances of success. Animal societies also provide easier chances for mating, and raising offspring as a group can increase offspring survival chances.

Topic 8.1 Responses to the Environment
Check for Understanding Quiz

1. Which of the following best describes a response that is both behavioral and physiological?
   A. Growth
   B. Color change
   C. Territory marking
   D. Foraging

2. Cooperative behavior among individuals in an animal society improves the fitness of the whole group. Which of the following activities is LEAST likely to provide a benefit to individuals in an animal society?
   A. Defending against competitors
   B. Finding mating partners
   C. Acquiring prey through pack hunting
   D. Raising offspring alone

Note: Answers to this quiz are in the back of the book (appendix).