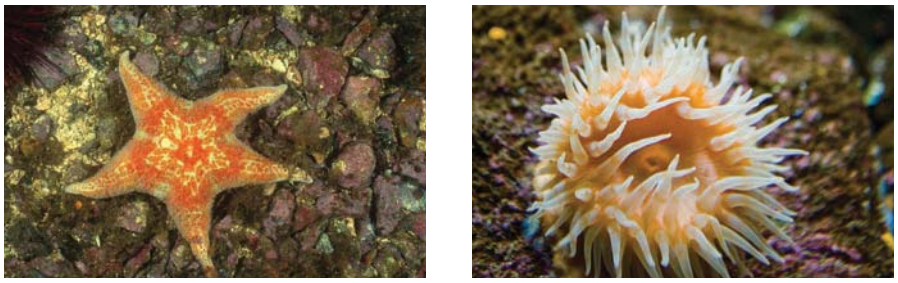
Evolution of Behavior

FIGURE 2: Normally motionless, this sea anemone will swim away when it detects a sea star.

Explore Online



a Sea Star, *Dermasterias imbriacata*

b Sea Anemone, *Stomphia coccinea*

The sea anemone, *Stomphia coccinea*, has no brain or spinal cord and usually sits motionless. Yet, when it comes in contact with the sea star, *Dermasterias imbriacata*—its predator—the anemone detaches itself from its perch and swims away to safety. At other times, with other organisms, the anemone will not swim away.

Predict How does the sea anemone know when it comes into contact with a sea star versus some other object?

Responsive Behavior

The environment of every organism constantly changes. In order to thrive, organisms, such as the sea anemone, must respond to these changes. Anything that triggers a response is called a stimulus (*pl. stimuli*). An internal stimulus triggers a response to a change in an organism's internal environment, such as an infection. An external stimulus is any change in the external environment, such as contact with a predatory sea star, that causes a response.

Sense organs have specialized cells with receptors that detect changes in the environment and communicate information through nerves to the brain. The brain then sends a message back to the appropriate system telling it how to respond. This works well in organisms with complex nervous systems. However, this feedback mechanism also works in organisms such as the anemone, which only has a network of neurons with no centralized brain. Receptor cells on the outer surface of the anemone detect an external stimulus, which elicits an escape response.

Model Draw a model of the processes that occur when you interact with an internal or external stimulus, such as touching something very hot.

The sea anemone in Figure 2 never learned to swim away from the sea star, but it still knows to move to safety. This is an example of an innate behavior, sometimes called an *instinctive behavior*. Innate behaviors are passed from generation to generation without learning. 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.

Innate behaviors are typically found where mistakes can have severe consequences. A sea anemone that does not swim away from the sea star, *Dermasterias imbriacata*, may be attacked. By having set reactions to particular stimuli, animals can automatically respond correctly in a life-or-death situation.

Function of Behavior

Collaborate With a partner, discuss how innate behaviors help organisms maintain homeostasis.

A lizard sunning itself on a rock is likely not just relaxing. If the rock becomes shaded, the lizard will shift its position to a warmer part of the rock. These behaviors actually help the lizard regulate its internal body temperature. Too hot? No problem. The lizard simply moves to a shadier spot. This behavior explains how ectotherms interact with their external environment to control their internal body temperature.

Maintaining a balanced internal state, or homeostasis, is critical to the health and functioning of an organism. When your internal temperature is below a normal temperature of 37 °C (98.6 °F), your body responds by shivering to produce heat. This is a biological response to an internal stimulus. Behavioral responses to the environment also help organisms maintain homeostasis. These responses are often movements or reactions that will help support a balanced state, increasing the chance of survival.

Cause and Effect

FIGURE 3: Red crabs migrate during mating season.

Migration

To survive and reproduce, animals need water, food, and shelter. For many species, this requires individuals to move from one location to another or migrate. Each species has one or more triggers that cue migration. Certain species of birds often migrate from one area to another in a seasonal pattern. Each season brings changes in temperature, availability of food, and length of day.

Some migration cues are biological. In some species, depletion of energy reserves may signal a need to travel to available food sources. In others, changes in hormone levels or reproductive life cycles trigger mass movements. The breeding ritual of the red crabs of Christmas Island starts at the beginning of the rainy season. The crabs must migrate at this time because their eggs must be released in the sea before sunrise during the last quarter phase of the moon.

Predict According to what you know about natural selection and evolution, how does a behavior evolve, such as mass migration of a species, where all individuals respond in the same way at the same time?

FIGURE 4: A Swarm of Locusts

Weighing the Costs of Behavior

Every behavior has benefits and costs. A swarm is a large, dense group of animals, such as insects or birds. A swarm offers many advantages to living and traveling. Swarms confuse predators, which protects individual members. A swarm also may be better at finding food than an individual.

A swarm has disadvantages too. The size of a swarm can actually attract predators, leaving individuals on the outer edges of the swarm particularly at risk. A group with more individuals requires greater resources, which must be shared.

Gather Evidence When would swarming behavior be beneficial and when would it be too costly? How might a behavior such as swarming evolve among species?

Costs of Behavior

Behavioral costs can be measured in terms of energy, risk, and opportunity.

Energy costs describe the difference between the energy used in carrying out an activity and the energy used if the individual had done nothing. For example, it takes energy for a lizard to move from a shady spot to a sunny spot. However, it is worth that energy cost in order to maintain body temperature.

Risk costs are the increased chance of being injured or killed by carrying out a certain behavior versus doing nothing. Consider the wolves in Figure 5. Wolves risk injury or even death by fighting with other wolves. However, they may win access to mates or better territory if they win. Sometimes, the benefits outweigh the risks.

Opportunity costs result when an animal spends time doing one behavior and loses an 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 foraging or mating.

FIGURE 5: Fighting can result in serious injury or even death.

Benefits of Behavior

If a predator approaches an animal suddenly, the stimulus elicits an involuntary, or innate, behavior such as running that is meant to protect the animal. One of the main benefits of an innate behavior is that it increases survivorship, or the number of individuals that survive from one year to the next. This will in turn increase an animal's fitness by natural selection. A behavior will be expressed if its benefits outweigh its costs. So, the benefit of maintaining homeostasis by basking in the sun outweighs the risk cost of a lizard exposing itself to predators. Behaviors that improve an individual's fitness will be passed on to future generations.

All organisms require food to survive. At times it is more beneficial for an individual to gather food alone. A solitary hunter only needs to find enough food for itself or its young. In other species, such as lions, group hunting is more beneficial. The division of labor reduces the energy cost and risk cost per individual. Group hunts increase the potential to take down bigger or more prey and the group has greater protection. However, a group must find more food and there is more competition for that food.

In some group hunts, the pack works together to pursue and take down the prey. In other groups, such as bottlenose dolphins, individuals have specific roles. Bottlenose dolphins forage in groups of three to six, with one individual acting as the driver to herd the fish toward other dolphins lined up as barriers to prevent the fish from escaping. The driver slaps its tail, causing the fish to leap into the air. This makes it easier for the dolphins to catch the fish. Clearly the energy cost per individual and risk from predators is less for the group, which gathers far more fish than a solitary hunter.

Analyze Some spiders build webs that include visible zigzag lines. But more visible webs catch fewer insects than do less visible webs. What benefits do you think the spider gets by building such a visible web?

FIGURE 6: Lions hunt in a group.

Murmurations

Murmurations are a form of group behavior in which thousands of starlings flock together as shape-shifting clouds. The birds fly together as one, creating incredible patterns as the flock twists and turns in the sky. Murmurations are often triggered by the presence of a predator, which is outmaneuvered by the rapid pattern changes.

Explain Murmurations require a great deal of energy expenditure. Explain the function of this behavior and the cost-benefit relationship. Does the benefit derived from the behavior outweigh the cost?