43 Ecological and Evolutionary Consequences of Interactions within and among Species

Chapter Outline

When you watch a butterfly sipping nectar from a flower or a bat swooping and diving after insects at night, you are seeing species interact with one another. The butterfly is drinking the flower's nectar, but it is also moving pollen from flower to flower, helping the plant achieve sexual reproduction. In turn, the butterfly is prey for many species of birds, much as the night insects are prey for the bats. These are but a few of the many and often intertwined relationships among organisms.

As organisms adapt to avoid being eaten, many new novel structures and features evolve. These include protective adaptations like thorns, camouflage, armored shells, and bitter or spicy compounds. As one organism evolves to avoid being eaten, its predator also evolves or adapts to the new defensive mechanisms. For example, as seeds became larger and thicker, bird bills became larger to enable the birds to crack the seeds. These consumer-resource interactions lead to evolutionary "arms races," often with contrary results. Hot chili peppers, for example, synthesize a repellent compound known as capsaicin. While many organisms find this too bitter or spicy to eat, many people enjoy—even prefer—spicy dishes.

Chapter 43 has ideas that span **Big Idea 1**, **Big Idea 2**, and **Big Idea 4**. The specific parts of the AP Biology curriculum covering **Big Idea 1**: The process of evolution drives the diversity and unity of life, include:

- **1.A.2**: Natural selection acts on phenotypic variations in populations.
- **1.C.1**: Speciation and extinction occurred throughout the Earth's history.
- **1.C.3**: Populations of organisms continue to evolve.

The specific parts covering **Big Idea 2**: Biological systems utilize free energy and molecular building blocks to grow, to reproduce, and to maintain dynamic homeostasis, include:

- **2.D.1**: All biological systems from cells and organisms to populations, communities, and ecosystems are affected by complex biotic and abiotic interactions involving exchange of matter and free energy.
- **2.D.3**: Biological systems are affected by disruptions to their dynamic homeostasis.

The specific parts addressing **Big Idea 4:** Biological systems interact, and these systems and their interactions possess complex properties, include:

- **4.A.5**: Communities are composed of populations of organisms that interact in complex ways.
- **4.B.3**: Interactions between and within populations influence patterns of species distribution and abundance.

Chapter Review

Concept 43.1 *notes that species interactions can be positive, neutral, or negative. There are five broad categories of interactions between organisms: competition, consumer-resource, mutualism, commensalism, and amensalism.*

1. For each of the relationships below, indicate in the appropriate column if the first species mentioned (Species 1) is affected negatively (-), positively (+), or not at all (0). Do the same for the second species (Species 2), then write the type of interaction in the third column. The first example is completed for you.

Example	Species 1	Species 2	Type of Interaction
American bison feed on grasses.	+	-	Consumer resource
Wrasses (small fish) clean the teeth of larger fish.			
Mosquito feeds on the blood of a deer.			
Bread mold secretes penicillin that kills local bacteria that generally have little to no effect on the mold.			
A cactus wren builds a nest in a cholla cactus without affecting the cactus.			
A hawk captures a small squirrel for food.			
A rabbit rests in the shade of a small bush.			
Deer create a trail through a forest where they routinely travel.			
Plovers (a bird) remove insects from the backs of large animals.			

2. Many types of trees can be found in a forest. Identify three different biotic factors and discuss how they can affect the growth and health of trees.

3. Explain how predation is different from parasitism.

Concept 43.2 *examines how interspecific interactions affect growth. When two species compete directly with each other for resources, per capita growth rates usually decrease for at least one of the species, one species goes extinct, or resource partitioning occurs.*

4. The intertidal zone along ocean shorelines is teeming with life as species compete for living space. Twice a month, as the moon circles the earth, higher-than normal tides submerge the shoreline, which is normally only splashed by waves.

Two species of barnacles (small crustaceans that filter seawater for food particles in the intertidal zone) exhibit interspecific competition as they compete for space. The rock barnacles, *Semibalanus balanoides*, are found in a narrow range between the lower intertidal zone and the average high-tide line. The stellate barnacles, *Chthamalus stellatus*, are found across a broader range, between the lower intertidal zone and the highest high-tide line.

a. Draw a diagram of the intertidal zone showing a region where only stellate barnacles are found. Include in your diagram the low-tide line, average high-tide line, and highest high-tide line.

b. Explain how stellate barnacles can survive above the average high-tide line.

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c. Explain why rock barnacles cannot survive above the average high-tide line.

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d. When the two barnacles are found living in the same location, the rock barnacles grow on top of the stellate barnacles, killing them. Draw a diagram showing what happens when these two species are found together in the intertidal zone.

e. A researcher clears organisms and debris off a patch of rock in the middle of the intertidal zone. Describe what happens as both types of barnacles attempt to colonize that zone.

5. In a forest ecosystem, foxes prey on rabbits and mice, yet foxes are unlikely to consume all of the rabbits. Propose a reason that not all rabbits are eaten.

6. Propose the consequences of two species competing for the same resources in the same location at the same time.

Concept 43.3 *considers how human-introduced species can alter species interactions, using food webs as illustrative examples per the AP Biology Curriculum Framework. Introduced species often establish themselves in environments that lack the regulatory controls found in their native habitats, sometimes resulting in out-of-control growth. Kudzu, purple loosestrife, fire ants, and Eurasian weevil are examples of introduced species that have grown out of control and have altered many ecological relationships in North America.*

Questions 7 and 8 refer to problems with kudzu, an invasive plant species.

Kudzu, *Pueraria lobata*, is a climbing vine native to Japan and China. It is usually classified as a weed, because it climbs over trees and shrubs and grows so rapidly that it blocks sunlight and kills them. Kudzu spreads primarily by rhizomes and by vegetative propagation via runners that form new plants. It can grow at a rate of 0.3m/day in optimal conditions and is now common along roadsides and other areas throughout the southeastern United States.

The plant was introduced to the United States at the Japanese pavilion in the 1876 Centennial Exposition in Philadelphia. In 1935, the Soil Conservation Service began to test kudzu as a solution to the eroded lands in Alabama and Georgia. After a few years, that agency proclaimed that kudzu, with its fast growth and deep roots, could solve the erosion problems of the South. Farmers were paid $8 per acre to plant

kudzu and prevent erosion. During the Great Depression, the Civilian Conservation Corps planted over 70 million seedlings of kudzu from Maryland to Texas.

In the 1950s, scientists concerned about kudzu's rapid spread began to classify it as a weed. The damage was already done; by the 1980s, kudzu had covered an estimated 7 million acres of the South, and it continues to spread by 320,000 acres per year.

7. Discuss why kudzu continues to spread so quickly across the United States.

8. Discuss the impact of kudzu on species diversity in afflicted areas.

Questions 9 and 10 refer to the inadvertent introduction of various species, such as the fungus that causes Dutch Elm disease.

Dutch elm disease is caused by a fungus that is spread by bark beetles, quickly killing susceptible elm trees. The fungus is thought to have been introduced to the United States by a shipment of logs from the Netherlands in 1928. Although the name may imply otherwise, Dutch elm disease is most likely native to Asia and was probably introduced to Europe around 1910. Elm trees, once dominant across the forests of the northeastern United States, have been known to survive up to 400 years. Now they rarely live more than 15 years.

9. Identify three ways species are inadvertently introduced to new areas.

10. Describe why the inadvertent introduction of various species has increased over the past century.

Concept 43.4 *explores how interactions between species can affect individual fitness, thus shaping evolutionary changes. The interests of consumer and resource species are at odds with each other, leading to an evolutionary "arms race," in which prey continually evolve better defenses, predators evolve better offenses, and neither gains a lasting advantage over the other.*

11. In the context of evolution, fitness is not how fast you can run a mile or how many push-ups you can perform. Define the term *fitness* in its evolutionary sense, and give an example.

12. Africa's Lake Victoria is home to many different species of *cichlids*. A researcher saw five different species of these fish in one location. Using the concept of resource partitioning, explain how these species can coexist in one place.

13. The Red Queen analogy, based on Lewis Carroll's *Through the Looking-Glass*, originates with the quote "It takes all the running you can do, to keep in the same place." Explain how this analogy could apply to the evolutionary arms race between chili peppers and the animals that eat them.

14. Many believe that plants purposefully produce fruit for other organisms to eat so their seeds will be spread to new locations. Discuss why this is untrue.

Science Practices & Inquiry

In the AP Biology Curriculum Framework, there are seven **Science Practices**. In this chapter, we focus on **Science Practice 4**: The student can plan and implement data collection strategies appropriate to a particular scientific question. More specifically, we focus on **Science Practice 4.1**: The student can justify the selection of the kind of data needed to answer a particular scientific question, and **Science Practice 4.2**: The student can design a plan for collecting data to answer a particular scientific question.

Question 15 asks you to justify the selection of the kind of data needed to answer scientific questions about the interaction of populations within communities (**Learning Objective 4.11**).

15. Some consider the black walnut tree to be an example of an amensal species, as its roots secrete the chemical juglone that harms or kills plants that attempt to grow near it. However, this interaction may also be considered an odd form of consumer–resource if the death of nearby plants removes competition and allows the walnut tree greater access to scarce resources. Design an experiment that would allow you to determine the correct type of ecological interaction between black walnut trees and neighboring plants.