Chapter 28

Community Interactions
28.1 Why Are Interactions In Ecological Communities Important?

- An ecological community consists of all the interacting populations in an ecosystem.
  - The populations in a community interact in the following ways:
    - Competition
    - Predation (including parasitism)
    - Symbiosis (excluding parasitism)
  - These distinctions are based on whether the interactions are help or harm each participant.
28.1 Why Are Interactions In Ecological Communities Important?

<table>
<thead>
<tr>
<th>Type of Interaction</th>
<th>Effect on Organism A</th>
<th>Effect on Organism B</th>
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<tbody>
<tr>
<td>Competition between A and B</td>
<td>Harms</td>
<td>Harms</td>
</tr>
<tr>
<td>Predation* by A on B</td>
<td>Benefits</td>
<td>Harms</td>
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<tr>
<td>Commensalism of A with B</td>
<td>Benefits</td>
<td>No effect</td>
</tr>
<tr>
<td>Mutualism between A and B</td>
<td>Benefits</td>
<td>Benefits</td>
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</table>

*Predation includes parasitism and herbivory.
28.1 Why Are Interactions In Ecological Communities Important?

- Community interactions help limit population size.
  - The interactions that form a community tend to maintain a balance between resources and the number of individuals consuming them.
  - This balance is susceptible to disruption, especially when foreign organisms are introduced into an ecosystem.
28.1 Why Are Interactions In Ecological Communities Important?

- Community interactions influence evolutionary change.
  - When members of different populations interact they may influence each other’s ability to survive and reproduce.
  - Community interactions, therefore, serve as agents of natural selection.
  - Predators tend to kill prey that are easiest to eat leaving behind individuals with better defenses against predation.
  - These individuals survive longer and leave more offspring.
28.1 Why Are Interactions In Ecological Communities Important?

- Community interactions influence evolutionary change \((\text{continued})\).
  - Simultaneously the increasingly effective defenses of prey favor the survival and reproduction of predators that are best able to overcome those defenses.
  - Thus, even as predator–prey interactions limit population size, they also shape the bodies and behaviors of the interacting populations.
  - This process, in which interacting species influence one another’s evolution, is called coevolution.
28.2 What Are The Effects Of Competition Among Species?

- When different species compete for a limited resource, the interaction is called **interspecific competition**.
  - In interspecific competition, each species is harmed, because access to resources is reduced for both.
  - The intensity of interspecific competition depends on how similar the requirements of the competing species are.
  - Ecologists express the degree of competition as the degree to which the ecological niches of the competing species overlap.
28.2 What Are The Effects Of Competition Among Species?

- Each species has a unique place in its ecosystem.
  - Each species occupies a unique ecological niche that encompasses all aspects of its way of life.
  - A species’ niche includes
    - the type of habitat in which it lives
    - the environmental factors necessary for its survival
    - the methods by which it acquires its nutrients.
28.2 What Are The Effects Of Competition Among Species?

- The ecological niches of coexisting species never overlap completely.
  - No two species ever occupy exactly the same ecological niche.
  - This concept is called the competitive exclusion principle (G. F. Gause 1934).
  - Gause ran an experiment with Paramecium: *P. aurelia*, *P. caudatum*, and *P. bursaria*. 
28.2 What Are The Effects Of Competition Among Species?

- Grown separately, and provided with food, the two species flourished.
28.2 What Are The Effects Of Competition Among Species?

- When Gause placed the two species together in a single flask, one species always died out because they used the same food source.
28.2 What Are The Effects Of Competition Among Species?

- The ecological niches of coexisting species never overlap completely (continued).
  - Gause then placed *P. aurelia* and *P. bursaria* together and they coexisted indefinitely because they fed in different parts of the flask and therefore their niches did not overlap as strongly as the first pair.
28.2 What Are The Effects Of Competition Among Species?

- Competitive exclusion helps determine how populations are distributed.
  - Joseph Connell experimented with barnacles of the genera *Chthamalus* and *Balanus*, that live permanently attached to rocks in the intertidal zone of the sea shore.
  - *Chthamalus* dominated the upper shore and *Balanus* dominated the lower.
  - When he scraped off *Balanus*, the *Chthamalus* population increased, spreading downward into the area that its competitor had once inhabited.
28.2 What Are The Effects Of Competition Among Species?

- Interspecific competition affects spatial distribution.
28.2 What Are The Effects Of Competition Among Species?

- Competitive exclusion helps determine how populations are distributed (*continued*).
  
  - Connell concluded that *Balanus*, by virtue of growing faster, competitively excluded *Chthamalus* from the lower zone.
  
  - *Chthamalus* survives in the drier upper zone, which is submerged only by the highest tides, because it is better than *Balanus* at tolerating the dry conditions there.
  
  - Therefore, interspecific competition can limit the distribution of populations.
28.2 What Are The Effects Of Competition Among Species?

- Species evolve in ways that reduce niche overlap.
  - Robert MacArthur documented the effects of competitive exclusion by observing five warbler species in the wild.
  - All five species lived and built nests in the same spruce trees, so it appeared at first glance that their niches overlapped significantly.
28.2 What Are The Effects Of Competition Among Species?

- Species evolve in ways that reduce niche overlap (*continued*).
  - MacArthur found that the different species nested at different times, and searched for food in different portions of the tree, employing different hunting tactics.
  - The five species in effect divided up the resources reducing niche overlap and limiting interspecific competition.
28.2 What Are The Effects Of Competition Among Species?

- Reducing niche overlap

![Birds and Trees Illustration]

- Yellow-rumped warbler
- Bay-breasted warbler
- Cape May warbler
- Black-throated green warbler
- Blackburnian warbler

Fig. 28-3
28.2 What Are The Effects Of Competition Among Species?

- Species evolve in ways that reduce niche overlap (*continued*).
  - When two species with similar requirements coexist, they typically occupy a smaller niche than either would if it were by itself.
  - This is called *resource partitioning*. 
28.2 What Are The Effects Of Competition Among Species?

- Species evolve in ways that reduce niche overlap (*continued*).
  
  - A dramatic example of resource partitioning is found among the 13 species of Darwin’s finches in the Galapagos Islands.
  
  - Each finch species have evolved a different bill size and shape, as well as different feeding behaviors that reduce competition among them.
28.3 What Are The Effects Of Predator–Prey Interactions?

- Predators and prey coevolve.
  - When a predator consumes its prey, one species benefits at the expense of another.
  - Parasites live on or inside their prey, or host, and feed on its body without necessarily killing it.
  - Herbivores are also predators that do not necessarily kill the prey on which they feed.
28.3 What Are The Effects Of Predator–Prey Interactions?

- Predation

(a) Pika
(b) Long-eared bat
(c) Red-tailed hawk
28.3 What Are The Effects Of Predator–Prey Interactions?

- Predators and prey coevolve *(continued).*
  - Predator and prey exert intense natural selection pressure on one another.
  - As prey become more difficult to catch, predators must become more adept at hunting.
  - As predators become more adept at hunting, prey must get better at eluding them.
  - Coevolution has endowed the cheetah with speed and camouflage spots, and its zebra prey with speed and camouflage stripes.
28.3 What Are The Effects Of Predator–Prey Interactions?

- Predators and prey coevolve (continued).
  - Bats hunt at night using echolocation to locate their prey.
  - In response to this prey-detection system, some moth species evolved ears sensitive to the frequencies used for echolocation.
  - When a moth hears those sound frequencies, it takes evasive action, flying erratically or dropping to the ground.
28.3 What Are The Effects Of Predator–Prey Interactions?

- Both predators and prey have evolved colors, patterns, and shapes that resemble their surroundings (camouflage).

(a) A camouflaged fish  
(b) A camouflaged bird

Fig. 28-5
28.3 What Are The Effects Of Predator–Prey Interactions?

- Camouflaged prey animals may resemble specific objects such as leaves, twigs, seaweed, thorns, or bird droppings.
28.3 What Are The Effects Of Predator–Prey Interactions?

- Predators may also be camouflaged.

(a) A camouflaged cheetah
28.3 What Are The Effects Of Predator–Prey Interactions?

- The frogfish closely resembles the algae-covered rocks on which it sits motionless; it dangles a small lure from a threadlike appendage on its upper lip, which attracts small fish that become a meal.

(b) A camouflaged frogfish
28.3 What Are The Effects Of Predator–Prey Interactions?

- Bright colors often warn of danger.
  - In contrast to camouflaged animals, some animal species have evolved bright, conspicuous warning coloration.
  - Animals with warning coloration are usually distasteful and/or poisonous.
  - Predators can learn from their mistakes and unpleasant experiences teach predators to avoid similarly colored prey in the future.
28.3 What Are The Effects Of Predator–Prey Interactions?

- Warning coloration
28.3 What Are The Effects Of Predator–Prey Interactions?

- Some organisms gain protection through mimicry.
  - In mimicry, one species evolves to resemble another.
  - Mimics gain added protection from predators as a result of their appearance.
  - This benefit can be gained in various ways.
28.3 What Are The Effects Of Predator–Prey Interactions?

- Harmless animals may evolve to resemble poisonous ones (Batesian mimicry).

(a) Coral snake (venomous)  
(b) Mountain king snake (non-venomous)
28.3 What Are The Effects Of Predator–Prey Interactions?

- A distasteful species may evolve to resemble another distasteful species (Mullerian mimicry).
  - Predators rapidly learn to avoid insects with striped patterns of stinging bees, hornets, and yellow jackets.
28.3 What Are The Effects Of Predator–Prey Interactions?

- The poisonous and distasteful monarch butterfly has wing patterns similar to those of the similarly distasteful viceroy butterfly.
28.3 What Are The Effects Of Predator–Prey Interactions?

- Prey species may evolve to mimic predators.
  - Snowberry flies are hunted by jumping spiders, but the colors on the fly and its behavior when confronted by a spider scares off the spider.
  - The markings on the fly’s wings closely resemble the legs of another jumping spider.

(a) Jumping spider (predator)  (b) Snowberry fly (prey)
28.3 What Are The Effects Of Predator–Prey Interactions?

- Prey species may evolve startle coloration, patterns that disrupt predation by distracting the predator.
28.3 What Are The Effects Of Predator–Prey Interactions?

- Some animal species have evolved patterns of color that closely resemble the eyes of a much larger animal, which may startle the predator and allow the prey to escape.

Fig. 28-11
28.3 What Are The Effects Of Predator–Prey Interactions?

- Some animal predators and prey engage in chemical warfare.
  - Some predators and prey have evolved toxic chemicals for attack and defense.
28.3 What Are The Effects Of Predator–Prey Interactions?

- A dramatic example of chemical defense is seen in the bombardier beetle that releases secretions from special glands into an abdominal chamber in the presence of a predator.
  - Enzymes catalyze an explosive reaction that shoots a toxic, boiling-hot spray onto the attacker.

(a) Bombadier beetle

Fig. 28-12a
28.3 What Are The Effects Of Predator–Prey Interactions?

- Plants have defenses against herbivores.
  - Plants have evolved chemical adaptations that deter their herbivorous predators.
  - Lupine plants produce chemicals that deter attack by the blue butterfly, whose larvae feed on the lupine’s buds.
  - Plants may also defend themselves by producing compounds that toughen their edible parts.
  - Some plants deter predation with structures such as thorns or thick bark.
28.3 What Are The Effects Of Predator–Prey Interactions?

- Herbivores have adaptations overcoming plant defenses.
  - Herbivorous predators have coevolved with the chemical defenses of plants.
  - Some insect species have evolved efficient ways to detoxify or even use the toxic chemicals present in many plant tissues.
28.3 What Are The Effects Of Predator–Prey Interactions?

- Monarch butterflies lay their eggs on milkweed, and when the larvae hatch, they consume the toxic plant.
28.4 What Is Symbiosis?

- Symbiosis is an intimate, prolonged interaction between organisms of different species.
  - In a symbiotic relationship, one species always benefits, but the second species may be unaffected, harmed, or helped by the relationship.
- In commensal interactions, one species benefits and the other is unaffected.
  - Barnacles attached to a whale benefit by getting a free ride through nutrient-rich water, and the whale does not seem to be affected.
28.4 What Is Symbiosis?

- In parasitic interactions, one species benefits and the other is harmed.
  - Parasites live in or on their hosts, usually harming or weakening them but not immediately killing them.
  - Symbiotic parasites include tapeworms, fleas, numerous disease-causing protists, fungi, bacteria, and viruses.
28.4 What Is Symbiosis?

- In parasitic interactions, one species benefits and the other is harmed (continued).
  - In parasitic symbiosis, one organism benefits by feeding on another.
  - Parasite-host interactions are a powerful source of coevolutionary change.
28.4 What Is Symbiosis?

- In parasitic interactions, one species benefits and the other is harmed \textit{(continued)}.
  - Effects of mutual selection are evident in the precision and complexity of the human immune system, and in the adaptations that help disease-causing parasites overcome the immune response.
  - The malaria protist parasite takes up residence inside human red blood cells and induces frequent changes in the protein coat of the cells, which the human immune system is then unable to recognize and destroy.
28.4 What Is Symbiosis?

- In mutualistic interactions, both species benefit.
  - A lichen is a mutualistic association between an algae and a fungus, which appears to be a single organism.
  - The fungal body in the lichen provides support and protection for the photosynthetic algae, which in turn provide sugars for the fungus.
28.4 What Is Symbiosis?

- Lichen

(a) Lichen
28.4 What Is Symbiosis?

- Animals and plants may have symbiotic mutualistic associations with microorganisms.
  - Animals lack the enzymes required to digest cellulose; however, some animals—such as cows, horses, rabbits, and termites—have cellulose-digesting protists and bacteria in their digestive tracts that digest this plant material for them.
28.4 What Is Symbiosis?

- Animals and plants may have symbiotic mutualistic associations with microorganisms (continued).
  - Plants and certain fungal species may associate to form mycorrhizae, in which the fungal bodies penetrate and become entwined with plant roots.
  - The fungi acquire sugars that the plant has produced by photosynthesis, and the plant acquires mineral nutrients that the fungi extract from the soil.
28.4 What Is Symbiosis?

- Not all mutualisms are symbiotic.
  - Many mutualistic interactions between species do not involve the prolonged intimacy of symbiosis.
  - Many flowering plants are pollinated by animals that visit only when the plant is in bloom.
  - In the mutualistic relationship between plant and pollinator, the plant gains transportation of its pollen, and the pollinator gains food.
28.4 What Is Symbiosis?

- Hawk moth

(b) Hawk moth
28.5 What Are Keystone Species?

- In some communities, a keystone species plays a major role in determining community structure
  - This role is out of proportion to its biomass.
  - If a keystone species is eliminated the diversity of the community is drastically reduced.
  - Removal of the sea otter from its community caused the collapse of the kelp forest communities of the Western Americas.
28.5 What Are Keystone Species?

- Removal of the starfish *Pisaster* from its intertidal community caused mussels to overrun the community and displace other species.
28.6 How Does A Community Change Over Time?

- As time passes, the makeup of a community may change; this gradual process of change is called succession.
  - Freshwater ponds and lakes tend to undergo a series of changes that transform them first into marshes, and then into dry land.
  - Coastal sand dunes tend to be stabilized by creeping plants and undergo changes that eventually lead to a forest.
28.6 How Does A Community Change Over Time?

- Succession can be observed because events frequently disrupt existing communities.
  - Forest fires destroy an existing community, but at the same time, release nutrients and create conditions that favor rapid succession.
  - Most succession events begin with a few hardy invaders called pioneers, and if undisturbed, progress to a diverse and relatively stable climax community—the end point of succession.
28.6 How Does A Community Change Over Time?

- Volcanic eruptions may create new islands ripe for colonization, or leave behind a nutrient-rich environment that is rapidly invaded by new life.

(a) Mt. St. Helens shortly after eruption
(b) Twenty years later

Fig. 28-15
28.6 How Does A Community Change Over Time?

- There are two types of succession: primary and secondary.
  - Primary succession starts “from scratch” on bare rock, on sand, in a clear glacial pool, or at some other location where there is no trace of a previous community.
  - Secondary succession begins only after an existing ecosystem is disturbed; for example, by a forest fire or abandonment of a farm field.
28.6 How Does A Community Change Over Time?

- Primary succession can begin on bare rock.
  - Primary succession begins on bare rock that is weathered over time by wind, rain, and cycles of freezing and thawing; this causes cracks and the release of minerals that serve as nutrients for plants.
  - Lichens settle on the weathered rocks, which in turn dissolves some of the rock through the acid they secrete; this liberates more nutrients, which mosses can then use to start to grow.
28.6 How Does A Community Change Over Time?

- Primary succession
28.6 How Does A Community Change Over Time?

- Primary succession can begin on bare rock.
  - Within the moss mat that forms, seeds of larger plants, such as bluebell and yarrow, germinate.
  - Later, these plants die, and their bodies contribute to a growing layer of soil.
  - Shrubs grow and shade out the lichens and moss, which die away.
  - Eventually, trees take root and form a tall climax community.
28.6 How Does A Community Change Over Time?

- Abandoned farmland may undergo secondary succession.
  - In secondary succession, the pioneer species are fast-growing annual plants—such as crabgrass, ragweed, and sorrel—which sprout in the rich soil already present and thrive in the direct sunlight.
  - A few years later, longer-lived perennial plants—such as asters, goldenrod, and broom sedge grass—invade, along with woody shrubs such as blackberry.
Abandoned farmland may undergo secondary succession (continued).

- These plants are replaced by pines and fast-growing deciduous trees, which become the dominate plants for about 25 years.
- Later, hardwood trees, such as oak and hickory, overtake the pines and shade them out.
- Eventually, a stable climax community of hardwood trees comes to dominate the landscape.
28.6 How Does A Community Change Over Time?

- Secondary succession

![Diagram showing the process of secondary succession with time (years) on the x-axis and various plant species on the y-axis.](image-url)
28.6 How Does A Community Change Over Time?

- Succession culminates in the climax community.
  - Succession ends with a relatively stable climax community that perpetuates itself as long as it is not disturbed by external forces.
  - The species in a climax community have ecological niches that allow them to coexist without replacing one another.
  - Climax communities have more species and more community interactions than do early stages of succession.
28.6 How Does A Community Change Over Time?

- Some ecosystems are maintained in a subclimax state.
  - The tallgrass prairie that covered northern Missouri and Illinois was a subclimax community whose climax would have been deciduous forest.
  - The prairie was maintained by periodic fires, some of which were set by Native Americans to increase grazing land for buffalo.
  - Forest now encroaches, and limited prairie preserves are maintained by carefully managed burning.
28.6 How Does A Community Change Over Time?

- Some ecosystems are maintained in a subclimax state (*continued*).
  - Agriculture also depends on the artificial maintenance of carefully selected subclimax communities.
  - A hayfield is a grass-dominated early stage of succession, maintained by people to feed their livestock.
  - A suburban lawn is a carefully maintained subclimax ecosystem where mowing destroys woody invaders and herbicides kill pioneers, such as crabgrass and dandelions.