Overview: What Is a Community?

• A biological community is an assemblage of populations of various species living close enough for potential interaction

• Animals and plants surrounding a watering hole in southern Africa are members of a savanna community
Concept 53.1: A community’s interactions include competition, predation, herbivory, symbiosis, and disease

- Ecologists call relationships between species in a community interspecific interactions
- Interspecific interactions affect species survival and reproduction
- Examples are competition, predation, herbivory, symbiosis (parasitism, mutualism, and commensalism), and disease
### Table 53.1 Interspecific Interactions

<table>
<thead>
<tr>
<th>Interaction</th>
<th>Effects on Interacting Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competition (−/−)</td>
<td>The interaction can be detrimental to both species.</td>
</tr>
<tr>
<td>Predation (+/−)</td>
<td></td>
</tr>
<tr>
<td>Herbivory (+/−)</td>
<td>The interaction is beneficial to one species and detrimental to the other.</td>
</tr>
<tr>
<td>Parasitism (+/−)</td>
<td></td>
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<tr>
<td>Disease (+/−)</td>
<td></td>
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<tr>
<td>Mutualism (+/+</td>
<td>The interaction is beneficial to both species.</td>
</tr>
<tr>
<td>Commensalism (+/0)</td>
<td>One species benefits from the interaction, and the other species is unaffected by it.</td>
</tr>
</tbody>
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Competition

• Interspecific competition occurs when species compete for a resource in short supply

• Strong competition can lead to competitive exclusion, local elimination of a competing species
The Competitive Exclusion Principle

- The competitive exclusion principle states that two species competing for the same limiting resources cannot coexist in the same place.
**Ecological Niches**

- The total of a species’ use of biotic and abiotic resources is called the species’ ecological niche.
- Ecologically similar species can coexist in a community if there are one or more significant differences in their niches.
- As a result of competition, a species’ fundamental niche may differ from its realized niche.
Chthamalus and Balanus have different realized niches during high tide and low tide.

- **Chthamalus**
  - Realized niche at high tide
  - Realized niche at low tide

- **Balanus**
  - Realized niche at high tide
  - Realized niche at low tide

**Chthamalus** and **Balanus** exhibit different fundamental niches as well.
Resource Partitioning

- Resource partitioning is differentiation of ecological niches, enabling similar species to coexist in a community
A. insolitus usually perches on shady branches.

A. distichus perches on fence posts and other sunny surfaces.

A. ricordii

A. insolitus

A. christophei

A. aliniger

A. distichus

A. cybotes

A. etheridgei
Character Displacement

• Character displacement is a tendency for characteristics to be more divergent in sympatric populations of two species than in allopatric populations of the same two species

• An example is variation in beak size between populations of two species of Galapagos finches
Beak depth (mm)

Santa María, San Cristóbal
Sympatric populations

Los Hermanos
G. fuliginosa, allopatric

Daphne
G. fortis, allopatric
Predation

- Predation refers to interaction where one species, the predator, kills and eats the other, the prey.
- Some feeding adaptations of predators are claws, teeth, fangs, stingers, and poison.
• Prey display various defensive adaptations

• Behavioral defenses include hiding, fleeing, self-defense, and alarm calls

• Animals also have morphological and physiological defense adaptations
• Cryptic coloration, or camouflage, makes prey difficult to spot
• Animals with effective chemical defense often exhibit bright warning coloration, called aposematic coloration

• Predators are particularly cautious in dealing with prey that display such coloration
• In some cases, a prey species may gain significant protection by mimicking the appearance of another species
In Batesian mimicry, a palatable or harmless species mimics an unpalatable or harmful model.
(a) Hawkmoth larva

(b) Green parrot snake
In Müllerian mimicry, two or more unpalatable species resemble each other.
(a) Cuckoo bee

(b) Yellow jacket
Herbivory

- Herbivory refers to an interaction in which an herbivore eats parts of a plant or alga.
- It has led to evolution of plant mechanical and chemical defenses and adaptations by herbivores.
Parasitism

• In parasitism, one organism, the parasite, derives nourishment from another organism, its host, which is harmed in the process

• Parasitism exerts substantial influence on populations and the structure of communities
Disease

- Effects of disease on populations and communities are similar to those of parasites
- Pathogens, disease-causing agents, are typically bacteria, viruses, or protists
Mutualism

- Mutualistic symbiosis, or mutualism, is an interspecific interaction that benefits both species.
Commensalism

• In commensalism, one species benefits and the other is apparently unaffected

• Commensal interactions are hard to document in nature because any close association of two species likely affects both
Interspecific Interactions and Adaptation

- Coevolution is reciprocal evolutionary adaptations of two interacting species.
- The term is often used too loosely in describing adaptations within a community.
- There is little evidence for true coevolution in most interspecific interactions.
Concept 53.2: Dominant and keystone species exert strong controls on community structure

• In general, a few species in a community exert strong control on that community’s structure.

• Two fundamental features of community structure are species diversity and feeding relationships.
Species Diversity

- Species diversity of a community is the variety of organisms that make up the community.
- It has two components: species richness and relative abundance.
- Species richness is the total number of different species in the community.
- Relative abundance is the proportion each species represents of the total individuals in the community.
• Two communities can have the same species richness but a different relative abundance

• A community with an even species abundance is more diverse than one in which one or two species are abundant and the remainder are rare
Community 1
A: 25%  B: 25%  C: 25%  D: 25%

Community 2
A: 80%  B: 5%  C: 5%  D: 10%
Trophic Structure

- Trophic structure is the feeding relationships between organisms in a community.
- It is a key factor in community dynamics.
- Food chains link trophic levels from producers to top carnivores.
A terrestrial food chain  
A marine food chain

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Food Webs

- A food web is a branching food chain with complex trophic interactions
• Food webs can be simplified by isolating a portion of a community that interacts very little with the rest of the community
Sea nettle
Fish larvae
Juvenile striped bass
Fish eggs
Zooplankton
Limits on Food Chain Length

- Each food chain in a food web is usually only a few links long
- Two hypotheses attempt to explain food chain length: the energetic hypothesis and the dynamic stability hypothesis
• The energetic hypothesis suggests that length is limited by inefficient energy transfer

• The dynamic stability hypothesis proposes that long food chains are less stable than short ones

• Most data support the energetic hypothesis
Species with a Large Impact

• Certain species have a very large impact on community structure

• Such species are highly abundant or play a pivotal role in community dynamics
Dominant Species

- Dominant species are those that are most abundant or have the highest biomass
- They exert powerful control over the occurrence and distribution of other species
• One hypothesis suggests that dominant species are most competitive in exploiting resources
• Another hypothesis is that they are most successful at avoiding predators
Keystone Species

- In contrast to dominant species, keystone species are not necessarily abundant in a community.
- They exert strong control on a community by their ecological roles, or niches.
• Field studies of sea stars exhibit their role as a keystone species in intertidal communities
Without *Pisaster* (experimental)  
With *Pisaster* (control)

![Graph showing the number of species present from 1963 to 1973 with and without *Pisaster*.](image)

(b)
• Observation of sea otter populations and their predation shows how otters affect ocean communities
Food chain before killer whale involvement in chain

Food chain after killer whales started preying on otters

(a) Sea otter abundance

(b) Sea urchin biomass

(c) Total kelp density

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Ecosystem “Engineers” (Foundation Species)

- Some organisms exert influence by causing physical changes in the environment that affect community structure
- For example, beaver dams can transform landscapes on a very large scale
Some foundation species act as facilitators that have positive effects on survival and reproduction of some other species in the community.
Salt marsh with *Juncus* (foreground)
Bottom-Up and Top-Down Controls

- The bottom-up model of community organization proposes a unidirectional influence from lower to higher trophic levels.
- In this case, presence or absence of mineral nutrients determines community structure, including abundance of primary producers.
• The top-down model proposes that control comes from the trophic level above

• In this case, predators control herbivores, which in turn control primary producers
• Long-term experimental studies have shown that communities can shift periodically from bottom-up to top-down controls
Percentage of herbaceous plant cover
• Pollution can affect community dynamics

• Biomanipulation can help restore polluted communities
Polluted State

Fish
Abundant

Zooplankton
Rare

Algae
Abundant

Restored State

Fish
Rare

Zooplankton
Abundant

Algae
Rare
Concept 53.3: Disturbance influences species diversity and composition

- Decades ago, most ecologists favored the view that communities are in a state of equilibrium.
- Recent evidence of change has led to a nonequilibrium model, which describes communities as constantly changing after being buffeted by disturbances.
What Is Disturbance?

- A disturbance is an event that changes a community, removes organisms from it, and alters resource availability
- Fire is a significant disturbance in most terrestrial ecosystems
- It is often a necessity in some communities
Before a controlled burn.
A prairie that has not burned for several years has a high proportion of detritus (dead grass).

During the burn. The detritus serves as fuel for fires.

After the burn. Approximately one month after the controlled burn, virtually all of the biomass in this prairie is living.
• The intermediate disturbance hypothesis suggests that moderate levels of disturbance can foster higher diversity than low levels of disturbance

• The large-scale fire in Yellowstone National Park in 1988 demonstrated that communities can often respond very rapidly to a massive disturbance
Soon after fire. As this photo taken soon after the fire shows, the burn left a patchy landscape. Note the unburned trees in the distance.

One year after fire. This photo of the same general area taken the following year indicates how rapidly the community began to recover. A variety of herbaceous plants, different from those in the former forest, cover the ground.
Human Disturbance

- Humans are the most widespread agents of disturbance
- Human disturbance to communities usually reduces species diversity
- Humans also prevent some naturally occurring disturbances, which can be important to community structure
Ecological Succession

- Ecological succession is the sequence of community and ecosystem changes after a disturbance
- Primary succession occurs where no soil exists when succession begins
- Secondary succession begins in an area where soil remains after a disturbance
Early-arriving species and later-arriving species may be linked in one of three processes:

- Early arrivals may facilitate appearance of later species by making the environment favorable
- They may inhibit establishment of later species
- They may tolerate later species but have no impact on their establishment
• Retreating glaciers provide a valuable field-research opportunity for observing succession
McBride glacier retreating
• Succession on the moraines in Glacier Bay, Alaska, follows a predictable pattern of change in vegetation and soil characteristics
(a) Pioneer stage, with fireweed dominant

(b) Dryas stage

(c) Spruce stage

(d) Nitrogen fixation by Dryas and alder increases the soil nitrogen content.
Concept 53.4: Biogeographic factors affect community diversity

• Two key factors correlated with a community’s species diversity are geographic location and size
Equatorial-Polar Gradients

• Two key factors in equatorial-polar gradients of species richness are probably evolutionary history and climate

• Species richness generally declines along an equatorial-polar gradient and is especially great in the tropics

• The greater age of tropical environments may account for the greater species richness
• Climate is likely the primary cause of the latitudinal gradient in biodiversity

• Two main climatic factors correlated with biodiversity are solar energy and water availability

• They can be considered together by measuring a community’s rate of evapotranspiration

• Evapotranspiration is evaporation of water from soil plus transpiration of water from plants
Area Effects

• The species-area curve quantifies the idea that, all other factors being equal, a larger geographic area has more species.

• A species-area curve of North American breeding birds supports this idea.
Island Equilibrium Model

- Species richness on islands depends on island size, distance from the mainland, immigration, and extinction.
- The equilibrium model of island biogeography maintains that species richness on an ecological island levels off at a dynamic equilibrium point.
Immigration and extinction rates

Equilibrium number

Number of species on island

Immigration

Extinction

Rate of immigration or extinction

(a) Immigration and extinction rates

Effect of island size

Small island

Large island

(b) Effect of island size

Effect of distance from mainland

Far island

Near island

(c) Effect of distance from mainland

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• Studies of species richness on the Galápagos Islands support the prediction that species richness increases with island size
Concept 53.5: Contrasting views of community structure are the subject of continuing debate

- In the 1920s and 1930s, two views on community structure emerged: the integrated hypothesis and the individualistic hypothesis.
Integrated and Individualistic Hypotheses

• The integrated hypothesis describes a community as an assemblage of closely linked species, locked into association by mandatory biotic interactions.

• The individualistic hypothesis proposes that communities are loosely organized associations of independently distributed species with the same abiotic requirements.
The integrated hypothesis predicts that presence or absence of particular species depends on presence or absence of other species.
Environmental gradient (such as temperature or moisture)

(a) Integrated hypothesis
• The individualistic hypothesis predicts that each species is distributed according to its tolerance ranges for abiotic factors
Environmental gradient (such as temperature or moisture)

(b) Individualistic hypothesis

Population densities of individual species
• In most actual cases, composition of communities seems to change continuously, with each species more or less independently distributed
(c) Trees in the Santa Catalina Mountains
Rivet and Redundancy Models

• The rivet model suggests that all species in a community are linked in a tight web of interactions.
• It also states that loss of even a single species has strong repercussions for the community.
• The redundancy model proposes that if a species is lost, other species will fill the gap.
• Community hypotheses and models represent extremes; most communities probably lie somewhere in the middle.