A biological community is an assemblage of populations of various species living close enough for potential interaction. For example, the “carrier crab” carries a sea urchin on its back for protection against predators.

Concept 54.1: Community interactions are classified by whether they help, harm, or have no effect on the species involved
- Ecologists call relationships between species in a community interspecific interactions.
- Examples are competition, predation, herbivory, symbiosis (parasitism, mutualism, and commensalism), and facilitation.
- Interspecific interactions can affect the survival and reproduction of each species, and the effects can be summarized as positive (+), negative (−), or no effect (0).

Interspecific competition (−/− interaction) occurs when species compete for a resource in short supply.

Competitive Exclusion
- Strong competition can lead to competitive exclusion, local elimination of a competing species.
- The competitive exclusion principle states that two species competing for the same limiting resources cannot coexist in the same place.

Ecological Niches and Natural Selection
- The total of a species’ use of biotic and abiotic resources is called the species’ ecological niche.
- An ecological niche can also be thought of as an organism’s ecological role.
- Ecologically similar species can coexist in a community if there are one or more significant differences in their niches.
• **Resource partitioning** is differentiation of ecological niches, enabling similar species to coexist in a community.

- A species' fundamental niche is the niche potentially occupied by that species.
- A species' realized niche is the niche actually occupied by that species.
- As a result of competition, a species' fundamental niche may differ from its realized niche.
  - For example, the presence of one barnacle species limits the realized niche of another species.

**Figure 54.2**

**EXPERIMENT**

- Chthamalus
- Balanus

**RESULTS**

- Chthamalus fundamental niche
- Balanus realized niche
- Chthamalus realized niche

**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 Galápagos finches.

- The common spiny mouse and the golden spiny mouse show temporal partitioning of their niches.
- Both species are normally nocturnal (active during the night).
- Where they coexist, the golden spiny mouse becomes diurnal (active during the day).

**Figure 54.4**

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**Figure 54.4**
Predation

- **Predation** (+/− interaction) 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, forming herds or schools, self-defense, and alarm calls

Animals also have morphological and physiological defense adaptations

- **Cryptic coloration**, or camouflage, makes prey difficult to spot

Canyon tree frog

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

(a) Cryptic coloration

(b) Aposematic coloration

(c) Aposematic coloration

Herbivory

- **Herbivory** (+/− interaction) 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

- 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

(c) Batesian mimicry: A harmless species mimics a harmful model

(d) Müllerian mimicry: Two unpalatable species mimic each other
Symbiosis

- **Symbiosis** is a relationship where two or more species live in direct and intimate contact with one another.

Parasitism

- In **parasitism** (+/- interaction), one organism, the **parasite**, derives nourishment from another organism, its **host**, which is harmed in the process.
- Parasites that live within the body of their host are called **endoparasites**.
- Parasites that live on the external surface of a host are **ectoparasites**.

Mutualism

- Mutualistic symbiosis, or **mutualism** (+/+ interaction), is an interspecific interaction that benefits both species.
- A mutualism can be:
  - Obligate, where one species cannot survive without the other.
  - Facultative, where both species can survive alone.

Commensalism

- In **commensalism** (+/0 interaction), one species benefits and the other is neither harmed nor helped.
- Commensal interactions are hard to document in nature because any close association likely affects both species.

Facilitation

- Facilitation (+/+ or 0/+ interaction) describes an interaction where one species can have positive effects on another species without direct and intimate contact:
  - For example, the black rush makes the soil more hospitable for other plant species.

Concept 54.2: Diversity and trophic structure characterize biological communities

- 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.

Diversity and Community Stability

- Ecologists manipulate diversity in experimental communities to study the potential benefits of diversity.
  - For example, plant diversity has been manipulated at Cedar Creek Natural History Area in Minnesota for two decades.
- Communities with higher diversity are:
  - More productive and more stable in their productivity.
  - Better able to withstand and recover from environmental stresses.
  - More resistant to **invasive species**, organisms that become established outside their native range.

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.
**Food Webs**

- A **food web** is a branching food chain with complex trophic interactions.

- Species may play a role at more than one trophic level.
- Food webs can be simplified by:
  - Grouping species with similar trophic relationships into broad functional groups.
  - Isolating a portion of a community that interacts very little with the rest of the community.

**Figure 54.15**

*Sea nettle* → *Juvenile striped bass* → *Fish larvae*

**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.

**Figure 54.16**

- The **energetic hypothesis** suggests that length is limited by inefficient energy transfer:
  - For example, a producer level consisting of 100 kg of plant material can support about 10 kg of herbivore **biomass** (the total mass of all individuals in a population).
- 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.
  - Dominant species exert powerful control over the occurrence and distribution of other species.
    - For example, sugar maples have a major impact on shading and soil nutrient availability in eastern North America; this affects the distribution of other plant species.

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Keystone Species and Ecosystem Engineers

- **Keystone species** exert strong control on a community by their ecological roles, or niches.
  - In contrast to dominant species, they are not necessarily abundant in a community.
  - Field studies of sea stars illustrate their role as a keystone species in intertidal communities.

One hypothesis suggests that dominant species are most competitive in exploiting resources.

- Another hypothesis is that they are most successful at avoiding predators.
- Invasive species, typically introduced to a new environment by humans, often lack predators or disease.

Observation of sea otter populations and their predation shows how otters affect ocean communities.

- Observation of sea otter populations and their predation shows how otters affect ocean communities.
  - For example, sea otters can control the abundance of urchins, which in turn affects the kelp forest ecosystem.

- Ecosystem engineers (or “foundation species”) cause physical changes in the environment that affect community structure.
  - For example, beaver dams can transform landscapes on a very large scale.
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**, also called the trophic cascade model, proposes that control comes from the trophic level above
- In this case, predators control herbivores, which in turn control primary producers

Biomanipulation can help restore polluted communities

- In a Finnish lake, blooms of cyanobacteria (primary producers) occurred when zooplankton (primary consumers) were eaten by large populations of roach fish (secondary consumers)
- The addition of pike perch (tertiary consumers) controlled roach populations, allowed zooplankton to increase and ended cyanobacterial blooms

Concept 54.3: Disturbance influences species diversity and composition

- Decades ago, most ecologists favored the view that communities are in a state of equilibrium
- This view was supported by F. E. Clements who suggested that species in a climax community function as a superorganism

- Other ecologists, including A. G. Tansley and H. A. Gleason, challenged whether communities were at equilibrium
- Recent evidence of change has led to a **nonequilibrium model**, which describes communities as constantly changing after being buffeted by disturbances
- A **disturbance** is an event that changes a community, removes organisms from it, and alters resource availability
Characterizing Disturbance

- Fire is a significant disturbance in most terrestrial ecosystems
- A high level of disturbance is the result of a high intensity and high frequency of disturbance
- The intermediate disturbance hypothesis suggests that moderate levels of disturbance can foster greater diversity than either high or low levels of disturbance
- High levels of disturbance exclude many slow-growing species
- Low levels of disturbance allow dominant species to exclude less competitive species

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
• Succession on the moraines in Glacier Bay, Alaska, follows a predictable pattern of change in vegetation and soil characteristics
  1. The exposed moraine is colonized by pioneering plants including liverworts, mosses, fireweed, *Dryas*, willows, and cottonwood

2. *Dryas* dominates the plant community

3. Alder invades and forms dense thickets

4. Alder are overgrown by Sitka spruce, western hemlock, and mountain hemlock

• Succession is the result of changes induced by the vegetation itself
• On the glacial moraines, vegetation lowers the soil pH and increases soil nitrogen content
Human Disturbance

- Humans have the greatest impact on biological communities worldwide
- Human disturbance to communities usually reduces species diversity

Concept 54.4: Biogeographic factors affect community biodiversity

- Latitude and area are two key factors that affect a community’s species diversity

Latitudinal Gradients

- Species richness is especially great in the tropics and generally declines along an equatorial-polar gradient
- Two key factors in equatorial-polar gradients of species richness are probably evolutionary history and climate

- Temperate and polar communities have started over repeatedly following glaciations
- The greater age of tropical environments may account for the greater species richness
- In the tropics, the growing season is longer such that biological time is faster

- 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

![Figure 54.25a](image-url)
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

- Studies of species richness on the Galápagos Islands support the prediction that species richness increases with island size