General Biology: Species Interactions

AI-Generated Study Guide

(Based on lectures delivered by Dr. Ty C.M. Hoffman)

I. Introduction to Ecology and Species Interactions

Ecology is the science concerned with the interactions between organisms and their environment, including how organisms respond to that environment. A key component of ecology is the study of interspecific, or species-species, interactions—interactions that occur between different species.

Interactions are often categorized using shorthand notation:

- **Plus (+):** Indicates a benefit or help to the species.
- **Minus (-):** Indicates harm or detriment to the species (which may include injury, wasted energy, or reduced fitness).
- **Zero (0):** Indicates neutrality (the species is neither helped nor harmed).

II. Types of Interspecific Interactions

Interaction Type	Notation	Description
Competition	(- -)	The only interaction detrimental to both species involved. Two different species compete for a shared, desired resource (e.g., food, sunlight, space).
Predation	(+ -)	One species (the predator) kills and eats the other species (the prey). This typically refers to animals eating other animals.
Herbivory	(+ -)	One species eats vegetation (plants or algae). It is distinct from predation because the organism being eaten is usually not killed, although it is still harmed.
Symbiosis (Category)		Literally meaning the condition of living together, this category describes interactions involving a close living arrangement.
Mutualism	(+ +)	A type of symbiosis where both species benefit.

Parasitism	(+ -)	A type of symbiosis where the parasite benefits (often living in or on the host), and the host is harmed.
Commensalism	(+ 0)	A type of symbiosis where one species benefits, and the other is theoretically neutral. True examples of a perfect zero effect are rare.
Facilitation	(+ + or 0 +)	An interaction where one species helps a second species exist in that location, often involving a plant species acting as the facilitator. The second species is always helped (+); the facilitator may be unaffected (0) or also helped (+) by the resulting community changes.

III. Ecosystem Structure, Niches, and Competition

Community vs. Ecosystem:

• A **Community** consists of all the populations, meaning all of the living things in a given area.

• An **Ecosystem** includes the entire community plus all the non-living components (e.g., air, water, rocks).

The Niche Concept:

• A **niche** is an ecological word referring to the set of all resources that a species uses within an ecosystem. This includes location (space), type of sunlight, water usage, and other requirements.

• Different species occupy different niches to minimize competition, which is detrimental to both species. Natural selection favors occupying unique niches.

Fundamental Niche vs. Realized Niche:

• **Fundamental Niche:** The niche a species *could* occupy if there were no limiting factors preventing it.

• **Realized Niche:** The actual niche a species occupies.

• The fundamental niche is at least as large as, or often larger than, the realized niche. If it is larger, external factors (like competition) are preventing the species from utilizing its full potential resources.

Competition Avoidance (Character Displacement):

• When closely related species occur together (coexist), they often evolve different specialized traits (e.g., different bill sizes in finches) that allow them to specialize in different kinds of diets or resources, thereby reducing resource overlap and avoiding direct competition.

IV. Anti-Predator Adaptations and Mimicry

Coloration Patterns:

• **Cryptic Coloration:** Camouflage that makes the organism hard to discover, helping it hide from predators. This is highly adaptive.

• **Aposematic Coloration:** Warning coloration (often bright colors like black, orange, and blue) where the organism intentionally stands out. This serves as an advertisement that the organism is harmful or poisonous, protecting it from predators who have learned to avoid that pattern.

Mimicry (Imitation):

• **Batesian Mimicry:** A harmless species mimics a harmful species. The harmless mimic benefits by being avoided by predators that mistake it for the dangerous species.

• **Müllerian Mimicry:** Multiple harmful or unpalatable species evolve to look similar to each other. This reinforces a common warning pattern that helps educate predators quickly.

V. Trophic Structures: Food Chains and Food Webs

Trophic structures describe the transfer of energy through an ecosystem.

Producers and Consumers:

• **Producers (Autotrophs):** Organisms at the base of the food chain. They perform **carbon fixation**, converting inorganic carbon (like CO_2) into organic compounds, typically through photosynthesis or chemosynthesis.

• **Consumers (Heterotrophs):** Organisms that require their carbon already in organic form. They rely entirely on producers for their existence.

Trophic Levels:

• **Primary Consumer:** Directly eats producers (e.g., herbivores).

• **Secondary Consumer:** Eats primary consumers.

• **Tertiary Consumer:** Eats secondary consumers.

• **Quaternary Consumer:** The fourth and usually highest level in an ecosystem, as the number of levels is generally limited.

Food Webs:

• A food web is a collection of interconnected food chains and is a more realistic representation of energy flow, reflecting that most consumers eat a variety of other organisms.

• High-level consumers, such as humans, are at the top of the food web. This is a precarious position because their reliance on all levels below them makes them susceptible to ecosystem disturbances.

VI. Special Species Categories

• **Dominant Species:** The species in a given area with the most individuals.

• **Keystone Species:** A species that is disproportionately important to the overall health of the ecosystem, often preventing certain populations from dominating or allowing other species to exist. It is usually not the dominant species (e.g., a sea star controlling a mussel population).

• **Ecosystem Engineer:** A species that fundamentally changes the physical makeup or geography of the ecosystem (e.g., a beaver building a dam and altering water flow).

VII. Disturbance and Succession

Disturbance:

• A sudden, out-of-the-ordinary event that causes life in an ecosystem to change (e.g., fire, storm, glacier movement, human trawling). Disturbances vary in intensity and frequency.

• **Intermediate Disturbance Hypothesis:** Posits that biodiversity is maximized when there is an intermediate level of disturbance. Too much disturbance kills off species; too little disturbance allows dominant species to become too successful and fill all niches, driving biodiversity down.

Succession (Recovery):

• The recovery process that occurs in stages following a major disturbance. Each stage features different organisms and prepares the environment for the next stage.

• **Secondary Succession:** Occurs after a disturbance where the soil remains (e.g., after a severe fire). Recovery does not require starting from bedrock because soil, seeds, and bacteria are still present.

• **Primary Succession:** Occurs after the most severe disturbances (e.g., glacial movement) where all soil is removed, leaving bare bedrock. The first stage involves organisms like lichens that break down rock and create organic material over long periods to form soil, allowing later plant life to establish.

VIII. Factors Influencing Biodiversity

Components of Biodiversity:

• **Species Richness:** The number of different species living in an area.

• **Relative Abundance:** The number of individuals of each species compared to the other species present.

• Overall biodiversity is critical to the health of an ecosystem, and its decline often leads to cascading effects (domino effect/snowball effect) of extinction.

Climate and Area Effects:

• **Moisture:** Places with greater overall moisture (indicated by high potential evapotranspiration, which measures water evaporated directly from the soil and transpired through plants) tend to have greater biodiversity (e.g., tropical rainforests).

• **Island Effect:** The ecological term "island" refers to any isolated area surrounded by different terrain (e.g., a traditional island or an oasis). The effect states that the smaller the island area, the lower the biodiversity. Smaller areas increase crowding and resource competition, reducing the number of species that can coexist.