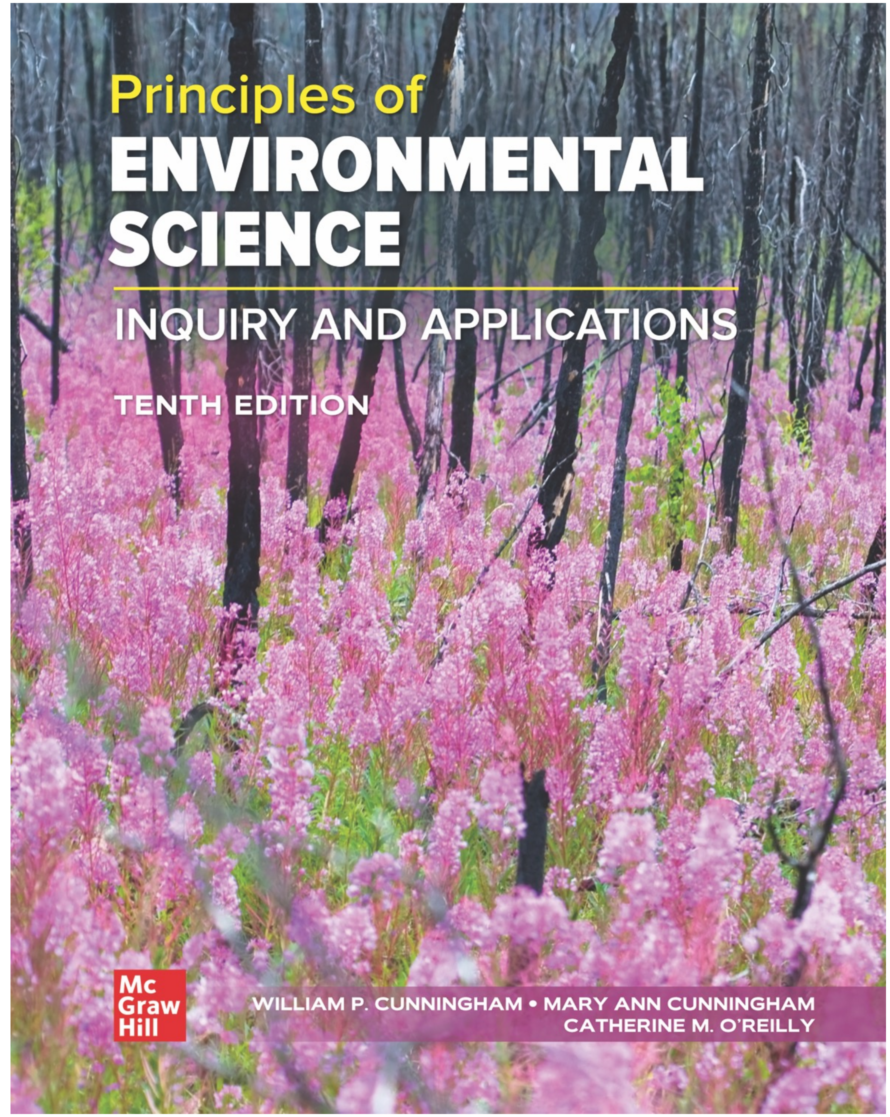
Because learning changes everything.®

Chapter 3 Lecture Outline



Learning Outcomes

After studying this chapter, you should be able to answer the following questions:

How does species diversity arise?

What do we mean by tolerance limits? Give examples.

How do interactions both aid and hinder species?

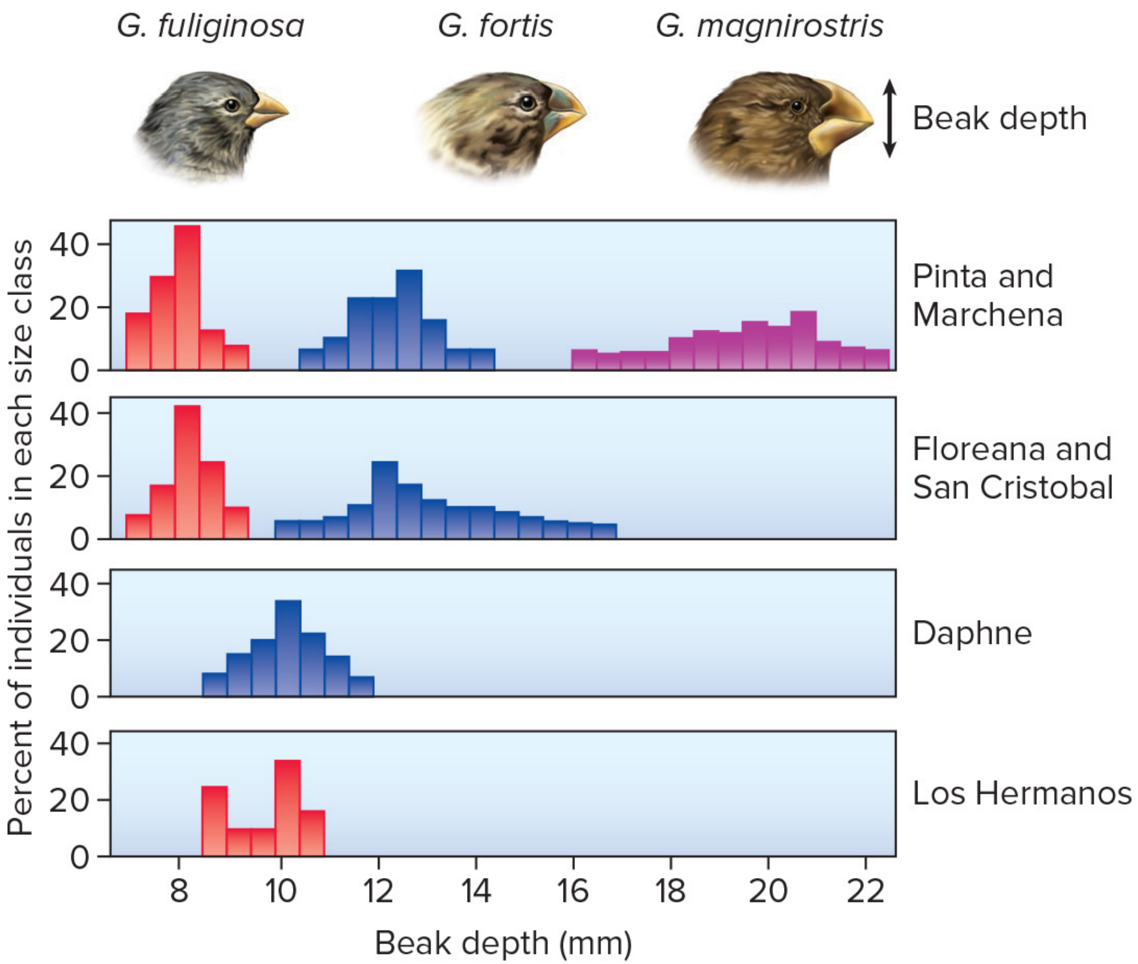
Why don’t species always reproduce up to their biotic potential?

What is the relationship between species diversity and community stability?

What is disturbance, and how does it affect communities?

Explain ecological succession and give examples of its stages

CASE STUDY: Natural Selection and the Galápagos Finches



Access the text alternative for slide images.

Charles Darwin–On the Origin of Species

When I view all beings not as special creations but as lineal descendants of some few beings which have lived long before the first bed of the Cambrian system was deposited, they seem to me to become ennobled.

Charles Darwin

©Westend61/Getty images

3.1 Evolution Leads to Diversity

Why does the earth support the astonishing biological diversity that we see around us?

What determines which species will survive in one environment or another, and why are some species abundant while others are rare?

In this chapter we will examine the mechanisms that have produced the extraordinary diversity of life that surrounds us.

Natural Selection and Adaptation Modify Species

Adaptation, the acquisition of traits that allow a species to survive in its environment, is one of the most important concepts in biology.

Adaptation involves changes in a population, with characteristics that are passed from one generation to the next.

The process of the fittest individuals passing their traits to the next generation is called **natural selection,** while others reproduce less successfully.

Giraffes with Longer Necks Get More Food and Have More Offspring

©Westend61/Getty images

Natural Selection Acts on Traits in the DNA

Where do the traits come from that make some individuals more successful?

Changes to the DNA of individuals, called **mutations**, occur and these changes are inherited by offspring.

Most mutations have little effect on fitness, and some can have a negative effect, but some happen to be useful in helping individuals exploit new resources or survive more successfully in new environmental conditions.

All Species Live Within Limits

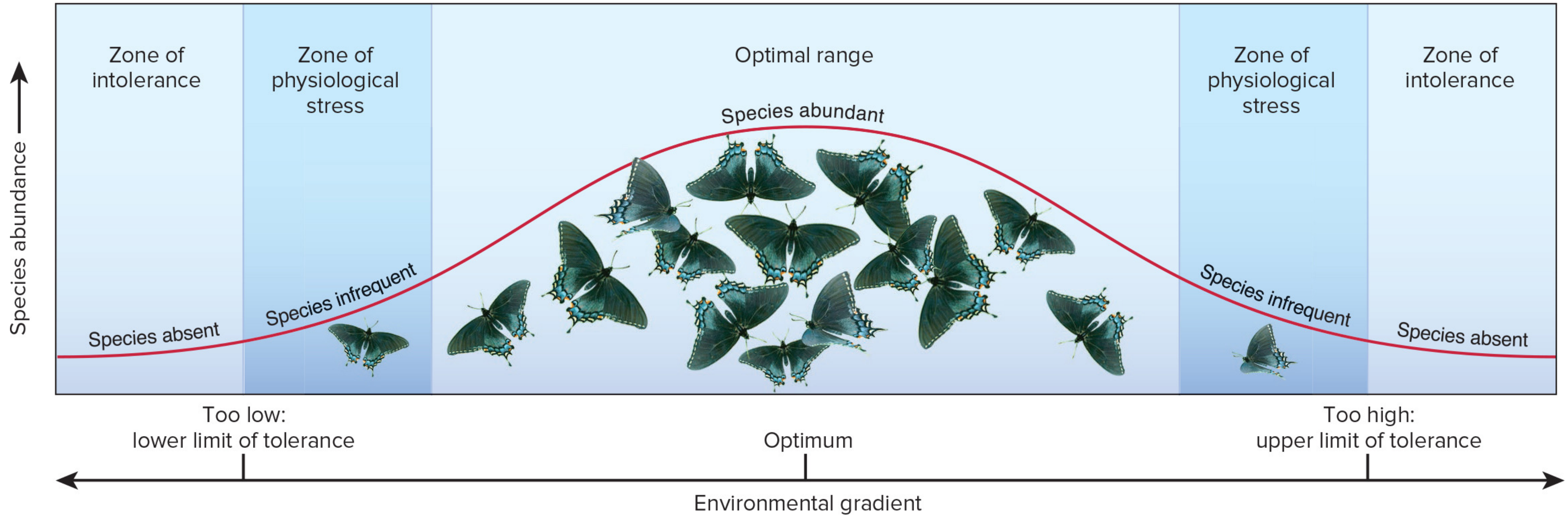
An organism's physiology and behavior allow it to survive only in certain environments.

Generally some critical limiting factor keeps an organism from expanding everywhere.

Ecologist Victor Shelford stated that each environmental factor has both minimum and maximum levels, called **tolerance limits**, beyond which a particular species cannot survive or is unable to reproduce.

Freezing Temps Limit the Northern Range of the Saguaro Cactus

Range of Tolerance Curve



Access the text alternative for slide images.

The Ecological Niche Is a Species' Role and Environment

Habitat describes the place or set of environmental conditions in which a particular organism lives.

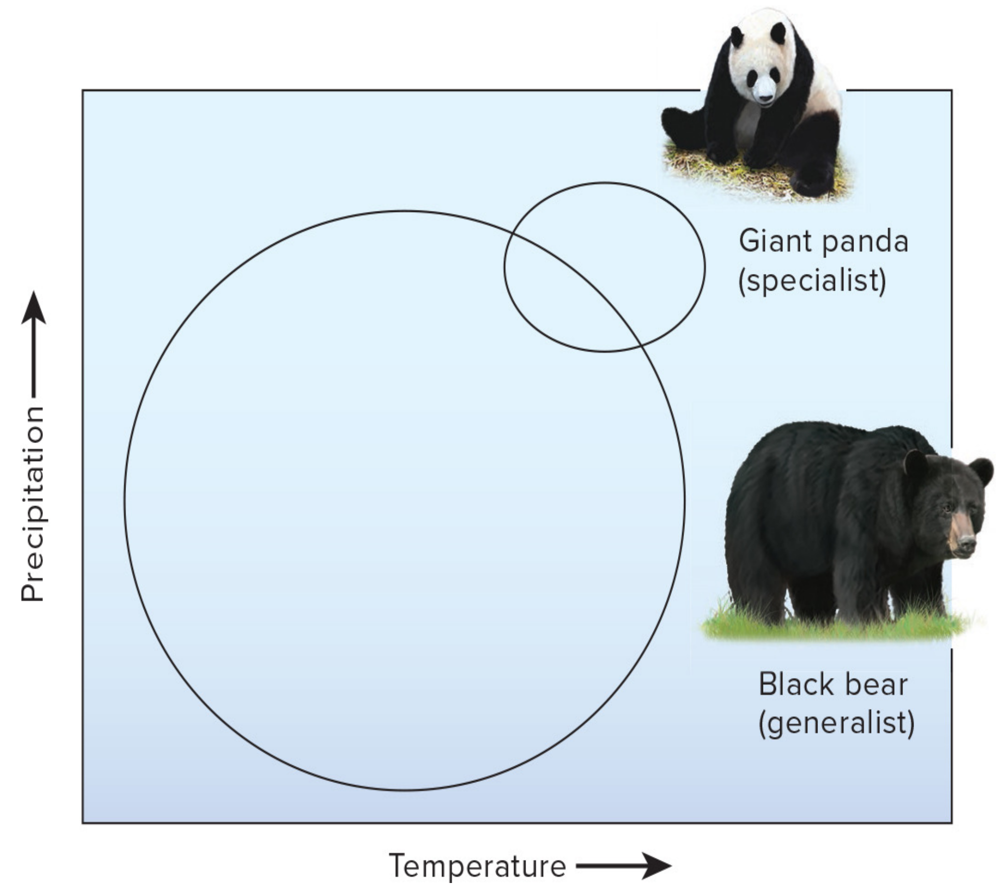
Ecological niche, describes both the role played by a species in a biological community and the set of environmental factors that determine its distribution.

© Mary Ann Cunningham

Niches: Generalists & Specialists

Generalists like the black bear tolerate a wide range of conditions.

Other species, such as the giant panda, are **specialists** and have a narrow ecological niche.



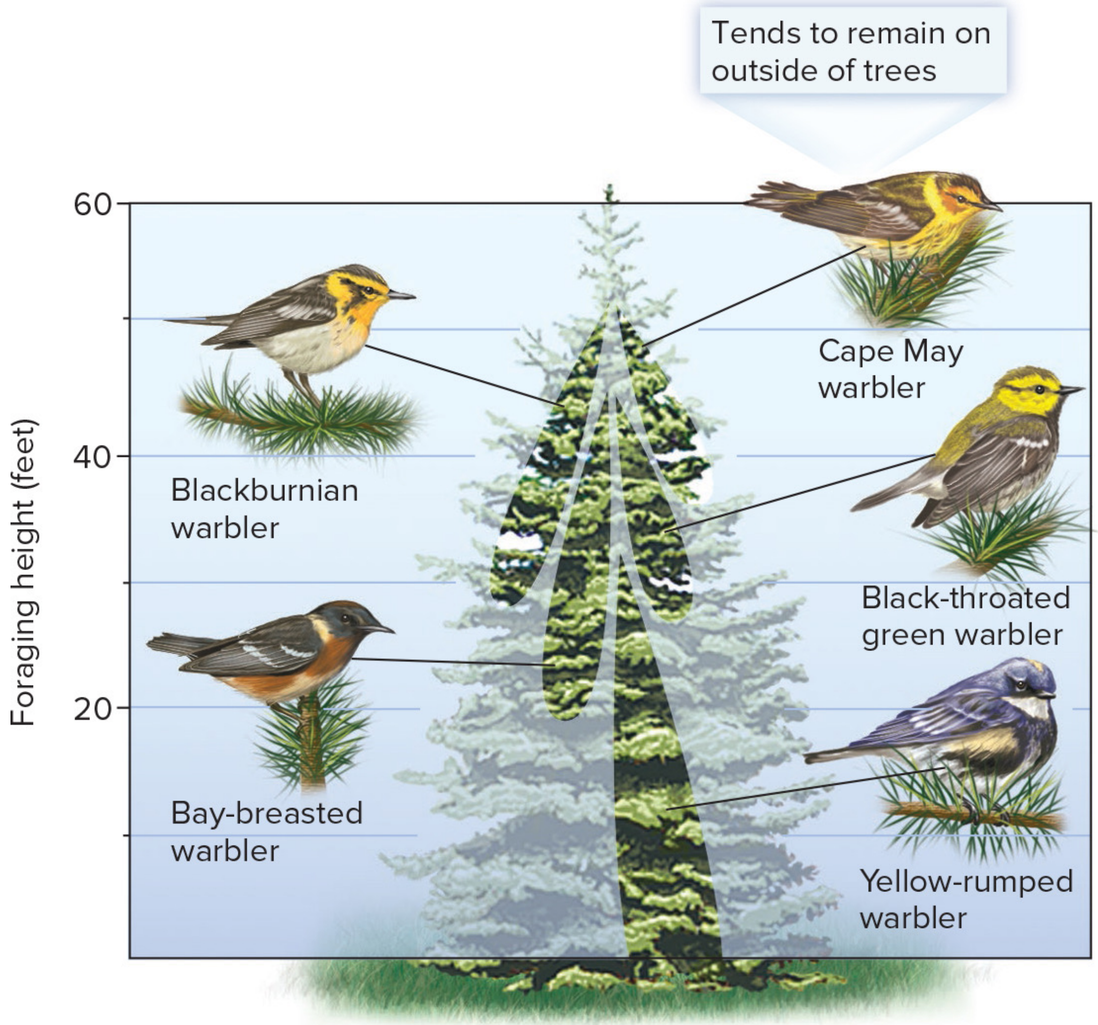
Access the text alternative for slide images.

The Competitive Exclusion Principle

The competitive exclusion principle states that no two species can occupy the same ecological niche for long.

- The one that is more efficient in using available resources will exclude the other.
- The other species disappears or develops a new niche, exploiting resources differently, a process known as **resource partitioning.**
- Partitioning can allow several species to utilize different parts of the same resource and coexist within a single habitat.

Warblers Partition Their Resource to Reduce Competition



Access the text alternative for slide images.

Speciation Leads to Species Diversity

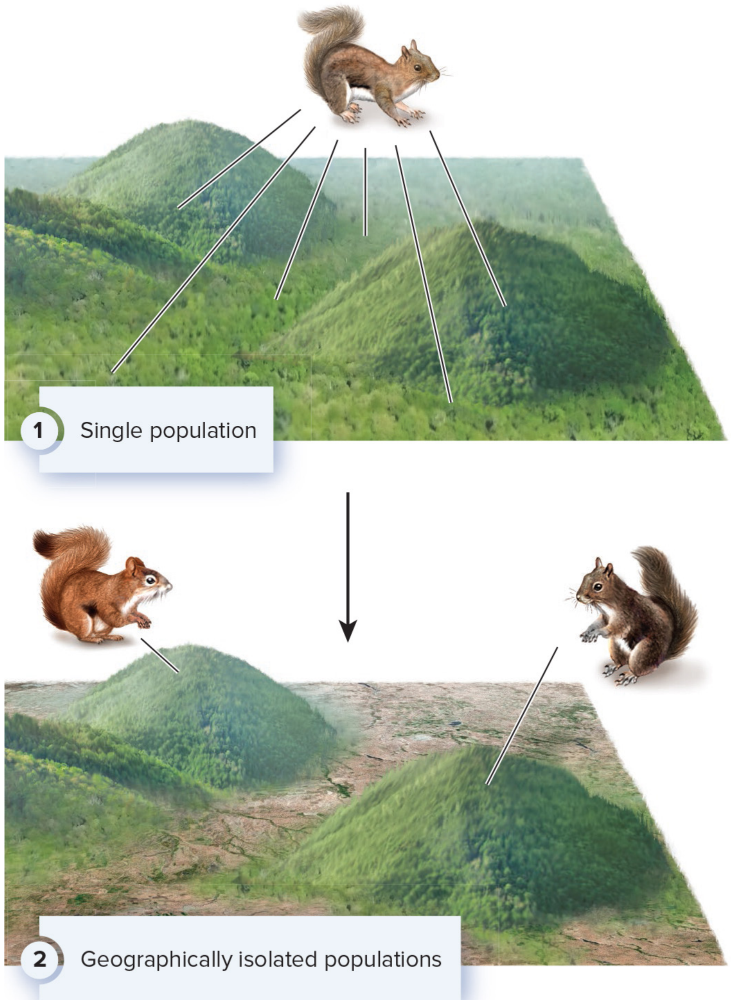
The development of a new species is called **speciation**.

In the Galápagos finches, speciation occurred largely because of **geographic isolation**.

Speciation that occurs when populations are geographically separated is known as **allopatric speciation**.

Behavioral isolation can result in speciation that occurs within one geographic area and is known as **sympatric speciation**.

Geographic Isolation Can Lead to Allopatric Speciation



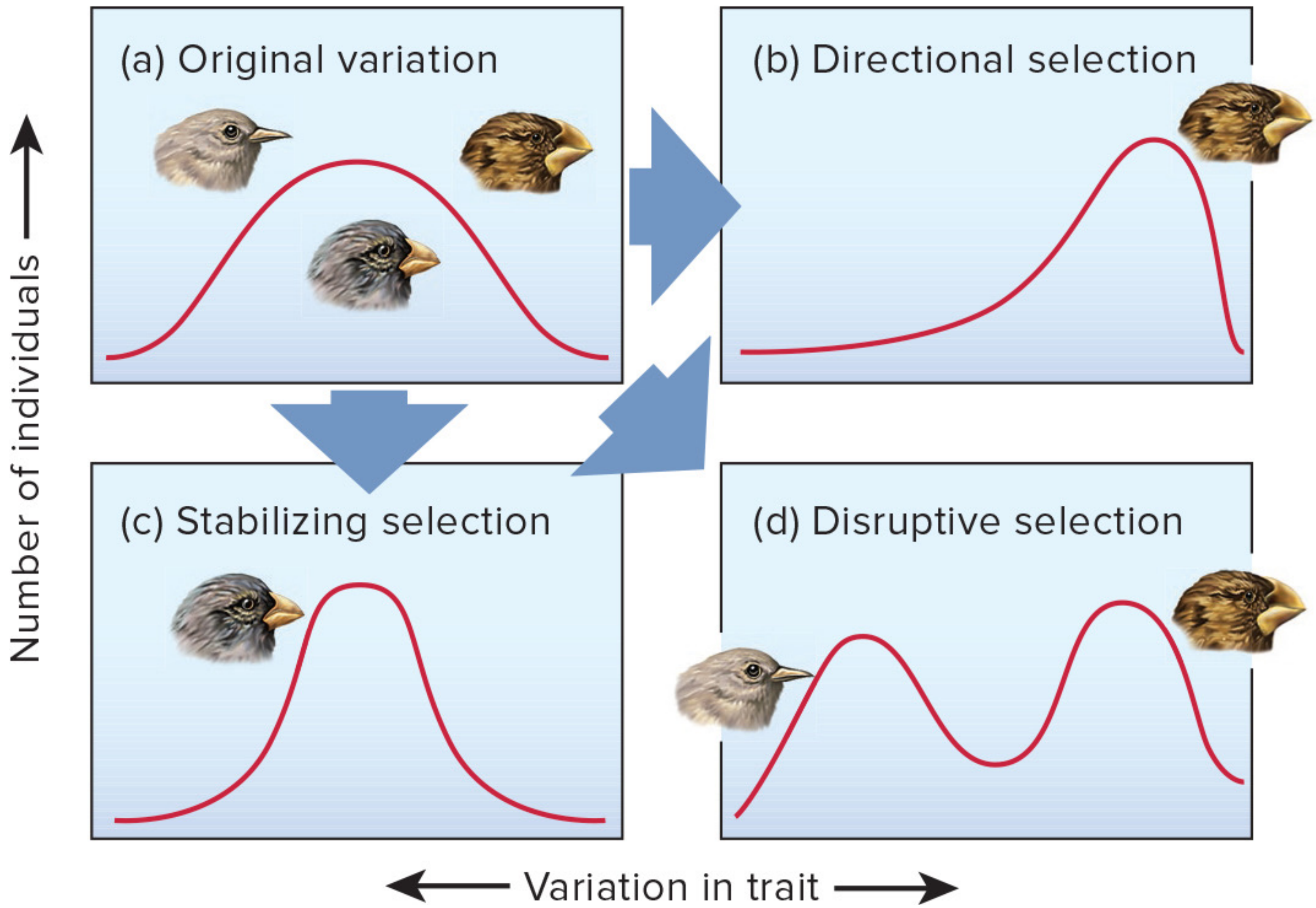
Selection Pressure Can Make Certain Mutations Advantageous

This shift toward one extreme of a trait is known as **directional selection**.

Sometimes environmental conditions can reduce variation in a trait. This is called **stabilizing selection**.

Other times environmental conditions can cause traits to diverge to the extremes, this is called **disruptive selection**.

Directional, Stabilizing, and Disruptive Selection



Access the text alternative for slide images.

Taxonomy Describes Relationships Among Species

Taxonomy is the study of types of organisms and their relationships.

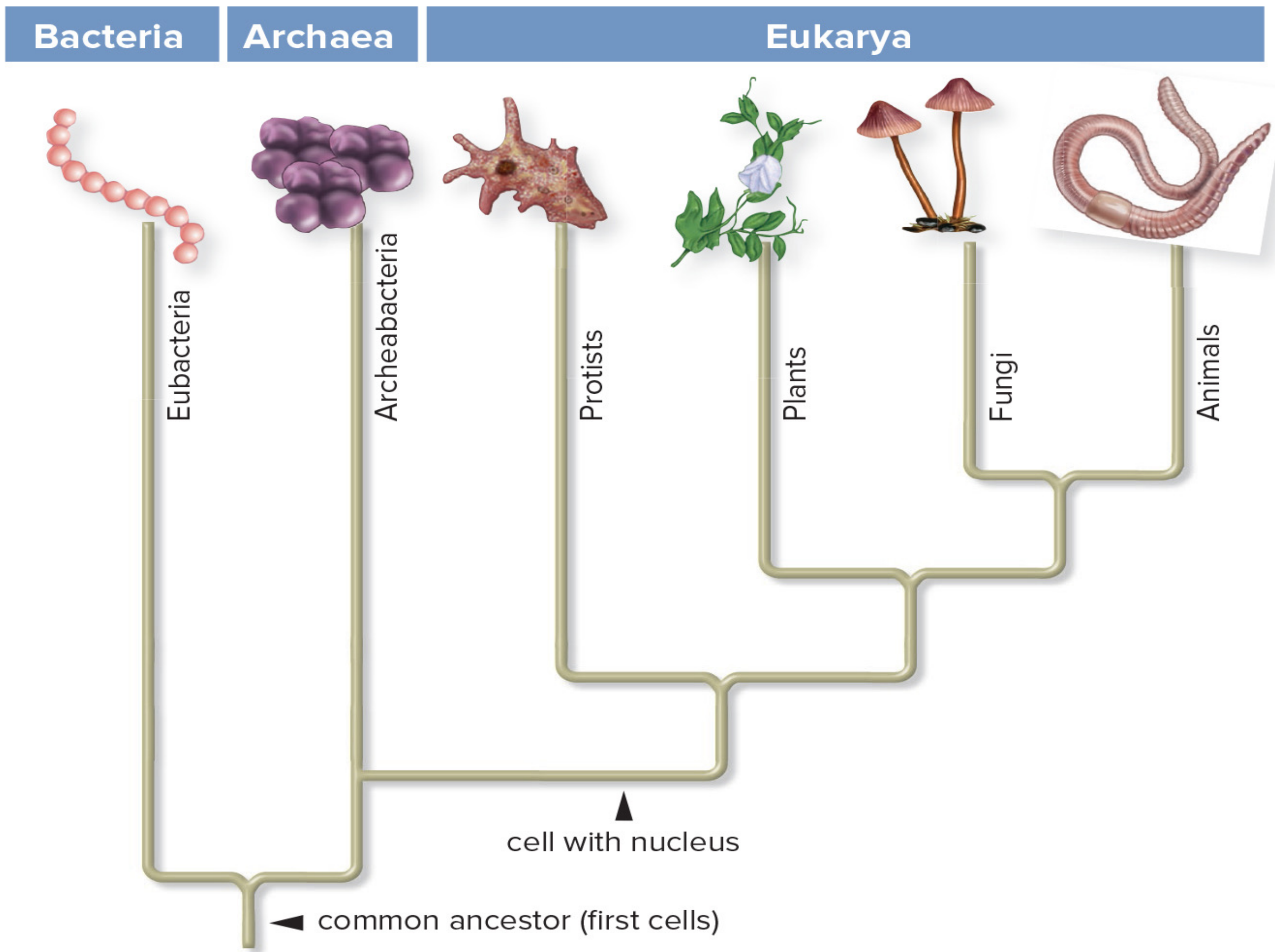
Taxonomists are continually refining their understanding, but most now classify all life into three general domains according to cell structure.

- Bacteria, Archaea, and Eukarya.

The organisms most familiar to us are in the four kingdoms of the Eukarya.

- Animals, plants, fungi, and protists.

Taxonomists Divide Living Organisms into Three Domains



Access the text alternative for slide images.

Scientists Use Binomials to Refer to Individual Species

Within these 4 kingdoms are millions of different species.

Scientists often use the two most specific levels of taxonomy, genus and species, to refer to species.

These two-part binomial names, also called scientific or Latin names, are more precise than common names.

The Taxonomic Hierarchy

TABLE 3.1 Taxonomy of Two Common Species

TAXONOMIC LEVEL	HUMANS	CORN
Kingdom	Animalia	Plantae
Phylum	Chordata	Anthophyta
Class	Mammalia	Monocotyledons
Order	Primates	Commenales
Family	Hominidae	Poaceae
Genus	*Homo*	*Zea*
Species	*Homo sapiens*	*Zea mays*
Subspecies	*H. sapiens sapiens*	*Zea mays mays*

3.2 Species Interactions

Interactions with other species help shape species' traits and behaviors.

Competition and predation cause species to evolve in response to each other's attributes.

Cooperative interactions and even interdependent relationships also confer advantages which can lead to evolution of traits.

In this section we will look at the interactions within and between species that affect their success and shape biological communities.

Competition Leads to Resource Allocation

Competition is a type of antagonistic relationship within a biological community.

Organisms compete for resources that are in limited supply.

Competition among members of the same species is called **intraspecific competition**.

Competition between members of different species is called **interspecific competition**.

Special Adaptions


(a)


(b)

(a): Eoind/Getty Images; (b): Peter Miller/Getty Images

Predation Affects Species Relationships

Often we think only of carnivores as predators, but ecologically a predator is any organism that feeds directly on another living organism, whether or not this kills the prey.

Herbivores, **carnivores**, and **omnivores**, which feed on live prey, are predators

Scavengers, **detritivores**, and **decomposers**, which feed on dead things, are not predators

Herbivory Is a Type of Predation

©Amble Design/Shutterstock

Predatory Relationships May Change with Life Stage

In marine ecosystems, crustaceans , mollusks, and worms release eggs directly into the water where they and hatchling larvae join the floating plankton community.

Planktonic animals eat each other and are food for larger carnivores, including fish.

Predators often switch prey in the course of their lives.

©Choksawatdikorn/Shutterstock

Predation Leads to Adaptation 1

Predator-prey relationships exert selection pressures that favor evolutionary adaptation.

Predators become more efficient at searching and feeding, and prey become more effective at escape and avoidance.

A general term for this close adaptation of two species is **coevolution.**

Predation Leads to Adaptation 2

Species with chemical defenses often display distinct coloration and patterns to warn away enemies.

©Allison Isztok/EyeEm/Getty Images

Prey Adaptation: Camouflage

Species display forms, colors, and patterns that help them hide. Insects that look exactly like dead leaves or twigs are among the most remarkable examples.

Courtesy Tom Finkle

Prey Defense Adaptations

(a) Wasp

(b) Beetle

Certain species that are harmless resemble poisonous or distasteful ones, gaining protection against predators who remember a bad experience with the actual toxic organism.

This is called **Batesian mimicry**.

Symbiosis Involves Cooperation

Symbiosis is a process where two or more species live intimately together, with their fates linked.

There are three major types of symbiotic relationships among species.

- **Mutualism**: both species clearly benefit.
- **Commensalism**: one member benefits and the other apparently is neither benefited nor harmed.
- **Parasitism**: one partner benefits while the other is harmed (a type of predation).

Symbiotic Relationships

Symbiotic relationships often involve coevolution.

Many plants and pollinators have forms and behaviors that benefit each other.

- Many moths, for example, are adapted to pollinate particular flowering plants.

Symbiotic relationships often enhance the survival of one or both partners.

- In lichens, a fungus and a photosynthetic partner (either an alga or a cyanobacterium) combine tissues to mutual benefit.

Coevolution

Coevolution has led to close evolutionary relationships between many species, as in this star orchid and the specially adapted hawk moth that pollinates it.

Types of Symbiosis: Intimate Relations Among Species

TABLE 3.2 Types of Species Interactions

INTERACTION BETWEEN TWO SPECIES	EFFECT ON FIRST SPECIES	EFFECT ON SECOND SPECIES
Mutualism	+	+
Commensalism	+	0
Parasitism	+	−
Predation	+	−
Competition	±	±

(+ beneficial; − harmful; 0 neutral; ± varies)

Examples of Symbiosis

(a) Symbiosis

(b) Mutualism

(c) Commensalism

Lichens are a mutualistic relationship between fungi and algae.

Mutualistic relationship between parasite eating red-billed oxpecker and parasite infested impala.

Commensalistic bromeliad grows on the trunk of a tropical tree.

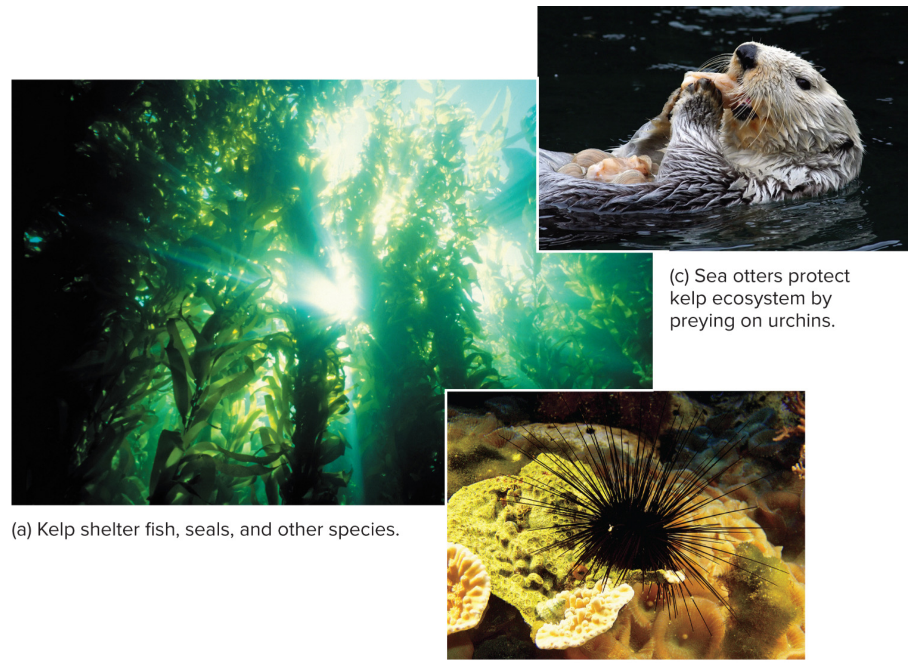
(a): Zelma Brezinska/Shutterstock; (b): P. de Graaf/Moment Open/Getty Images; (c): ©William P. Cunningham

Keystone Species Play Critical Roles

A **keystone species** plays a critical role in a biological community.

Originally, keystone species were thought to be only top predators.

Now scientists realize that the effect of a keystone species on communities ripples across multiple trophic levels.



(a) Kelp shelter fish, seals, and other species.

(b) Sea urchins graze on kelp.

(c) Sea otters protect kelp ecosystem by preying on urchins.

Access the text alternative for slide images.

(a): Island Effects/E+/Getty Images; (b): Medioimages/Getty Images; (c): Kirsten Wahlquist/Shutterstock

3.3 Population Growth

Apart from their interactions with other species, organisms have an inherent rate of reproduction that influences population size.

Many species have potential to produce almost unbelievable numbers of offspring. This is called the **biotic potential**— the unrestrained biological reproduction or an organism.

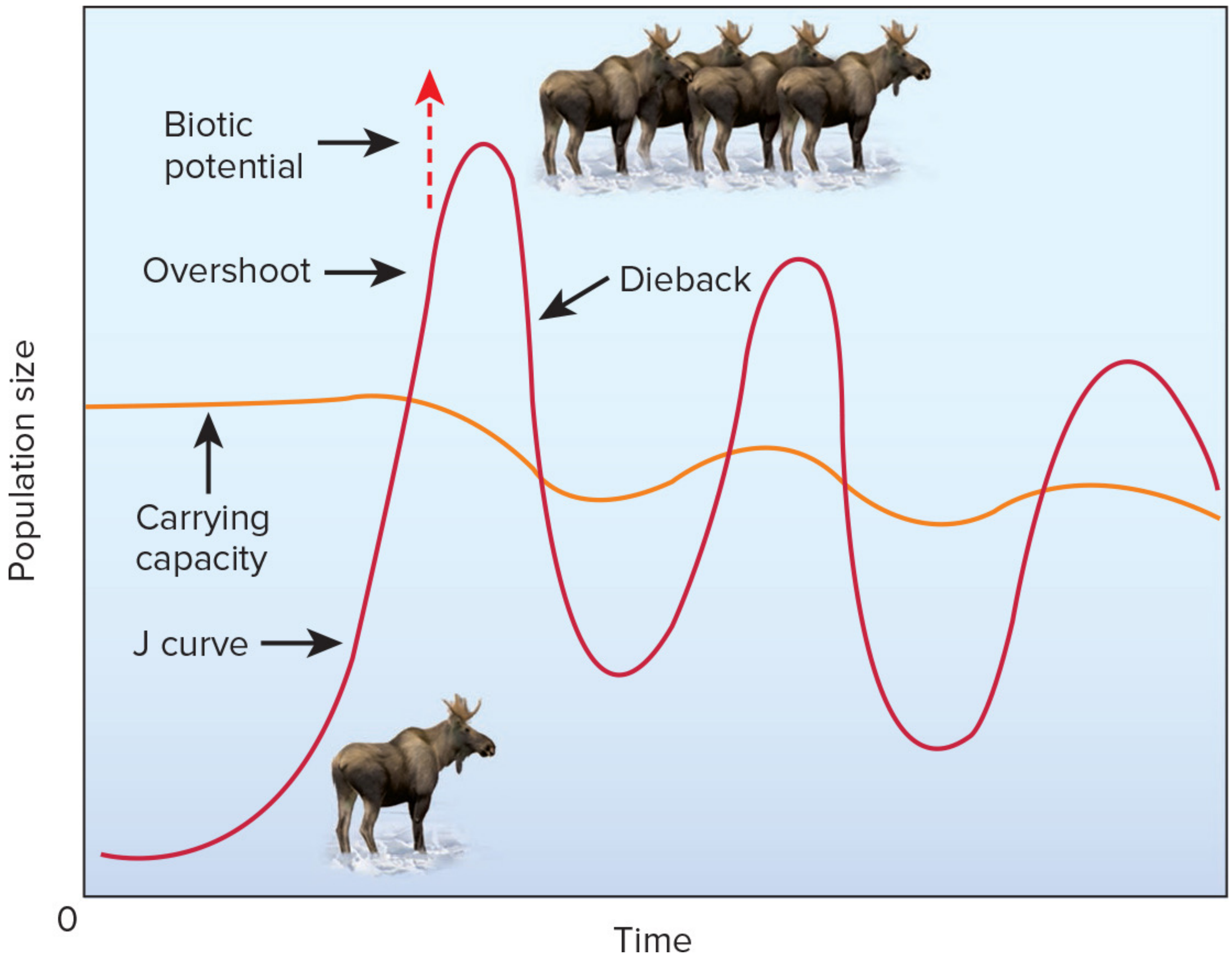
Exponential Growth Accelerates

Exponential (r) growth is population growth with no limits and has a distinctive shaped "J" growth curve when graphed over time.

The exponential growth equation is a very simple model; it is an idealized, simple description of the real world.

Populations of a species lose individuals and experience reduced biotic potential.

J Curve of Exponential Growth



Access the text alternative for slide images.

Carrying Capacity Limits Growth

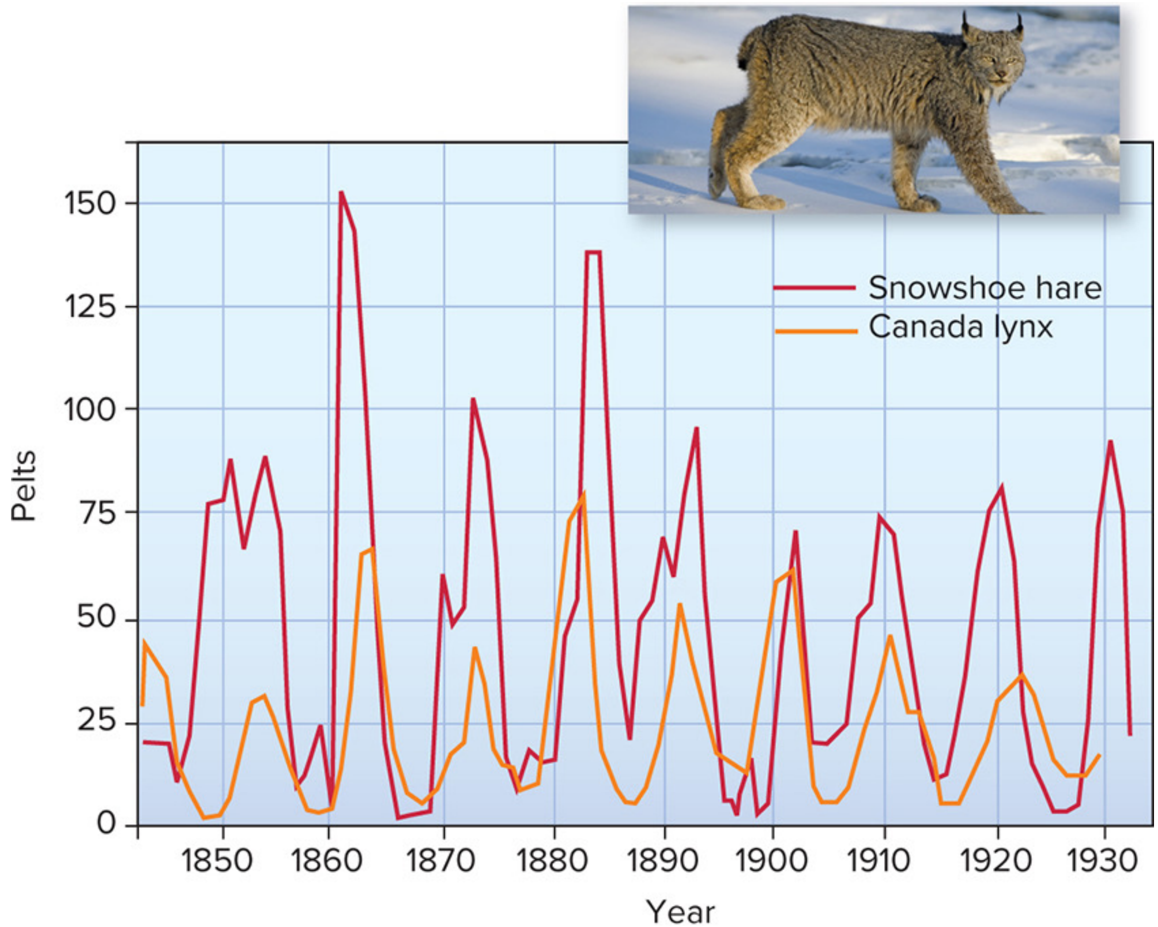
In the real world, there are limits to growth.

Originally, **carrying capacity** was defined as the number or biomass of animals that can be supported (without harvest) certain area of habitat.

The concept is now used more generally to suggest a limit of sustainability that an environment has in relation to the size of a species population.

When a population overshoots the carrying capacity of its environment, resources become limited and death rates rise and the population may crash.

Population Cycles Between Predator and Prey



Access the text alternative for slide images.

Source: Data from MacLulich, D. A. *Fluctuations in the Numbers of the Varying Hare* (*Lepus americanus*). University of Toronto Press, 1937, reprinted 1974.Erni/Shutterstock

Environmental Limits Lead to Logistic Growth

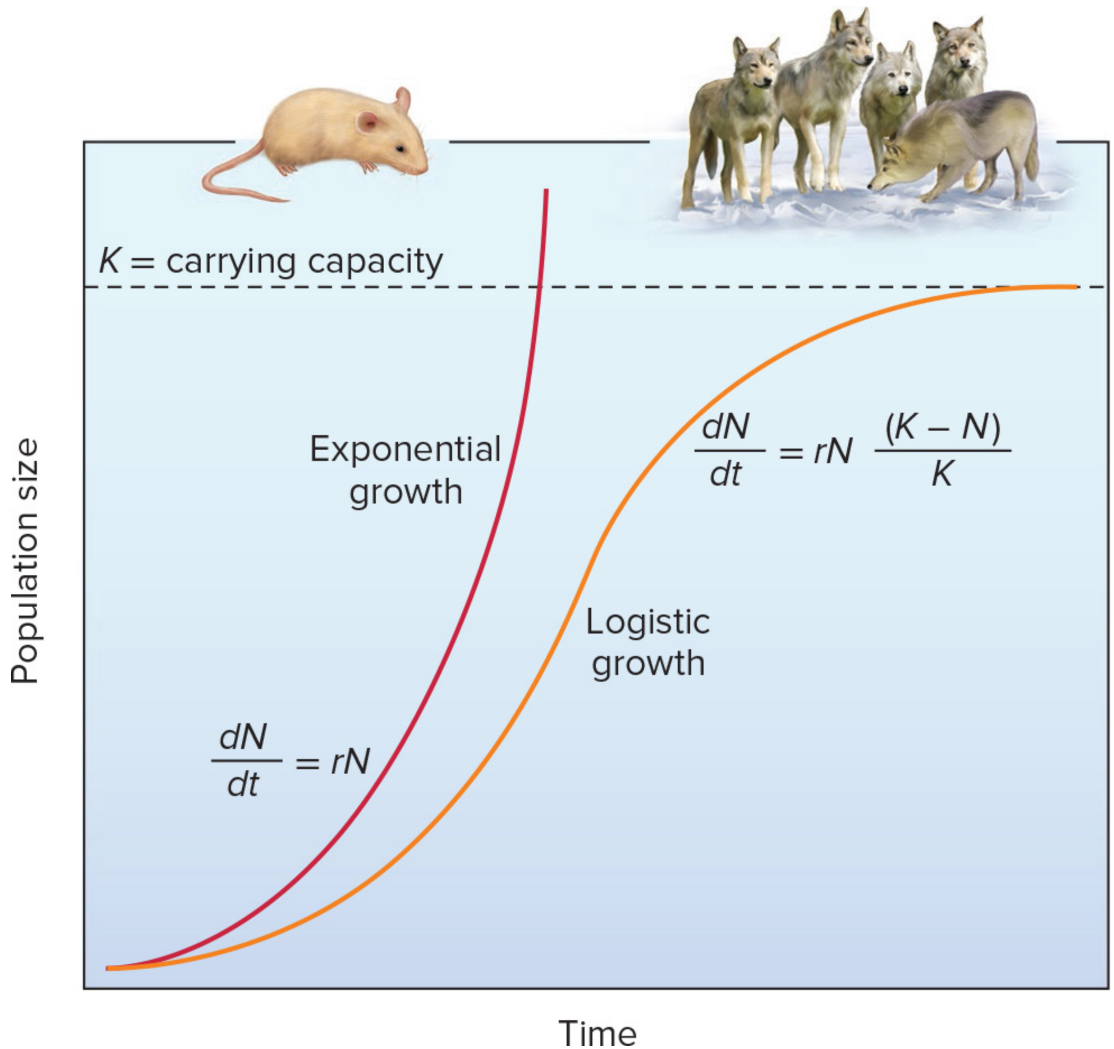
Not all biological populations cycle through exponential overshoot and catastrophic dieback.

Internal and external factors can bring a species into equilibrium with their environmental resources.

When resources are unlimited, they may grow exponentially, but this growth slows as the carrying capacity of the environment is approached.

This population dynamic is called **logistic growth** because of its changes in growth rate over time.

S-Shaped Logistic Growth Curve



Access the text alternative for slide images.

Limits to Population Size

Population growth rates are affected by external and internal factors:

- **Density-dependent factors** are those affected by population size . For example, there is an increased risk that disease or parasites will spread, or that predators will be attracted to the area as a population grows in size.
- **Density-independent factors** are limits to population that are nonbiological and are the result of capricious acts of nature . A population is affected no matter what its size.

Species Respond to Limits Differently: R- and K-Selected Species 1

Some organisms, such as dandelions and barnacles, depend on a high rate of reproduction and growth (*r)* to secure a place in the environment. These organisms are called ***r-selected species*** because they are adapted to employ a high reproductive rate.

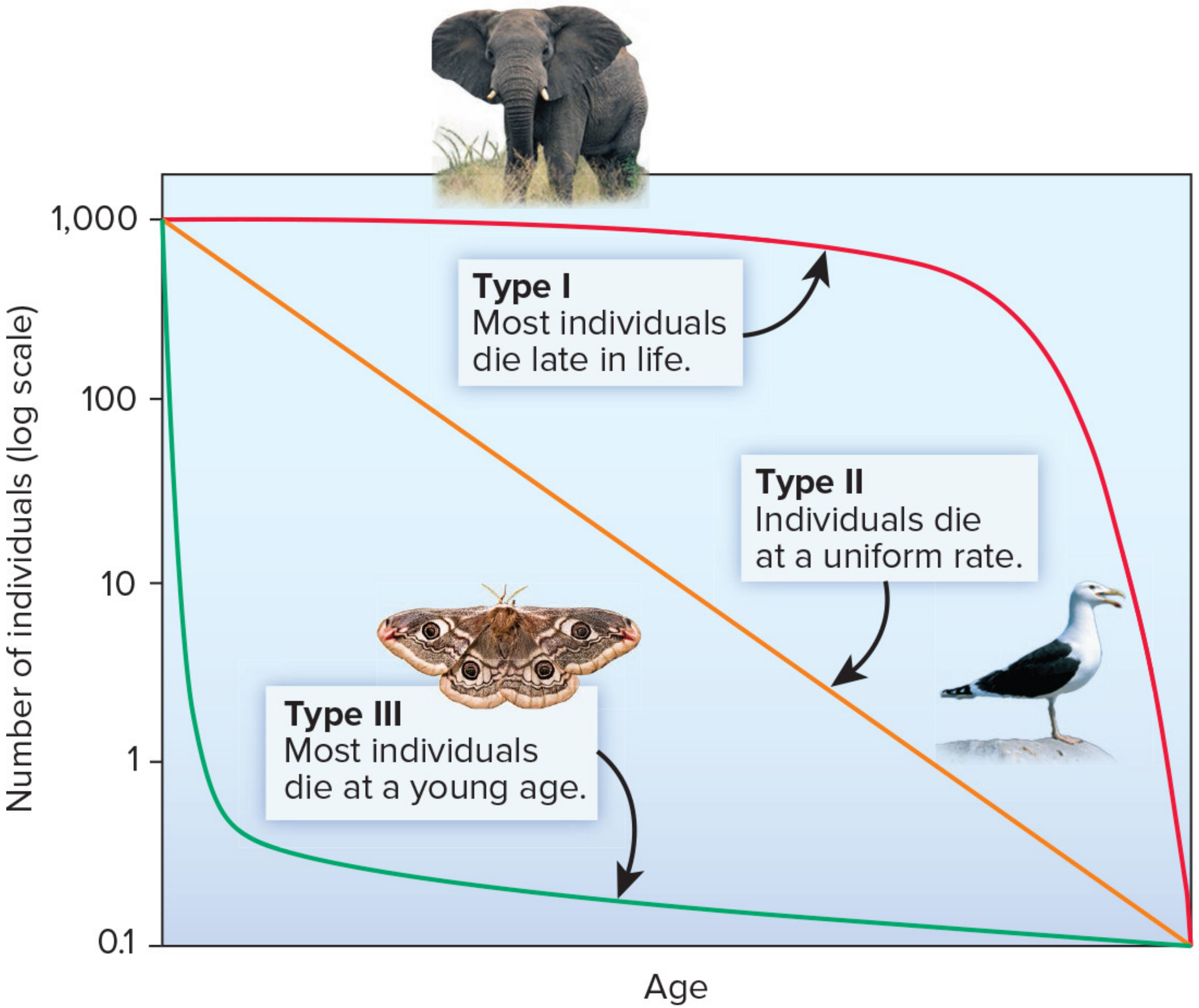
Organisms that reproduce more conservatively with longer generation times, late sexual maturity, fewer young—are referred to as ***K-selected species.*** They are adapted for slower growth conditions near the carrying capacity (*K*) of their environment.

Species Respond to Limits Differently: R- and K-Selected Species 2

TABLE 3-3 Reproductive Strategies

r-SELECTED SPECIES	*K*-SELECTED SPECIES
1. Short life	1. Long life
2. Rapid growth	2. Slower growth
3. Early maturity	3. Late maturity
4. Many, small offspring	4. Few, large offspring
5. Little parental care and protection	5. High parental care or protection
6. Little investment in individual offspring	6. High investment in individual offspring
7. Adapted to unstable environment	7. Adapted to stable environment
8. Pioneers, colonizers	8. Later stages of succession
9. Niche generalists	9. Niche specialists
10. Prey	10. Predators
11. Regulated mainly by intrinsic factors	11. Regulated mainly by extrinsic factors
12. Low trophic level	12. High trophic level

Survivorship Curves



Access the text alternative for slide images.

(a): ©Digital Vision./Getty Images; (b): ©Stockbyte/Getty Images; (c): ©Simon Kovacic/123RF

3.4 Community Diversity

No species is an island. It always lives with other species in a biological community in a particular environment.

In this section, we'll consider how the many species in an area together produce the basic properties of biological communities and ecosystems. The main properties of interest to ecologists are:

- diversity and abundance.
- community structure and patchiness.
- complexity, resilience, productivity, and stability.

Diversity and Abundance

Diversity is the number of different species in an area or the number per unit area.

Abundance refers to the number of individuals of a particular species (or of a group) in an area.

Diversity and abundance are often related.

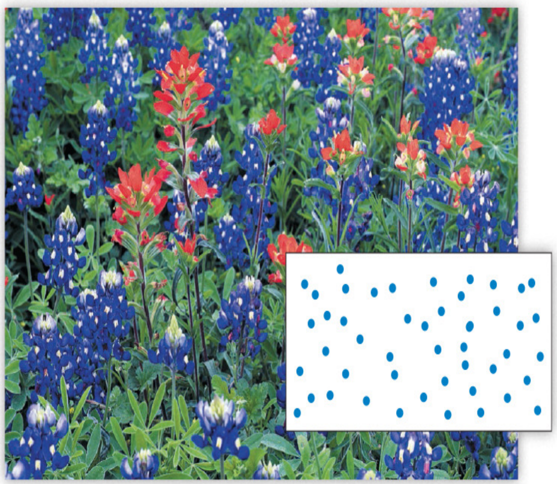
- Communities with high diversity often have few individuals of any one species.
- Most communities contain a few common species and many rarer ones.

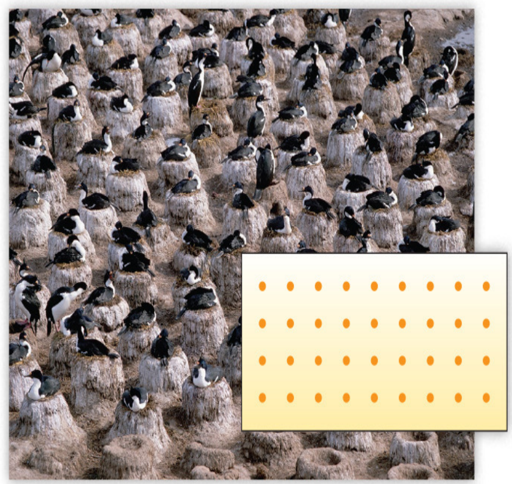
Patterns Produce Community Structure

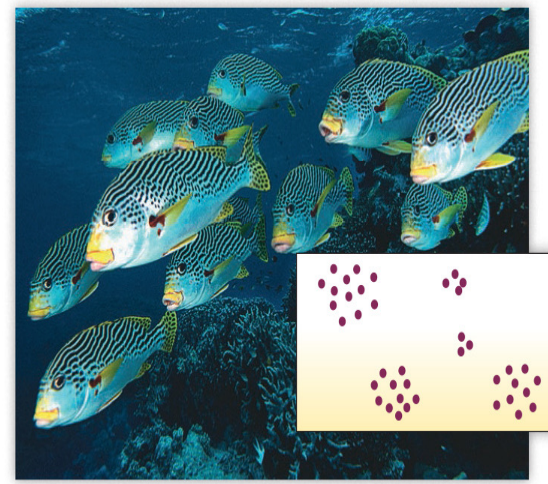
Community structure, or spatial patterns can be **random**, **ordered**, or **patchy**:

- In **randomly** distributed populations, individuals live wherever resources are available and chance events allow them to settle.
- **Ordered** or **Uniform** patterns often arise from competition and territoriality.
- **Patchy** patterns result when species clump together for protection, mutual assistance or reproduction.

Individuals in Communities Are Distributed in Various Ways


(a) Random


(b) Uniform


(c) Clustered

(a): ©Jim Zuckerman/Getty Images; (b): ©Eric and David Hosking/Getty Images; (c): ©anopdesingnstock/Getty Images

Communities Can Also Be Distributed Vertically

Access the text alternative for slide images.

Communities Form Patterns in Landscapes

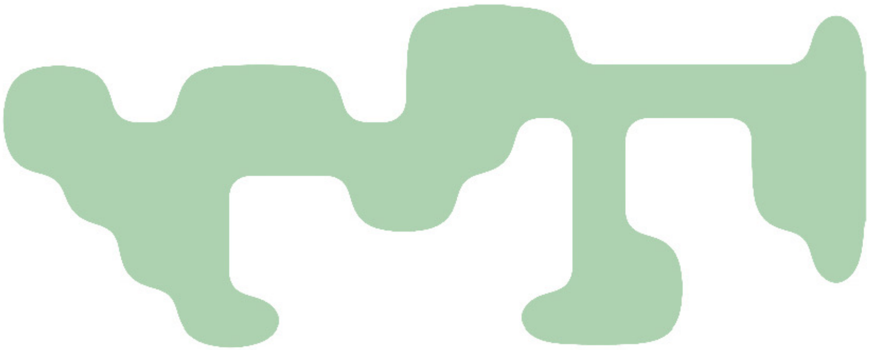
Core habitat- Large patch of relatively uniform environment that is free of the influence of edges.

Edge effects- Where communities meet, the environmental conditions blend and the species and microclimate of one community can penetrate the other.

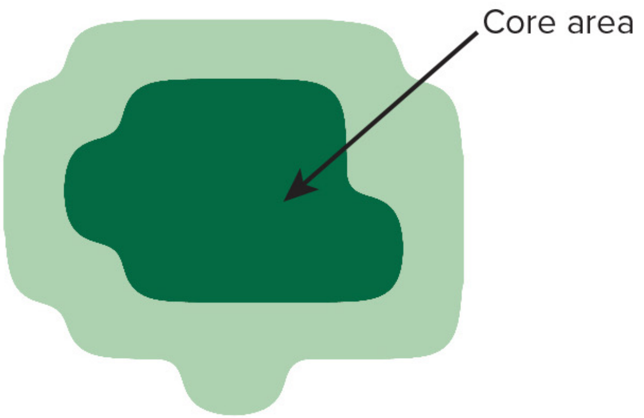
Edges Between a Lake, Wetland, and Forest


© Vol. 262/Corbis RF

Edge Effects



Total area: 50 ha
Core area: 0



Total area: 50 ha
Core area: 25 ha

Resilience Seems Related to Complexity

Complexity refers to the number of trophic levels in a community and to the number of species at each of those trophic levels.

A complex, interconnected community might have many trophic levels and groups of species performing the same functions.

In most cases the more complexity a community possesses, the more resilient it is when disturbance strikes.

Productivity Varies in Ecosystems

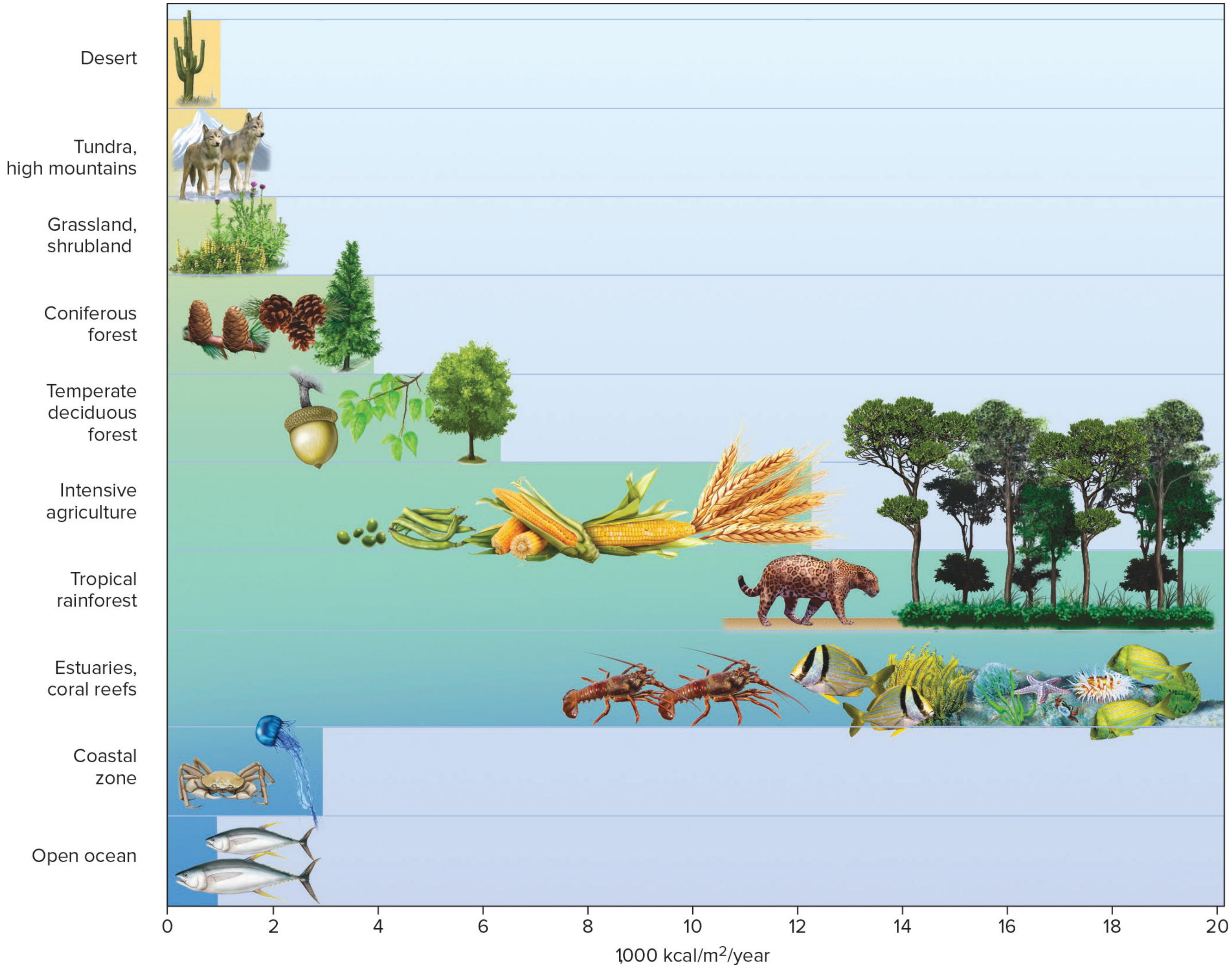
Another factor that can contribute to resilience is productivity.

Primary productivity is the production of biomass by photosynthesis. Plants, algae, and some bacteria produce biomass by converting solar energy into chemical energy.

Primary productivity is expressed as units of biomass or energy per unit area per year.

Productivity depends on light levels, temperature, moisture, and nutrient availability, so it varies dramatically among different ecosystem types.

Biomass Accumulates at Different Rates in Different Ecosystems



Access the text alternative for slide images.

3.5 Communities Are Dynamic and Change Over Time

The idea that dramatic, periodic change could be a part of normal ecosystems is relatively new in ecology.

We used to consider **stability** the optimal state of ecosystems, but with more observations and more studies, we have learned that communities can be dynamic, with dramatic changes over time.

Are Communities Like Organisms or Assemblages of Individuals?

Henry Chandler Cowles proposed that communities develop in a sequence of stages, with the final and longest lasting stage called the **climax community**.

F. E. Clements felt this process resembled the maturation of an organism.

H. A. Gleason saw this process as more unpredictable where species are individualistic. Each establishing in an environment according to its own ability to colonize, tolerate the environmental conditions, and reproduce there.

Gleason’s view is more widely held.

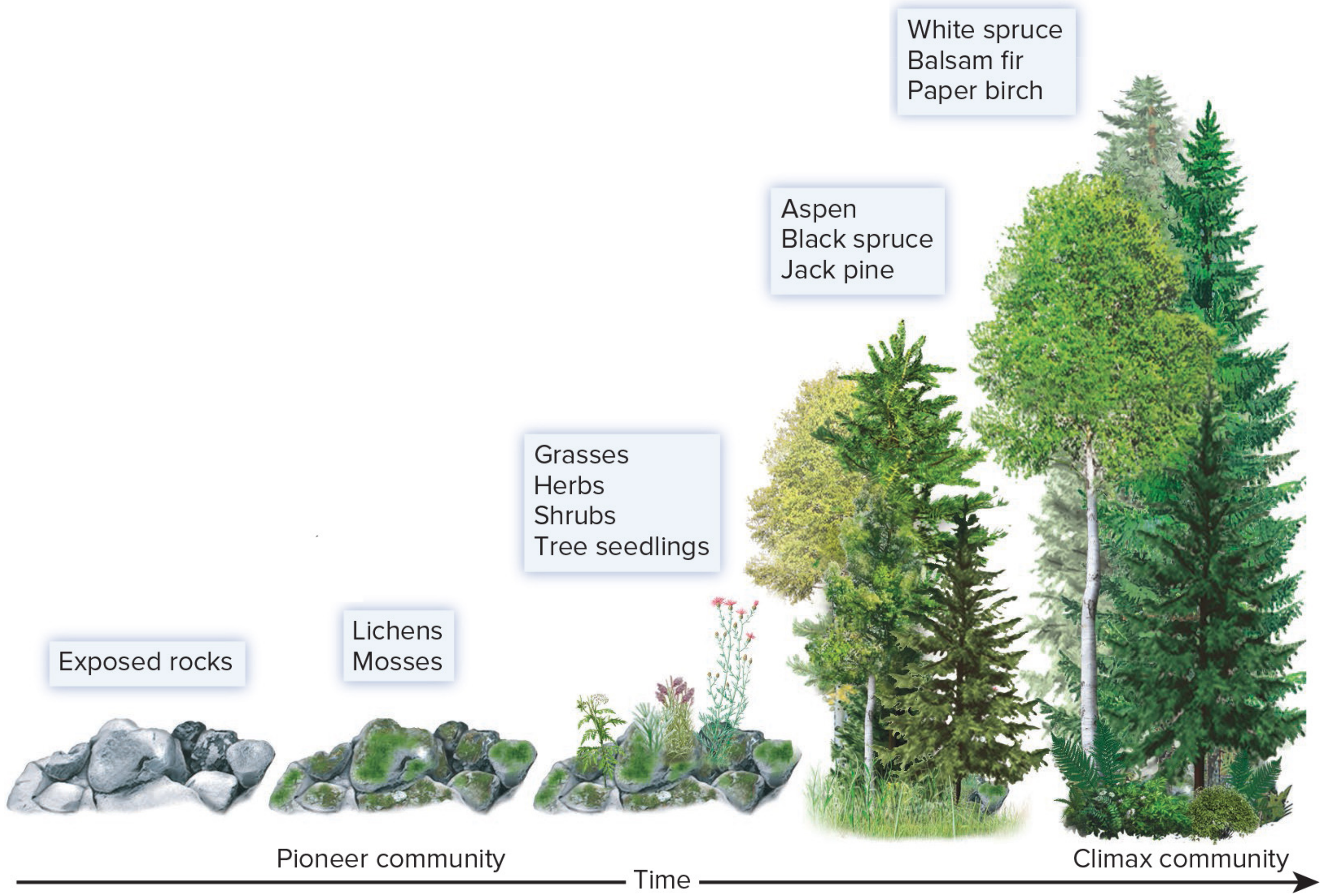
Succession Describes Community Change

Succession is a process in which organisms occupy a site and change its environmental conditions, gradually making way for another type of community.

In **primary succession,** bare land is colonized by living organisms where none lived before.

Secondary succession occurs after a disturbance, when a new community develops from the biological legacy of the previous one.

Primary Ecological Succession



Access the text alternative for slide images.

Some Communities Depend on Disturbance

Ecologically, a **disturbance** is any force that disrupts the established patterns of species diversity and abundance, community structure, or community properties.

Ecologists have found that disturbances like floods and forest fires actually benefit many species.

- These are called **disturbance-adapted species**.

Sometimes Communities Recover from Disturbances Very Slowly

Sometimes Communities Recover From Disturbances Quickly

Because learning changes everything.®

www.mheducation.com