Biology: Life on Earth

Eighth Edition

Lecture for Chapter 27

Community Interactions

Chapter 27 Opener Biology: Life on Earth, 8/e

Chapter 27 Outline

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Section 27.1 Outline

- **27.1 Why Are Community Interactions Important?**

Community Interactions

- An **ecological community** consists of all the interacting populations in an ecosystem

Community Interactions

- Interactions between populations in a community help limit their size
  - Populations are kept in balance with their resources

Community Interactions

- Community interactions take many forms, including
  - **Competition**: harms both species
  - **Predation**: benefits predator but harms prey
  - **Parasitism**: benefits parasite but harms host

Community Interactions

- Community interactions take many forms, including
  - **Commensalism**: benefits one species but has no effect on the other
  - **Mutualism**: benefits both species

Table 27-1 Interactions Among Organisms

Type of Interaction	Effect on Organism A	Effect on Organism B
Competition between A and B	Harms	Harms
Predation by A on B	Benefits	Harms
Symbiosis		
Parasitism by A on B	Benefits	Harms
Commensalism of A with B	Benefits	No effect
Mutualism between A and B	Benefits	Benefits

Table 27-1 Biology: Life on Earth, 8/e

Community Interactions

- Community interactions shape the evolution of the species in that community
- **Coevolution** occurs when two species act as agents of natural selection on each other

Section 27.2 Outline

- **27.2 What Are the Effects of Competition Among Species?**
  - The Ecological Niche Defines the Place and Role of Each Species in Its Ecosystem
  - Adaptations Reduce the Overlap of Ecological Niches Among Coexisting Species
  - Competition Helps Control Population Size and Distribution

Ecological Niche

- Encompasses all aspects of a species' way of life, including
  - Physical home or **habitat**
  - Physical and chemical environmental factors necessary for survival
  - How the species acquires its energy and materials
  - All the other species with which it interacts

Competition

- **Competition** is an interaction that may occur between individuals or species vying for the same, limited resources
  - Energy
  - Nutrients
  - Space
- **Interspecific competition** occurs between different species

Competition Among Species

- During **interspecific competition**, two or more species attempt to use the same limited resources
  - Each species is harmed as access to resources is reduced
  - The greater the overlap of *ecological niches*, the more intense the interspecific competition

Reduction of Niche Overlap

- The **competitive exclusion principle** states that if two species occupy exactly the same niche, one will eliminate the other

Reduction of Niche Overlap

- The competitive exclusion principle was formulated by microbiologist G. F. Gause…

Reduction of Niche Overlap

- Gause's Competitive exclusion principle
  - Performed laboratory experiments with protists
  - *Paramecium aurelia* and *P. caudatum* have identical niches—invariably one excludes the other
  - However, *P. aurelia* and *P. bursaria* can coexist as they feed in different places—have different niches

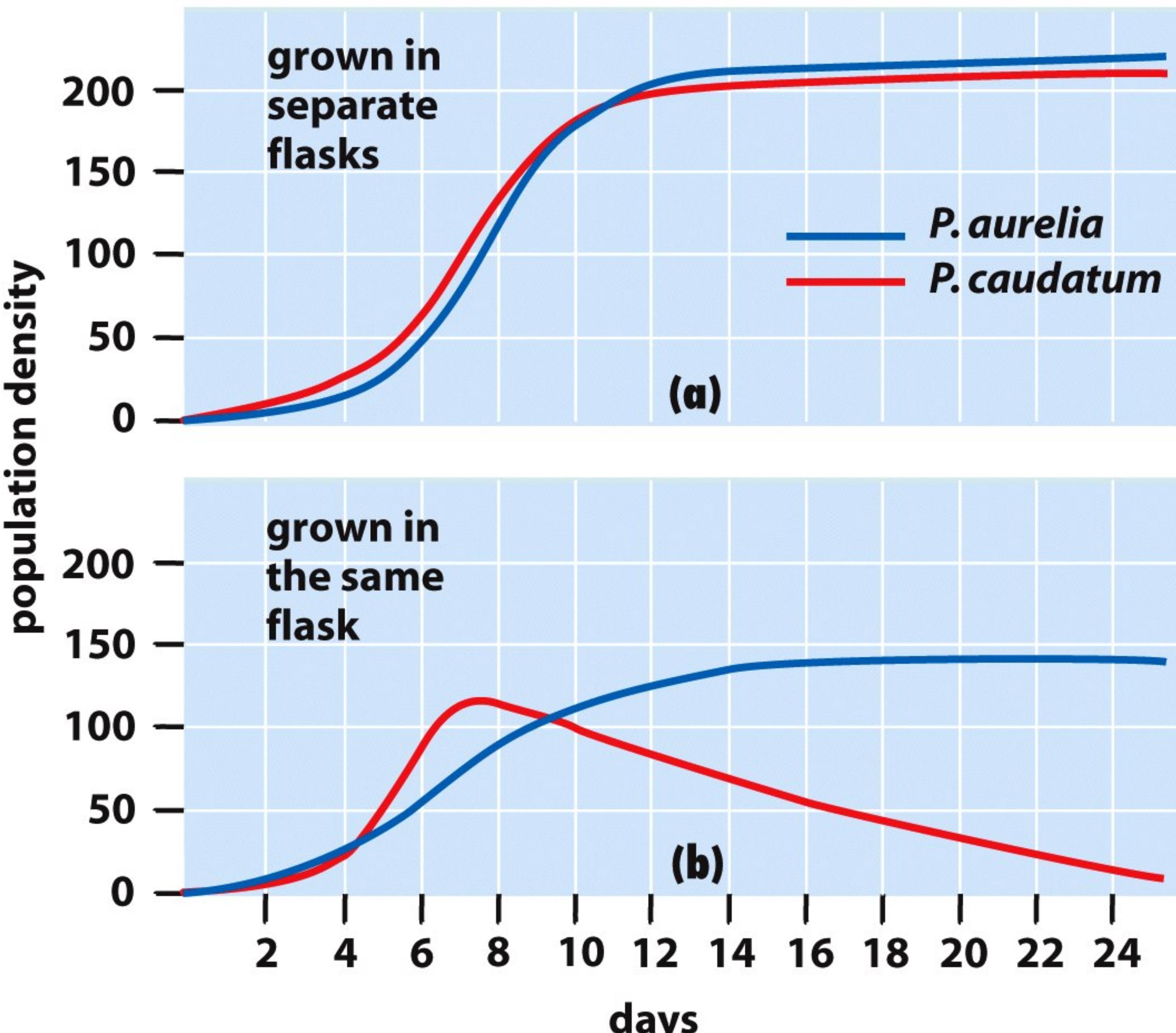


Figure 27-1 Biology: Life on Earth, 8/e

Reduction of Niche Overlap

- When species with largely overlapping niches are allowed to compete, their niches may focus on a different part of the resource spectrum
  - This is called **resource partitioning**
  - This reduces interspecific competition
  - Example: North American warblers

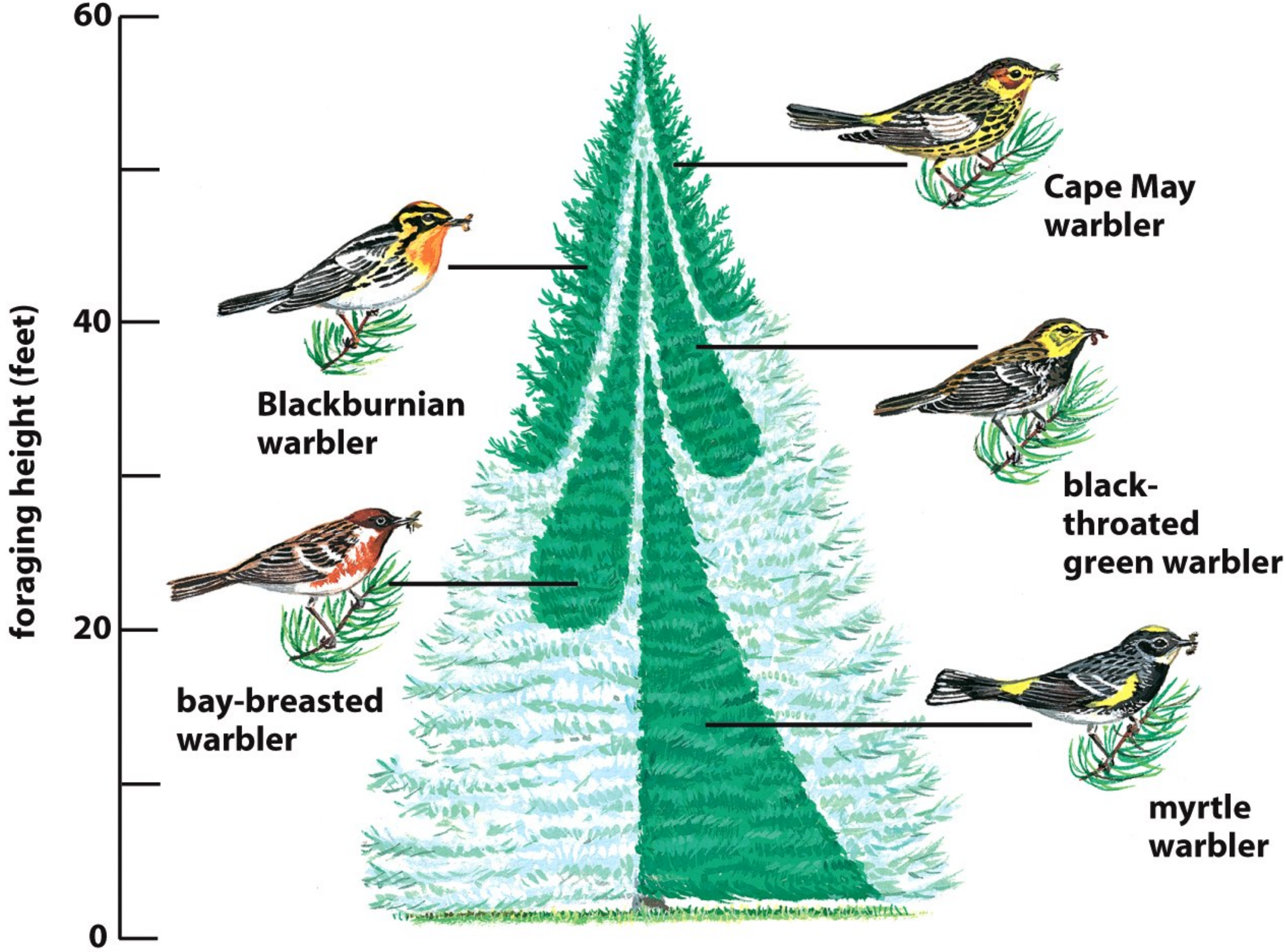


Figure 27-2 Biology: Life on Earth, 8/e

Interspecific Competition

- Although natural selection can reduce niche overlap, interspecific competition may still restrict the size and distribution of competing populations
  - Example: *Chtlamalus* and *Balanus* barnacles of the Scottish **intertidal** zone

Interspecific Competition

- **Intraspecific competition** is usually intense since individuals of the same species have virtually identical niches
  - If resources are limited, this is a major factor controlling population size

Section 27.3 Outline

- **27.3 What Are the Results of Interactions between Predators and Their Prey?**
  - Predator-Prey Interactions Shape Evolutionary Adaptations

Predator-Prey Interactions

- Predators kill and eat other organisms
  - Broadly defined, **predators** include **herbivorous** as well as **carnivorous** organisms, including cows, pika, and bats hunting moths
- Predators tend to be larger and more numerous than their prey

Figure 27-3a Biology: Life on Earth, 8/e

Figure 27-3b Biology: Life on Earth, 8/e

Evolutionary Adaptations

- Predators have evolved characteristics that increase their chances of catching prey
  - Examples: tearing claws of mountain lions and keen eyesight of hawks

Evolutionary Adaptations

- Prey have evolved characteristics that decrease the chances of being eaten
  - Examples: dappling spots and motionless behavior of deer fawns

Counteracting Behaviors

- Example: Night-hunting bats and their moth prey
  - Bats evolved high-intensity, high-frequency sound pulses to “image” surroundings and locate moths
  - Some moths evolved simple ears to detect bat pulses and take evasive maneuvers

Counteracting Behaviors

- Example: Night-hunting bats and their moth prey
  - Bats can switch frequencies outside of moths' sensitive range to avoid detection
  - Moths can emit pulses to confuse bats
  - Bats can turn off their pulses to listen for moths' pulses

Camouflage

- **Camouflage** renders animals inconspicuous even when in plain sight
  - May include evolved colors, patterns, and shapes that resemble one's surroundings

sand dab (fish)

Figure 27-4a Biology: Life on Earth, 8/e

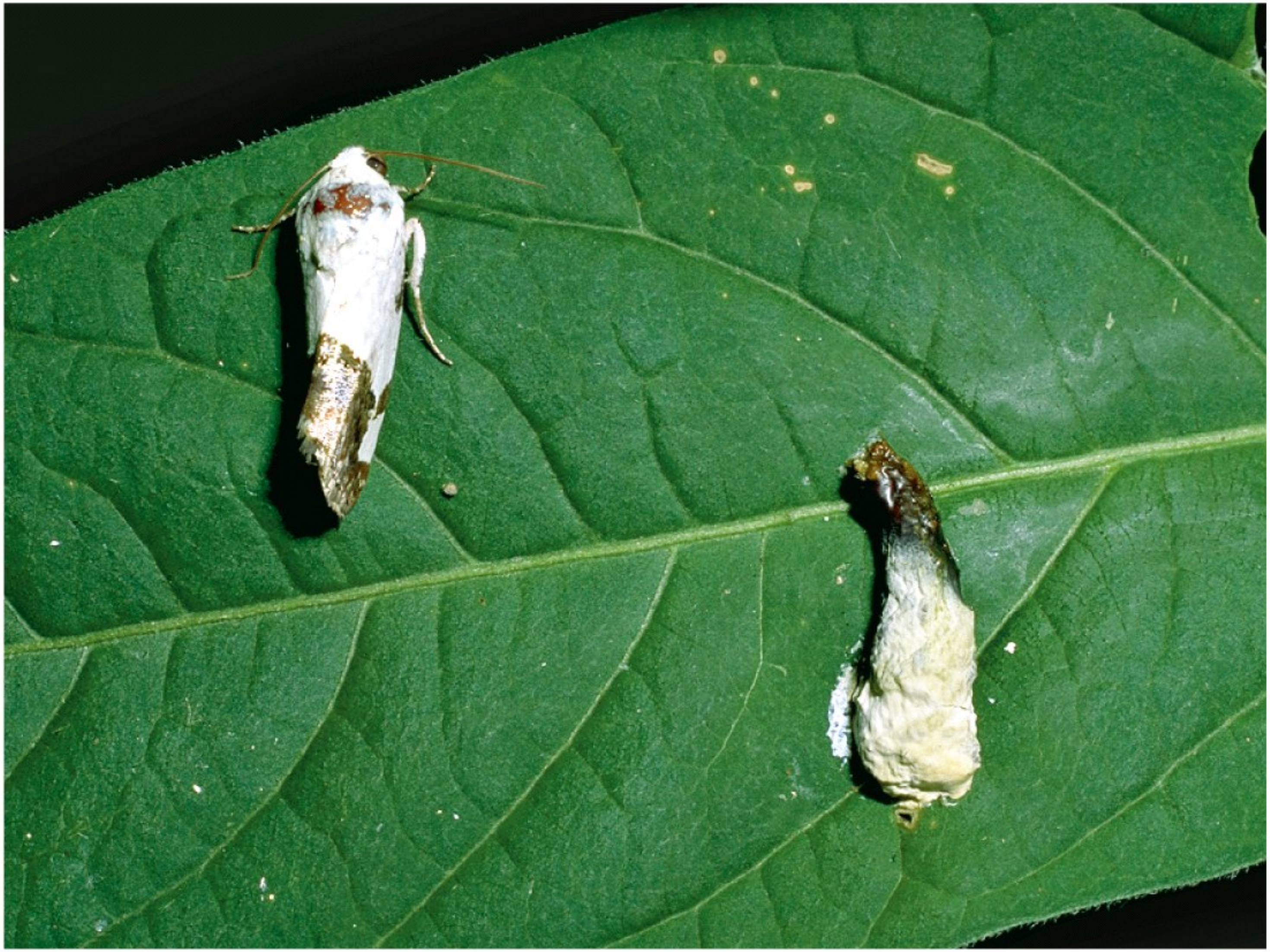
nightjar (bird)

Figure 27-4b Biology: Life on Earth, 8/e

Figure 27-19 Biology: Life on Earth, 8/e

Camouflage

- To avoid detection by predators, some animals have evolved to resemble objects such as bird droppings, leaves, or thorns



moth

Figure 27-5a Biology: Life on Earth, 8/e

leafy sea dragon

Figure 27-5b Biology: Life on Earth, 8/e

treehoppers

Figure 27-5c Biology: Life on Earth, 8/e

Camouflage

- Some plants have evolved to resemble rocks to avoid detection by herbivores

cactus

Figure 27-5d Biology: Life on Earth, 8/e

Camouflage

- **Camouflage** also helps predators ambush their prey
  - Examples: the cheetah blending with tall grass and the frogfish resembling a rock

cheetah

Figure 27-6a Biology: Life on Earth, 8/e

frogfish

Figure 27-6b Biology: Life on Earth, 8/e

Bright Colors

- Some animals have evolved bright **warning coloration** that attracts the attention of potential predators
  - Advertises that they are distasteful or poisonous *before* the predator attacks
  - Examples: poison arrow frogs, coral snakes, and yellow jackets

Figure 27-7 Biology: Life on Earth, 8/e

Protection Through Mimicry

- **Mimicry** refers to a situation in which one species has evolved to resemble another organism

Protection Through Mimicry

- Two or more distasteful species may each benefit from a *shared* warning coloration pattern (*Müllerian mimicry*)
  - Predators need only experience one distasteful species to learn to avoid all with that color pattern

Protection Through Mimicry

- Müllerian mimicry
  - Example: bees, hornets, and yellow jackets share black-and-yellow stripes
  - Example: monarch and viceroy butterflies share orange and black pattern

monarch butterfly (distasteful)

viceroy butterfly (distasteful)

Figure 27-8 Biology: Life on Earth, 8/e

Protection Through Mimicry

- Some harmless organisms can gain a selective advantage by resembling poisonous species *(Batesian mimicry)*
  - Example: harmless hoverfly resembles bee
  - Example: harmless mountain king snake resembles the venomous coral snake

bee (poisonous)

haverfly (non-poisonous)

Figure 27-9a Biology: Life on Earth, 8/e

coral snake
(venomous)

scarlet king snake
(non-venomous)

Figure 27-9b Biology: Life on Earth, 8/e

Protection Through Mimicry

- Some animals deter predators by employing **startle coloration**
  - Have spots that resemble eyes of a large predator

false-eyed frog

Figure 27-10a Biology: Life on Earth, 8/e

peacock moth

Figure 27-10b Biology: Life on Earth, 8/e

swallowtail butterfly caterpillar

Figure 27-10c Biology: Life on Earth, 8/e

Protection Through Mimicry

- In **aggressive mimicry**, predator resembles a harmless animal, or part of the environment, to lure prey within striking distance
  - Example: frogfish dangles wriggling lure that attracts a curious fish that is then eaten

frogfish

Figure 27-6b Biology: Life on Earth, 8/e

Protection Through Mimicry

- Snowberry flies avoid by jumping spider predation by mimicking them both visually and behaviorally

jumping spider (predator)

snowberry fly (prey)

Figure 27-11 Biology: Life on Earth, 8/e

Chemical Warfare

- Both predators and prey have evolved toxic chemicals for attack and defense

Chemical Warfare

- Spiders and poisonous snakes use venom to paralyze their prey and deter predators
- Many plants have evolved chemicals to deter herbivores
- Bombardier beetle sprays hot chemicals from its abdomen

bombardier beetle

Figure 27-12a Biology: Life on Earth, 8/e

Coevolutionary Adaptations

- Plants have evolved a variety of chemicals to deter herbivores
  - Example: the toxic and distasteful chemicals in milkweed

Coevolutionary Adaptations

- Some animals evolve ways to detoxify these chemicals, allowing them to eat the plants
  - Plants may then evolve other toxic substances

Coevolutionary Adaptations

- The monarch butterfly uses deterrent chemicals of milkweed, acquired by a feeding caterpillar, to make *itself* distasteful to its predators

monarch caterpillar

Figure 27-12b Biology: Life on Earth, 8/e

Section 27.4 Outline

- **27.4 What Is Symbiosis?**
  - – Parasitism Harms, but Does Not Immediately Kill, the Host
  - – In Mutualistic Interactions, Both Species Benefit

What Is Symbiosis?

- **Symbiosis** describes the close interaction between organisms of different species for an extended time

What Is Symbiosis?

- While one species always benefits, symbiotic relationships differ in their effects on the “other” species

What Is Symbiosis?

- There are three major symbiotic relationships
  - **Commensalism**
  - **Parasitism**
  - **Mutualism**

Commensalism

- In **commensalism**, one species benefits and the “other” is unaffected
  - Example: barnacles hitching a ride on the skin of a whale

Parasitism

- In **parasitism**, the **parasite** benefits but the host is harmed
  - The parasite lives in or on the host and benefits by feeding on it
  - Examples: tapeworms, fleas, and disease-causing protozoa, bacteria, and viruses, many of which have complex life cycles

Parasitism

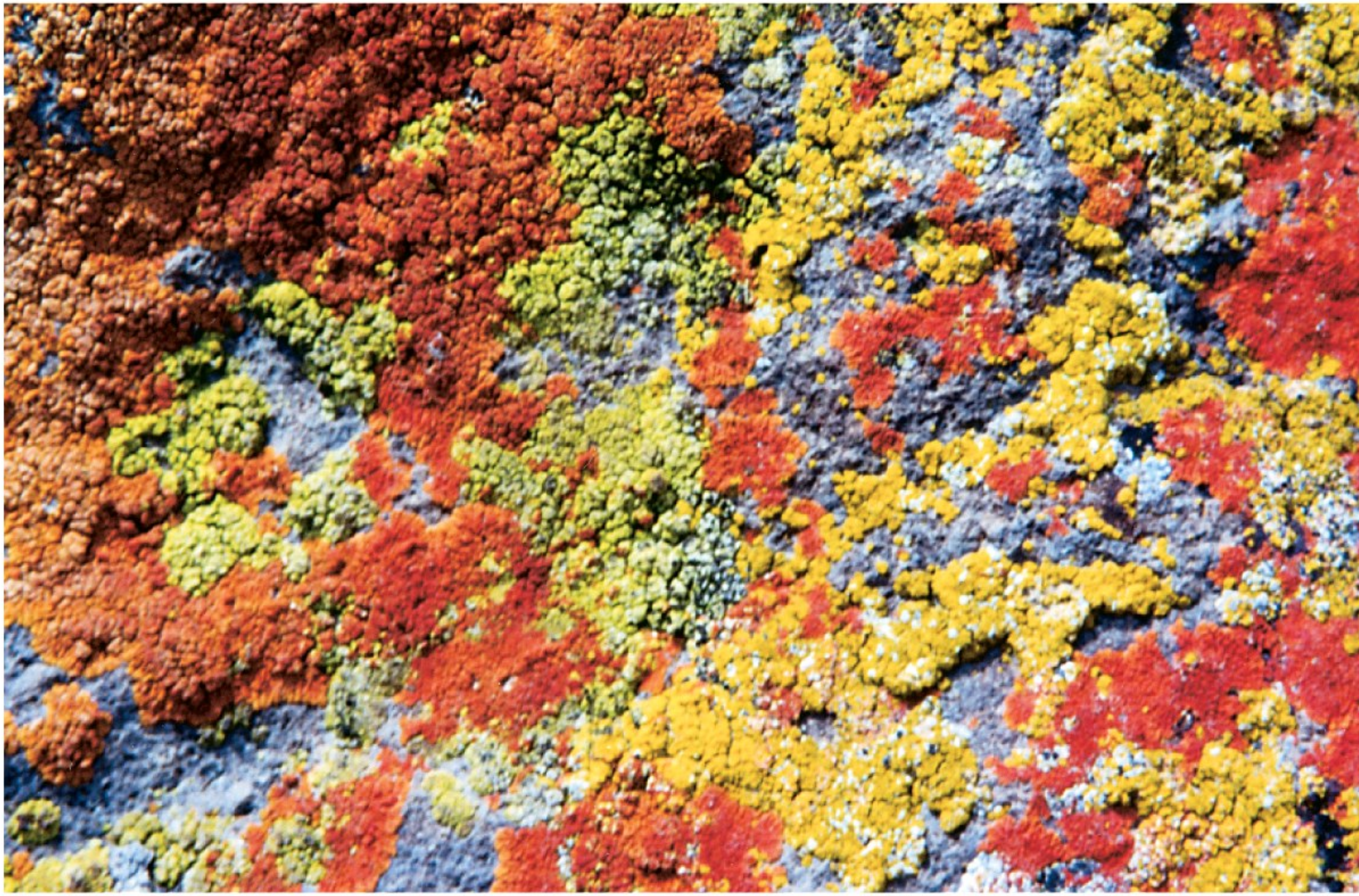
- Coevolution of parasites and hosts is intense
  - Example: the malaria parasite
    - Provided a strong selective pressure for humans to carry the defective hemoglobin gene that causes sickle-cell anemia
    - Sickle-cell anemia provides protection against malaria

Mutualism

- In **mutualism**, both the host and the “other” species benefit
  - Example: lichens, which are entities formed by fungi and algae living together
    - The algae provide the food by photosynthesis and the fungi provide protection

Mutualism

- In **mutualism**, both the host and the "other" species benefit
  - Example: clownfish and sea anemones
    - The fish obtain protection and anemones obtain protection, cleaning, and scraps of food



lichen

Figure 27-13a Biology: Life on Earth, 8/e

clownfish

Figure 27-13b Biology: Life on Earth, 8/e

Section 27.5 Outline

- **27.5 How Do Keystone Species Influence Community Structure?**

Keystone Species

- In some communities a **keystone species** plays a major role in determining community structure
- Role is out of proportion to its abundance
- Removal of keystone species dramatically alters community

Keystone Species

- Example: The predatory starfish *Pisaster* from Washington's rocky intertidal coast
  - When removed from their ecosystem their favored prey, mussels, increase and competitively exclude other invertebrates and algae, simplifying the community

Figure 27-14a Biology: Life on Earth, 8/e

Keystone Species

- Example: Destruction of encroaching shrubs and trees by African elephants
  - Helps maintain the grass savanna which supports many species

Figure 27-14b Biology: Life on Earth, 8/e

Keystone Species

- Keystone species need to be identified and protected so that human activities do not lead to the collapse of entire communities and ecosystems

Section 27.6 Outline

- **27.6 Succession: How Do Community Interactions Cause Change over Time?**
  - There Are Two Major Forms of Succession: Primary and Secondary
  - Succession Also Occurs in Ponds and Lakes
  - Succession Culminates in the Climax Community
  - Some Ecosystems Are Maintained in a Subclimax State

Succession

- Most communities do not emerge fully formed from bare rock or naked soil
  - Arise through **succession** by which they change structurally over time

Succession

- Succession is usually preceded by a **disturbance**
  - An event that disrupts the ecosystem either by altering the community, its abiotic structure, or both

Succession

- Succession is usually preceded by a **disturbance**
  - Examples: volcanic eruptions and forest fires that decimate existing ecosystems but leave behind nutrient-rich environments

Mt. Kilauea, Hawaii

Figure 27-15a Biology: Life on Earth, 8/e

Mt. St. Helens, Washington State

Figure 27-15b Biology: Life on Earth, 8/e

Yellowstone, Wyoming

Figure 27-15c Biology: Life on Earth, 8/e

Succession

- During succession, most terrestrial communities go through stages
  - Succession begins with arrival of a few hardy invaders called **pioneers**
    - They alter the ecosystem in ways that favor other species, which eventually displace the pioneers

Succession

- During succession, most terrestrial communities go through stages
  - Succession often progresses to a relatively stable and diverse **climax community**
  - Recurring disturbances can set back the progress of succession
    - Maintain communities in **subclimax stages**

Succession

- Succession takes two major forms
  - **Primary succession**
  - **Secondary succession**

Primary Succession

- **Primary succession** occurs "from scratch," where there is no trace of a previous community
  - May take thousands or even tens of thousands of years
  - Examples: succession starting on bare rock, sand, or in a clear glacial pool

Primary Succession

- Primary succession example: Isle Royale, Michigan

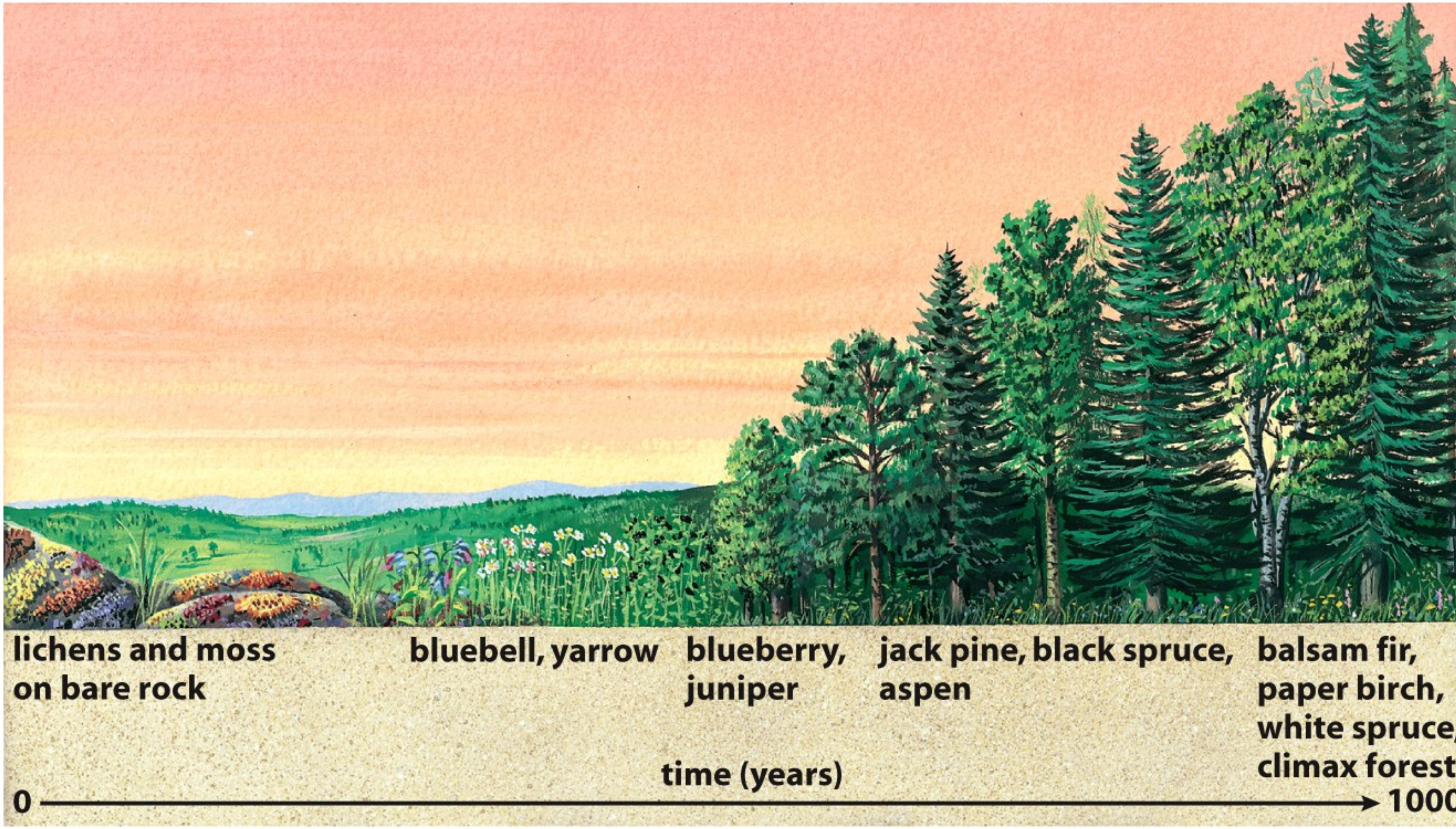


Figure 27-16 Biology: Life on Earth, 8/e

Secondary Succession

- **Secondary succession** occurs after a disturbance changes, but does not obliterate an existing community
  - Often takes just *hundreds of years*
  - Example: succession when a disturbance leaves behind soil and seeds

Secondary Succession

- Secondary succession example: an abandoned farm in the southeastern U.S.

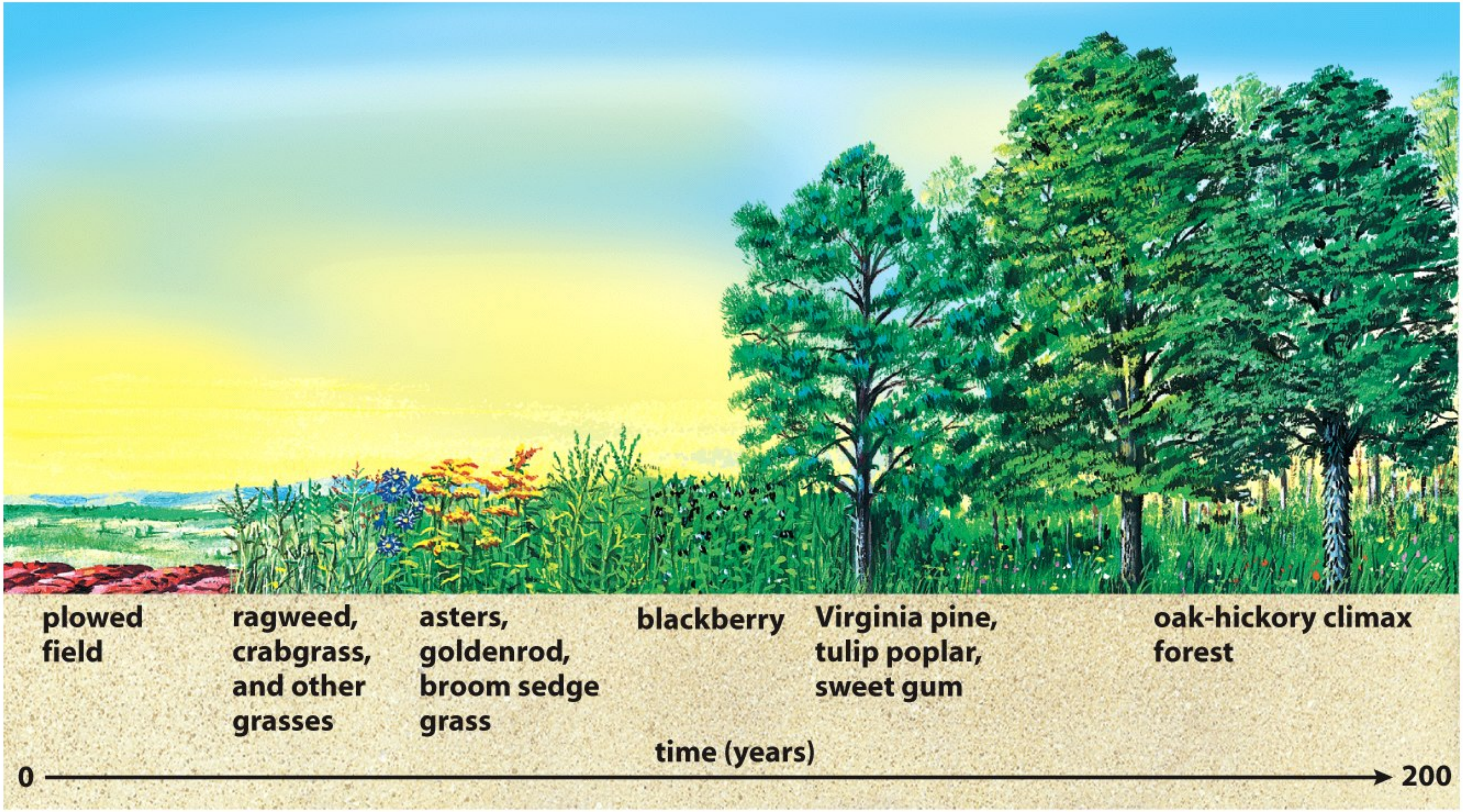


Figure 27-17 Biology: Life on Earth, 8/e

Succession in Ponds and Lakes

- Lakes and ponds form when a disturbance blocks the flow of a river or stream

Succession in Ponds and Lakes

- Nutrient influx, sediment deposition, and other aquatic processes can convert a body of water into a bog, then to a dry land community

(a)

(b)

Figure 27-18 Biology: Life on Earth, 8/e

Climax Community

- Unless disturbances intervene, succession usually ends with a relatively stable climax community

Climax Community

- Species in climax communities have narrower niches than pioneer species
  - Allows many species to coexist without replacing one another

Climax Community

- Climax species tend to be larger and longer-lived than pioneer species
- The exact nature of the climax community at a site reflects local geological and climatic conditions
  - Examples: type of bedrock, temperature, and rainfall

Climax Community

- A **biome** is a class of climax community that exists over a broad geographical range
  - Examples: desert, grassland, or deciduous forest

Subclimax State

- Frequent disturbances maintain subclimax communities in some ecosystems

Subclimax State

- Subclimax community example: Tallgrass prairies that once covered northern Missouri and Illinois
  - Periodic fires prevented forest from encroaching

Subclimax State

- Subclimax community example: Suburban lawns
  - Mowing and herbicides keep weeds and woody species in check

Subclimax State

- Subclimax community example: Agriculture
  – Plowing and pesticides keep competing weeds and shrubs from replacing early successional cereal grains