Biodiversity, Species Interactions, and Population Control

Chapter 5

Core Case Study: Southern Sea Otters: Are They Back from the Brink of Extinction?

- Habitat
- Hunted: early 1900s
- Partial recovery
- Why care about sea otters?
    - Ethics
    - Keystone species
    - Tourism dollars

Southern Sea Otter

5-1 How Do Species Interact?

- ***Concept 5-1*** *Five types of species interactions—competition, predation, parasitism, mutualism, and commensalism—affect the resource use and population sizes of the species in an ecosystem.*

Most Consumer Species Feed on Live Organisms of Other Species (1)

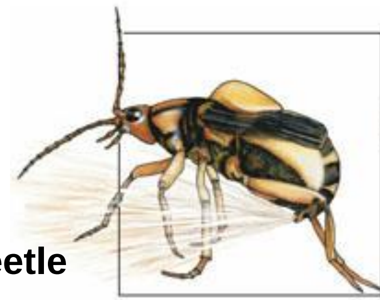
- **Predators** may capture prey by
  - Walking
  - Swimming
  - Flying
  - Pursuit and ambush
  - Camouflage
  - Chemical warfare

Most Consumer Species Feed on Live Organisms of Other Species (2)

- **Prey** may avoid capture by
  - Camouflage
  - Chemical warfare
  - Warning coloration
  - Mimicry
  - Deceptive looks
  - Deceptive behavior

(a) Span worm

(b) Wandering leaf insect



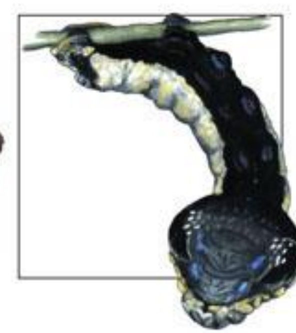
(c) Bombardier beetle

(d) Foul-tasting monarch butterfly

(e) Poison dart frog

(f) Viceroy butterfly mimics monarch butterfly

(g) Hind wings of Io moth resemble eyes of a much larger animal.



(h) When touched, snake caterpillar changes shape to look like head of snake.

Fig. 5-2, p. 103

Predator and Prey Species Can Drive Each Other's Evolution

- Intense natural selection pressures between predator and prey populations
- **Coevolution**

Coevolution: A Langohrfledermaus Bat Hunting a Moth

Some Species Feed off Other Species by Living on or in Them

- **Parasitism**

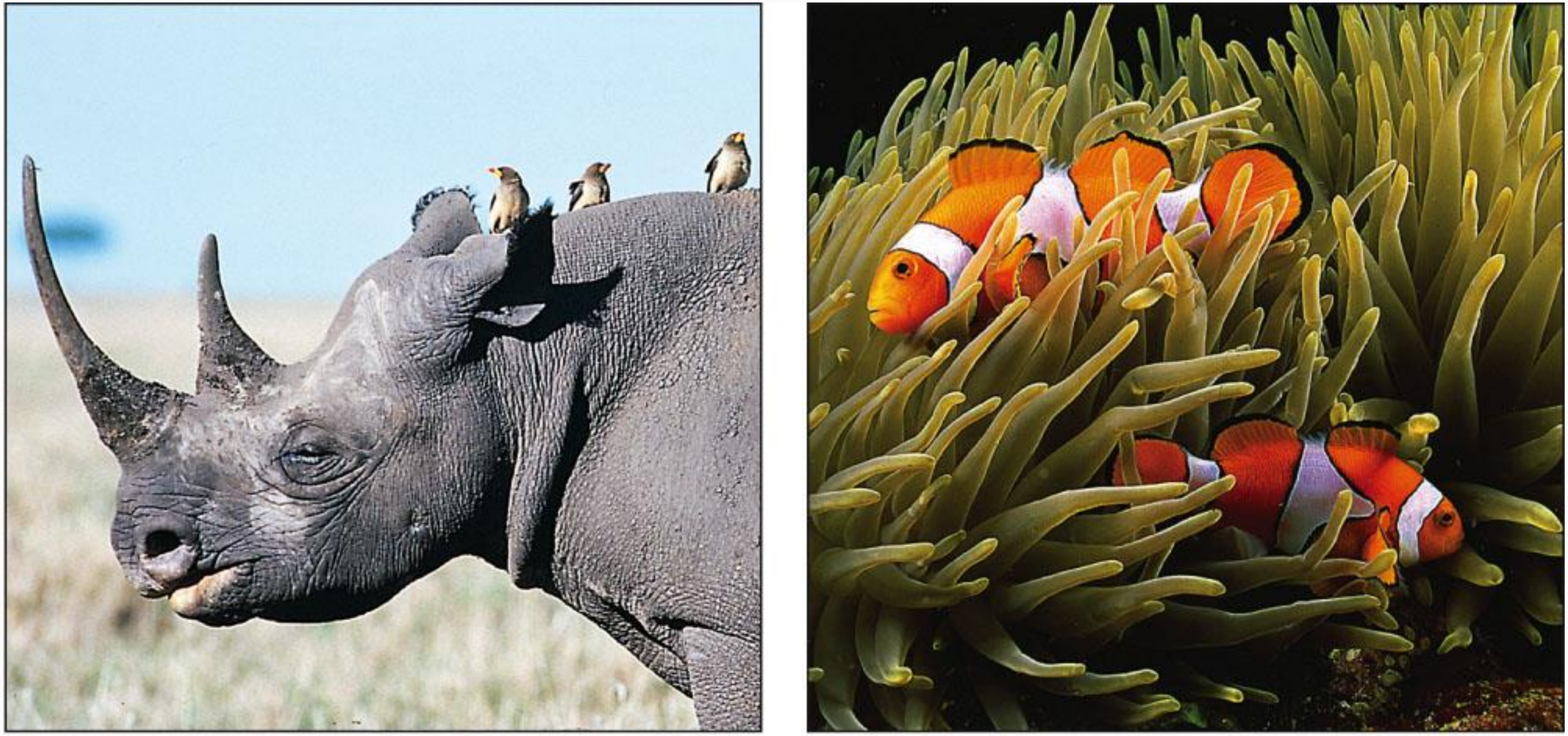
- Parasite-host interaction may lead to coevolution

Parasitism: Tree with Parasitic Mistletoe, Trout with Blood-Sucking Sea Lampreys

In Some Interactions, Both Species Benefit

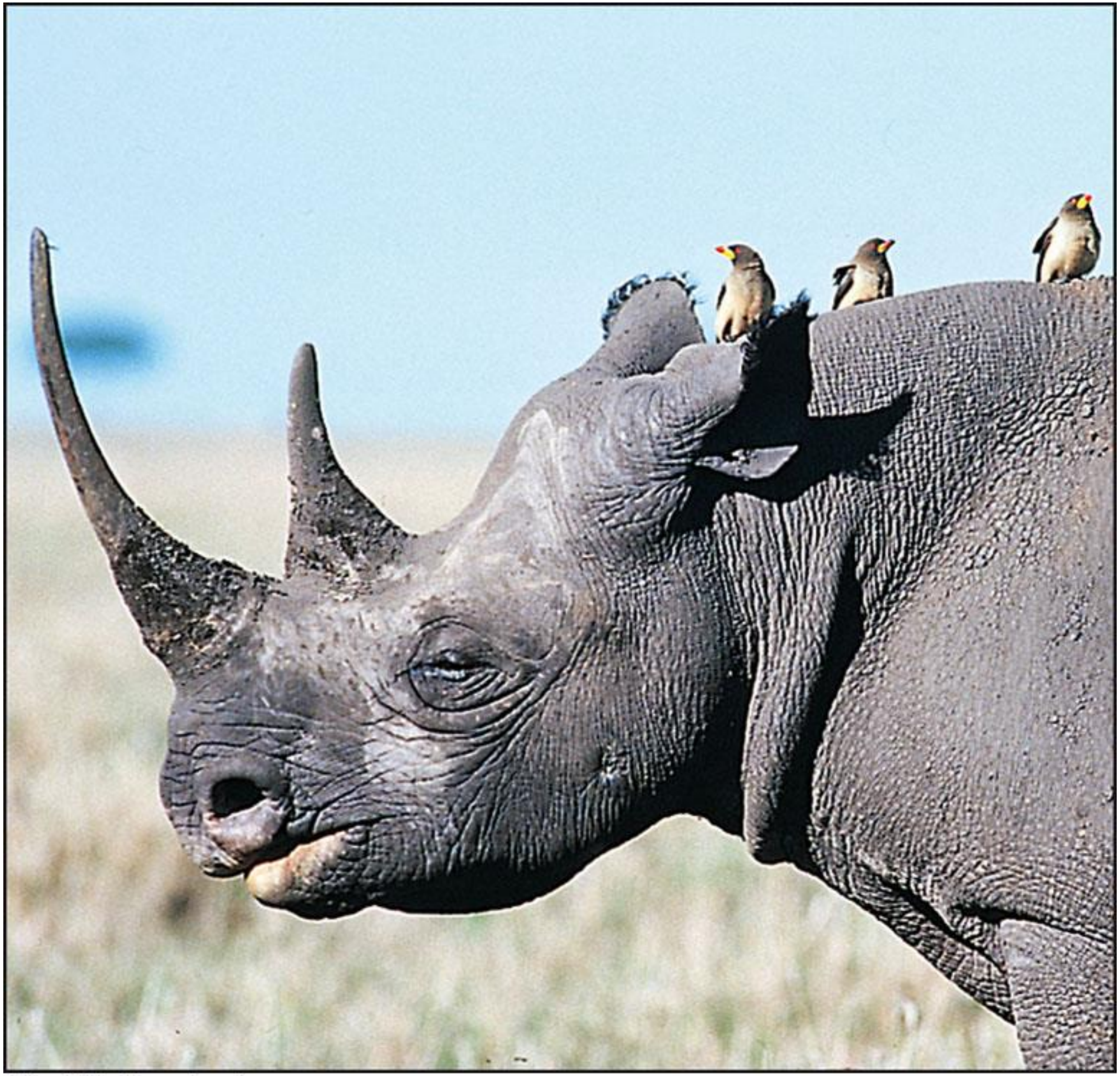
- **Mutualism**
- Nutrition and protection relationship
- Gut inhabitant mutualism

Mutualism: Oxpeckers Clean Rhinoceros; Anemones Protect and Feed Clownfish



(a) Oxpeckers and black rhinoceros

(b) Clownfish and sea anemone



(a) Oxpeckers and black rhinoceros

Fig. 5-5a, p. 106

(b) Clownfish and sea anemone

Fig. 5-5b, p. 106

In Some Interactions, One Species Benefits and the Other Is Not Harmed

- **Commensalism**
- Epiphytes
- Birds nesting in trees

Commensalism: Bromiliad Roots on Tree Trunk Without Harming Tree

Species Interactions

Or, An analogy for high school relationships.

Basic types of Species interaction

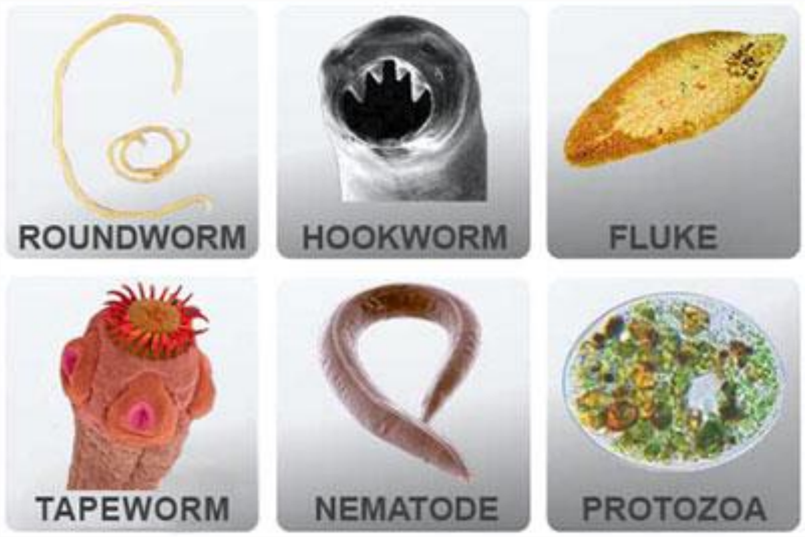
- Predation
- Parasitism
- Mutualism
- Commensalism
- Interspecific Competition
- Allelopathy

Predation

- **When a member of one species (the predator) feeds directly on all or part of a member of another species (the prey)**

Parasitism

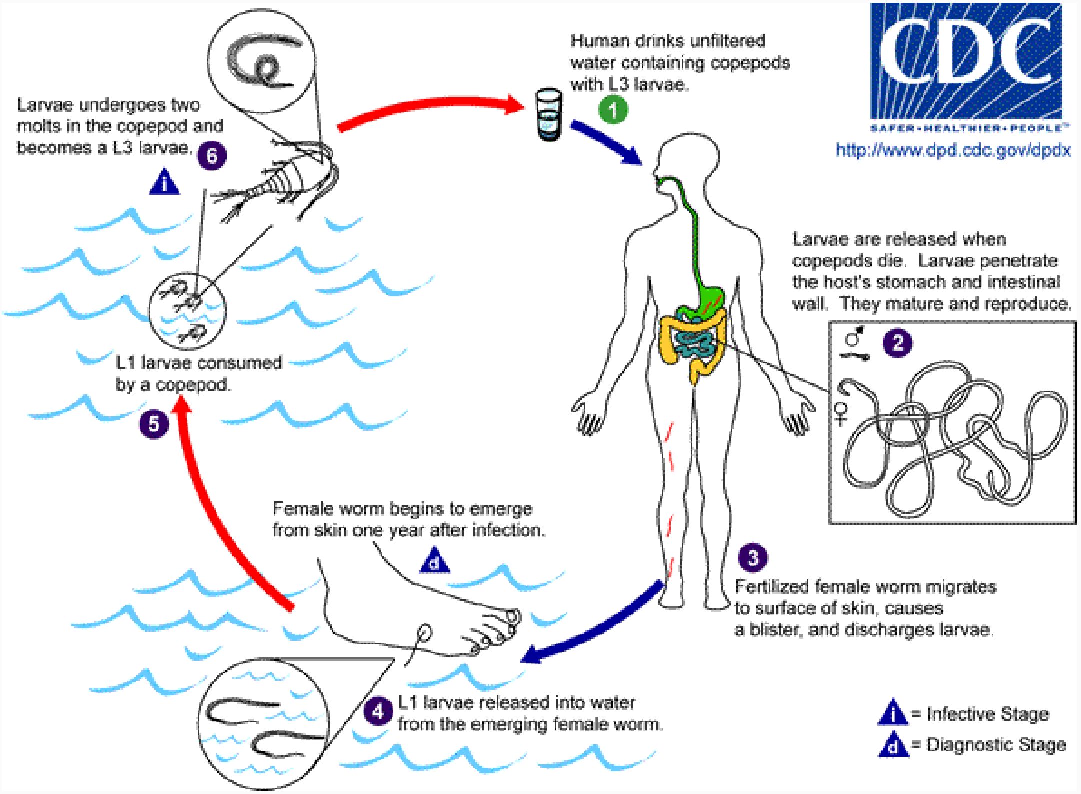
- **When one organism (the parasite) feeds on the body of, or the energy used by, another organism (the host), usually by living on or in the host.**



Look away. Bot Fly picture coming…

Oh dear, look away. Guinea Worm picture coming…

Drink Clean Water



Mutualism

- **An interaction that benefits both species by providing each with food, shelter, or some other resource.**

Commensalism

- An association between two organisms in which one benefits and the other derives neither benefit nor harm.

Interspecific Competition

- **When members of two or more species interact to gain access to the same limited resources (food, light, space)**

Allelopathy

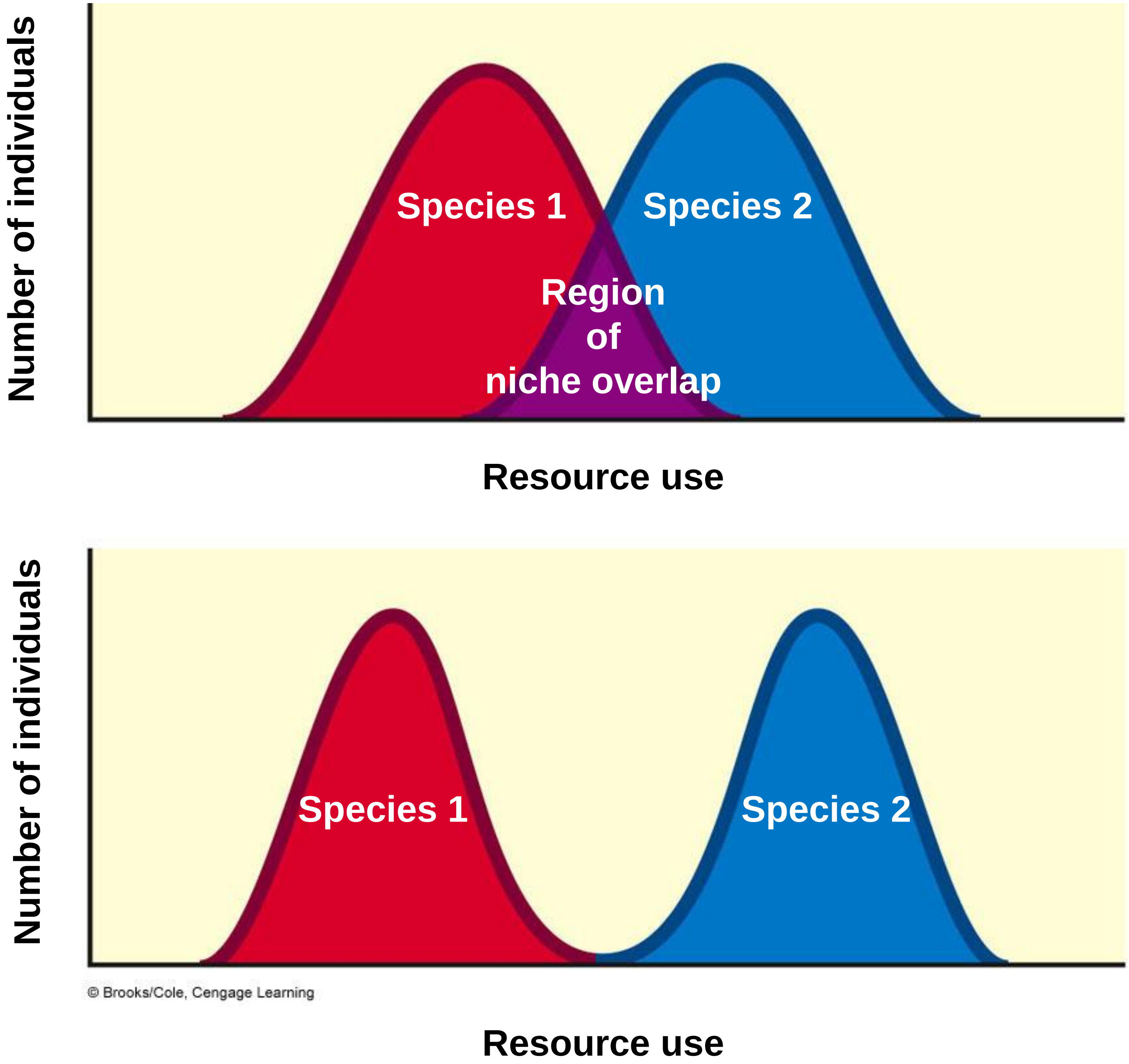
- **A biological phenomenon by which an organism produces one or more biochemicals that influence the growth, survival, and reproduction of other organisms.**

5-2 How Can Natural Selection Reduce Competition between Species?

- ***Concept 5-2*** *Some species develop adaptations that allow them to reduce or avoid competition with other species for resources.*

Some Species Evolve Ways to Share Resources

- **Resource partitioning**
- Reduce niche overlap
- Use shared resources at different
  - Times
  - Places
  - Ways



Number of individuals
Species 1
Species 2
Region
of
niche overlap
Resource use
Number of individuals
Species 1
Species 2
Resource use

Fig. 5-7, p. 107

Sharing the Wealth: Resource Partitioning

5-3 What Limits the Growth of Populations?

- ***Concept 5-3*** *No population can continue to grow indefinitely because of limitations on resources and because of competition among species for those resources.*

Populations Have Certain Characteristics (1)

- Populations differ in
  - Distribution
  - Numbers
  - Age structure

- **Population dynamics – The study of how populations change in response to environmental changes.**

Populations Have Certain Characteristics (2)

- Changes in population characteristics due to:
  - Temperature
  - Presence of disease organisms or harmful chemicals
  - Resource availability
  - Arrival or disappearance of competing species

Most Populations Live Together in Clumps or Patches (1)

- Population distribution
  - Clumping
  - Uniform dispersion
  - Random dispersion

Most Populations Live Together in Clumps or Patches (2)

- Why clumping?
  - Species tend to cluster where resources are available
  - Groups have a better chance of finding clumped resources
  - Protects some animals from predators
  - Packs allow some to get prey
  - Temporary groups for mating and caring for young

Populations Can Grow, Shrink, or Remain Stable (1)

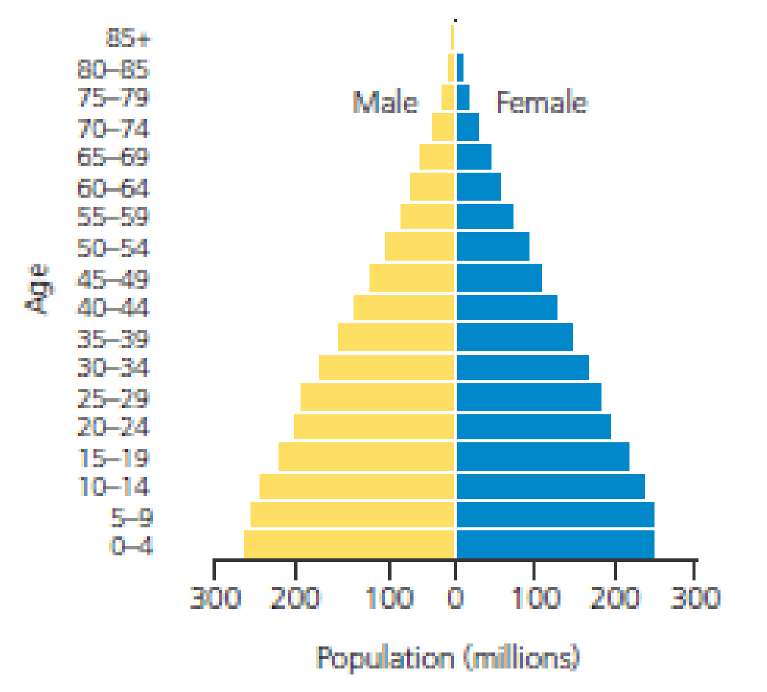
- Population size governed by
  - Births
  - Deaths
  - Immigration
  - Emigration

- Population change =

  (births + immigration) – (deaths + emigration)

Populations Can Grow, Shrink, or Remain Stable (2)

- Age structure
  - Pre-reproductive age
  - Reproductive age
  - Post-reproductive age



No Population Can Grow Indefinitely: J-Curves and S-Curves (1)

- Biotic potential
  - Low
  - High

- **Intrinsic rate of increase (r)**

- Individuals in populations with high **r**
  - Reproduce early in life
  - Have short generation times
  - Can reproduce many times
  - Have many offspring each time they reproduce

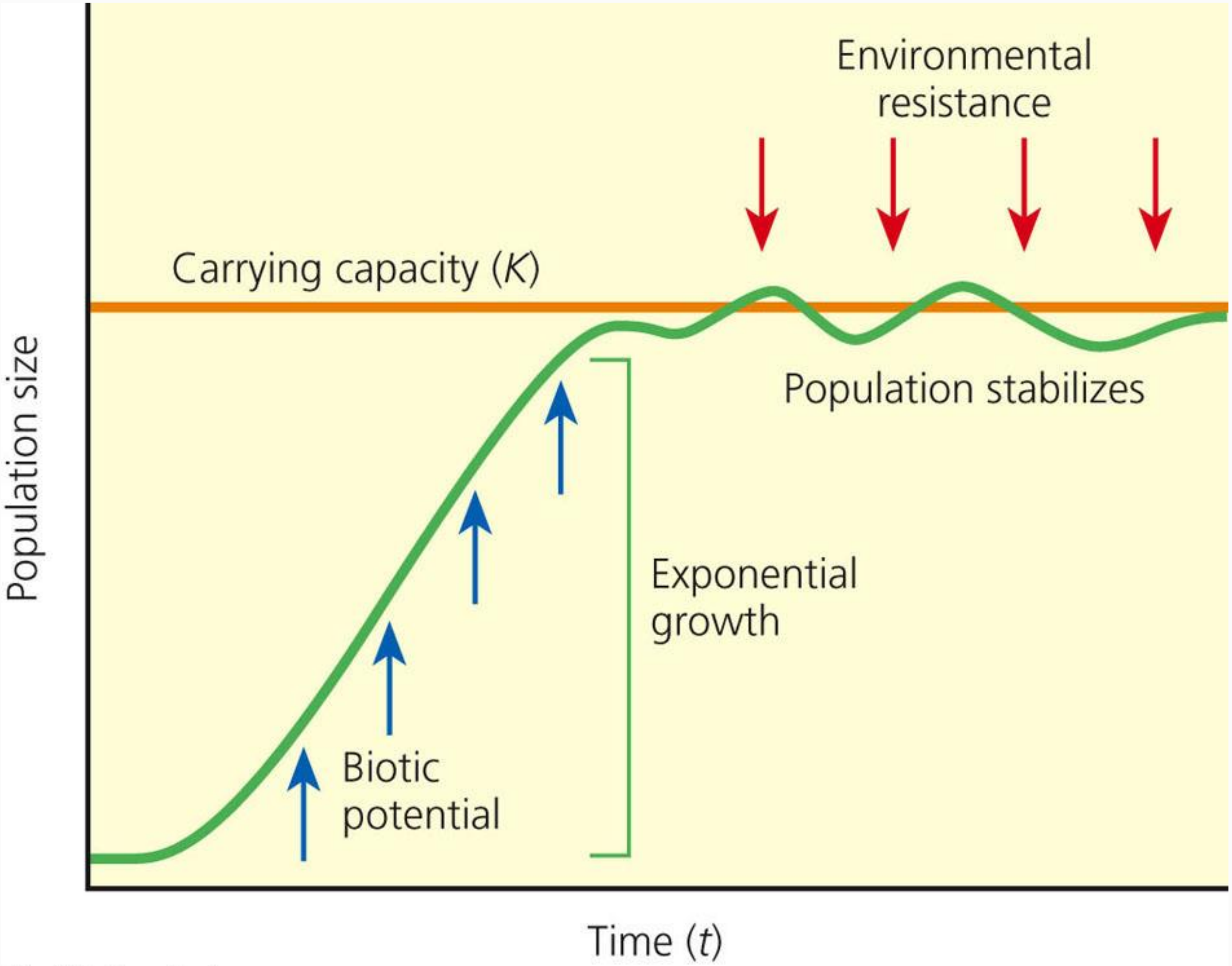
No Population Can Grow Indefinitely: J-Curves and S-Curves (2)

- Size of populations limited by
  - Light
  - Water
  - Space
  - Nutrients
  - Exposure to too many competitors, predators or infectious diseases

No Population Can Grow Indefinitely: J-Curves and S-Curves (3)

- **Environmental resistance – Combination of factors that limit population growth.**
- **Carrying capacity (K) – Maximum population a habitat can support.**
- **Exponential growth – Indefinite population growth.**
- **Logistic growth – Growth rate drops as environmental resistance increases.**

No Population Can Continue to Increase in Size Indefinitely



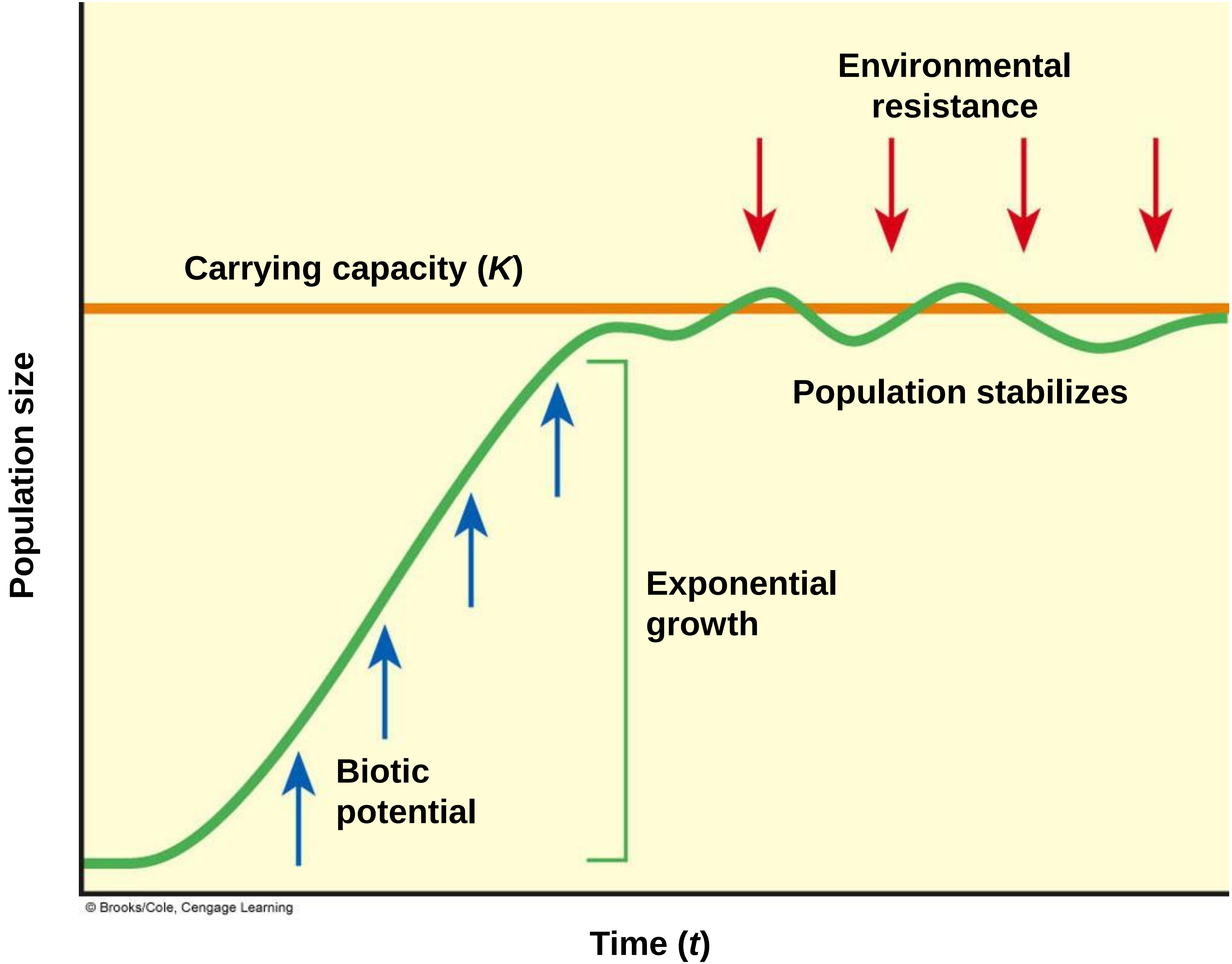
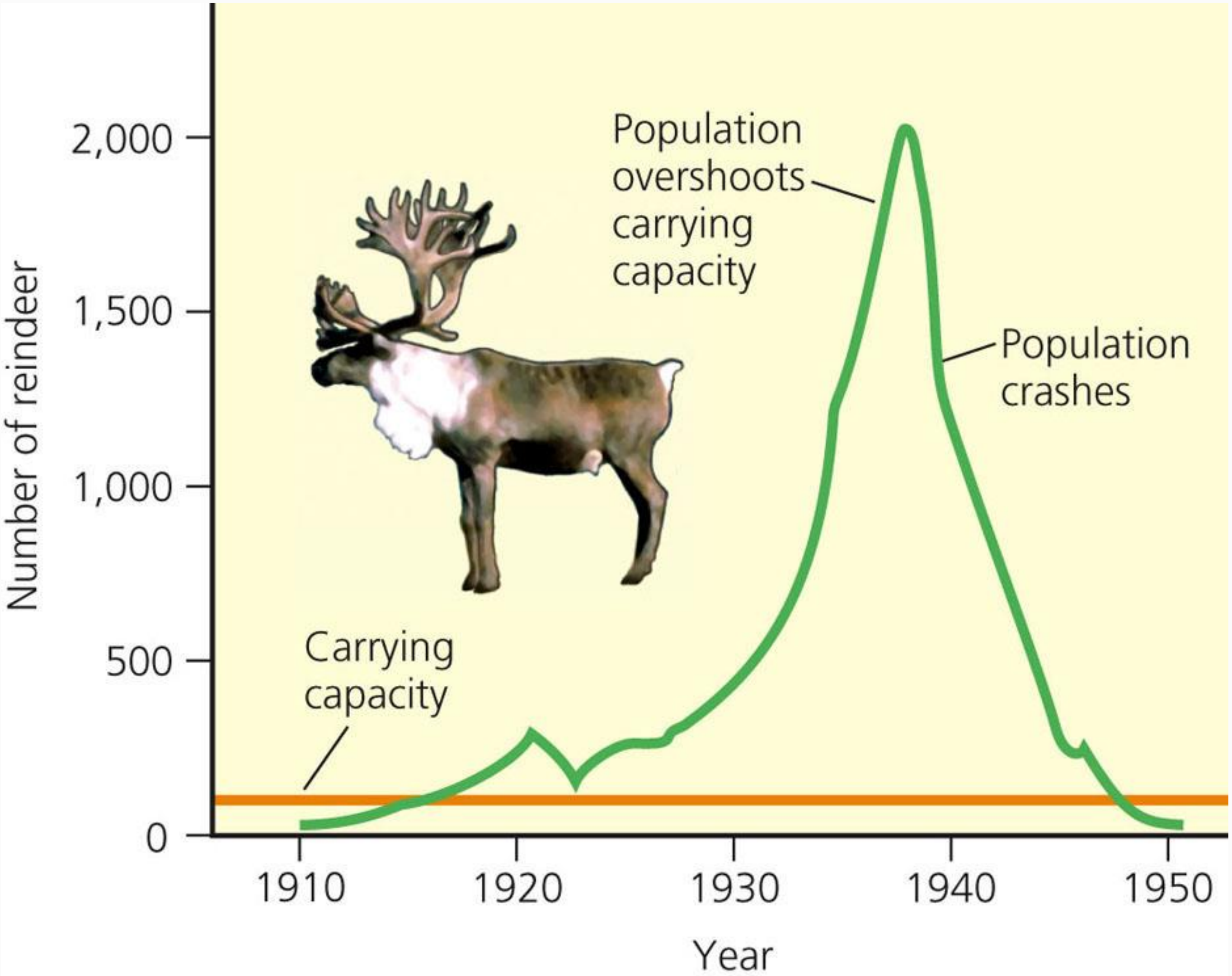

Environmental resistance
Carrying capacity (K)
Population stabilizes
Exponential growth
Biotic potential
Population size
Time (t)

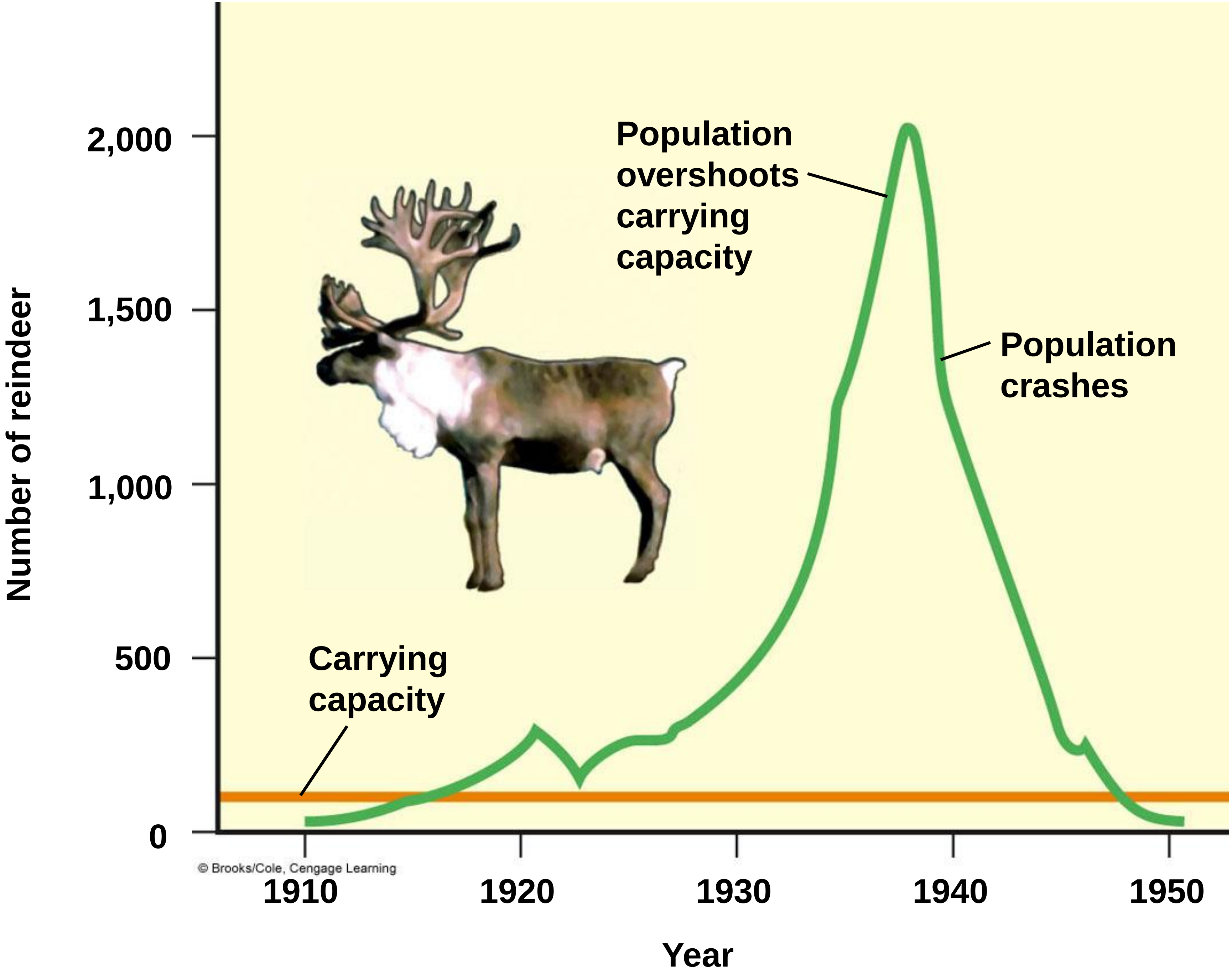
Fig. 5-11, p. 111

When a Population Exceeds Its Habitat's Carrying Capacity, Its Population Can Crash

- Carrying capacity: not fixed
- **Reproductive time lag** may lead to **overshoot**
  - **Dieback (crash)**
- Damage may reduce area's carrying capacity

Exponential Growth, Overshoot, and Population Crash of a Reindeer





Number of reindeer
2,000
1,500
1,000
500
0
Population
overshoots
carrying
capacity
Population
crashes
Carrying
capacity
1910
1920
1930
1940
1950
Year

Fig. 5-13, p. 112

Species Have Different Reproductive Patterns

- **r-Selected species, opportunists**
  - **Many, small offspring, very little parental care/protection.**

- **K-selected species, competitors**
  - **Reproduce later in life, small number of offspring with long lifespans, more parental care/protection.**

Genetic Diversity Can Affect the Size of Small Populations

- **Founder effect – A few individuals colonize a new, geo-isolated habitat.**

- **Demographic bottleneck – Only a few individuals survive a catastrophe.**
-
- **Genetic drift – Lack of genetic diversity leading to one "set" of genes dominating the population.**

Genetic Diversity Can Affect the Size of Small Populations

- **Inbreeding – Related individuals mating with one another.**
- **Minimum viable population size – The number of individuals a population needs to survive long-term.**

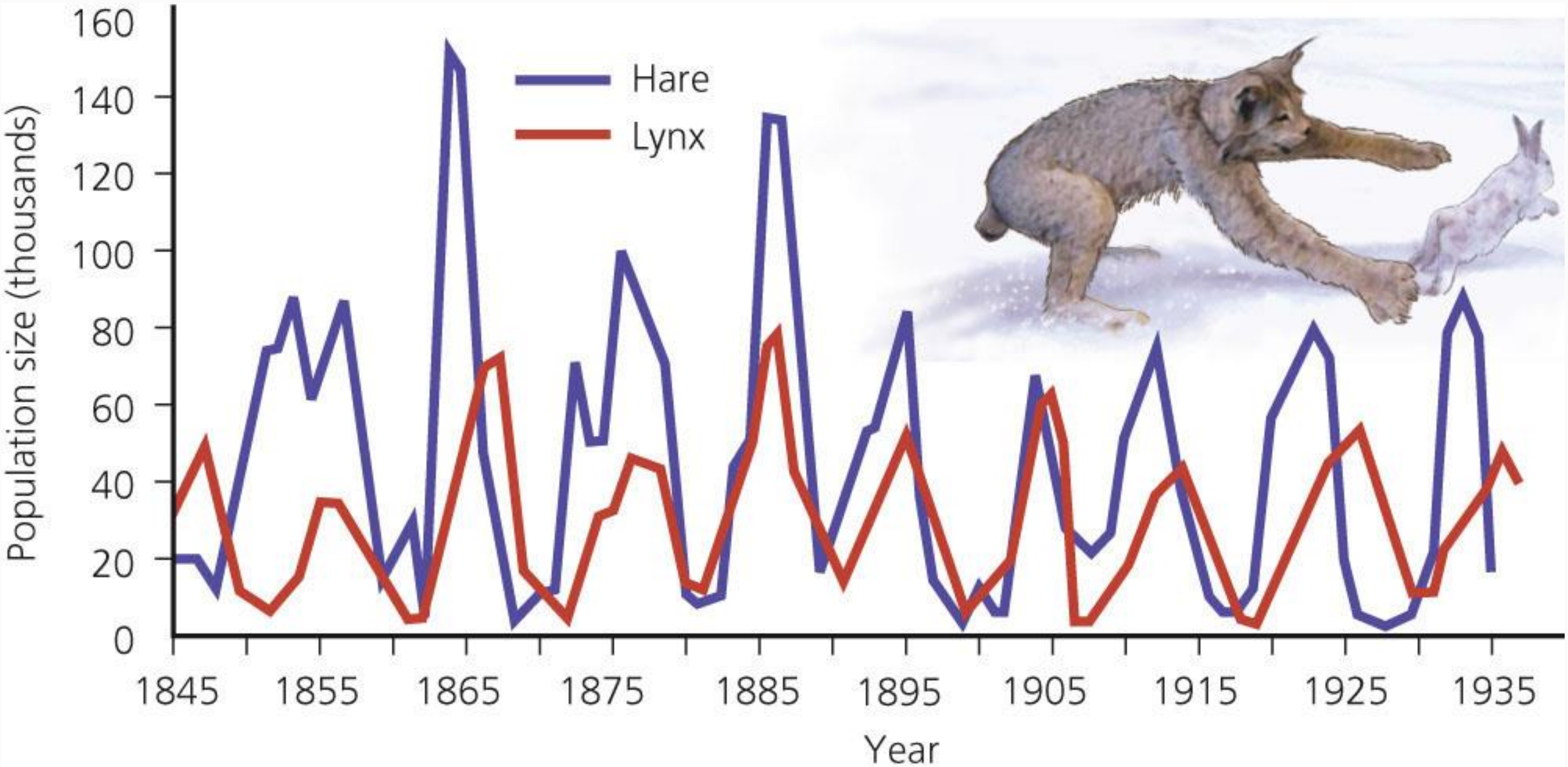
Under Some Circumstances Population Density Affects Population Size

- **Density-dependent population controls**
  - Predation
  - Parasitism
  - Infectious disease
  - Competition for resources

Several Different Types of Population Change Occur in Nature

- **Stable**
- **Irruptive**
- **Cyclic fluctuations, boom-and-bust cycles**
  - Top-down population regulation
  - Bottom-up population regulation
- **Irregular**

Population Cycles for the Snowshoe Hare and Canada Lynx



Humans Are Not Exempt from Nature's Population Controls

- Ireland
  - Potato crop in 1845
- Bubonic plague
  - Fourteenth century
- AIDS
  - Global epidemic

5-4 How Do Communities and Ecosystems Respond to Changing Environmental Conditions?

- ***Concept 5-4*** *The structure and species composition of communities and ecosystems change in response to changing environmental conditions through a process called ecological succession.*

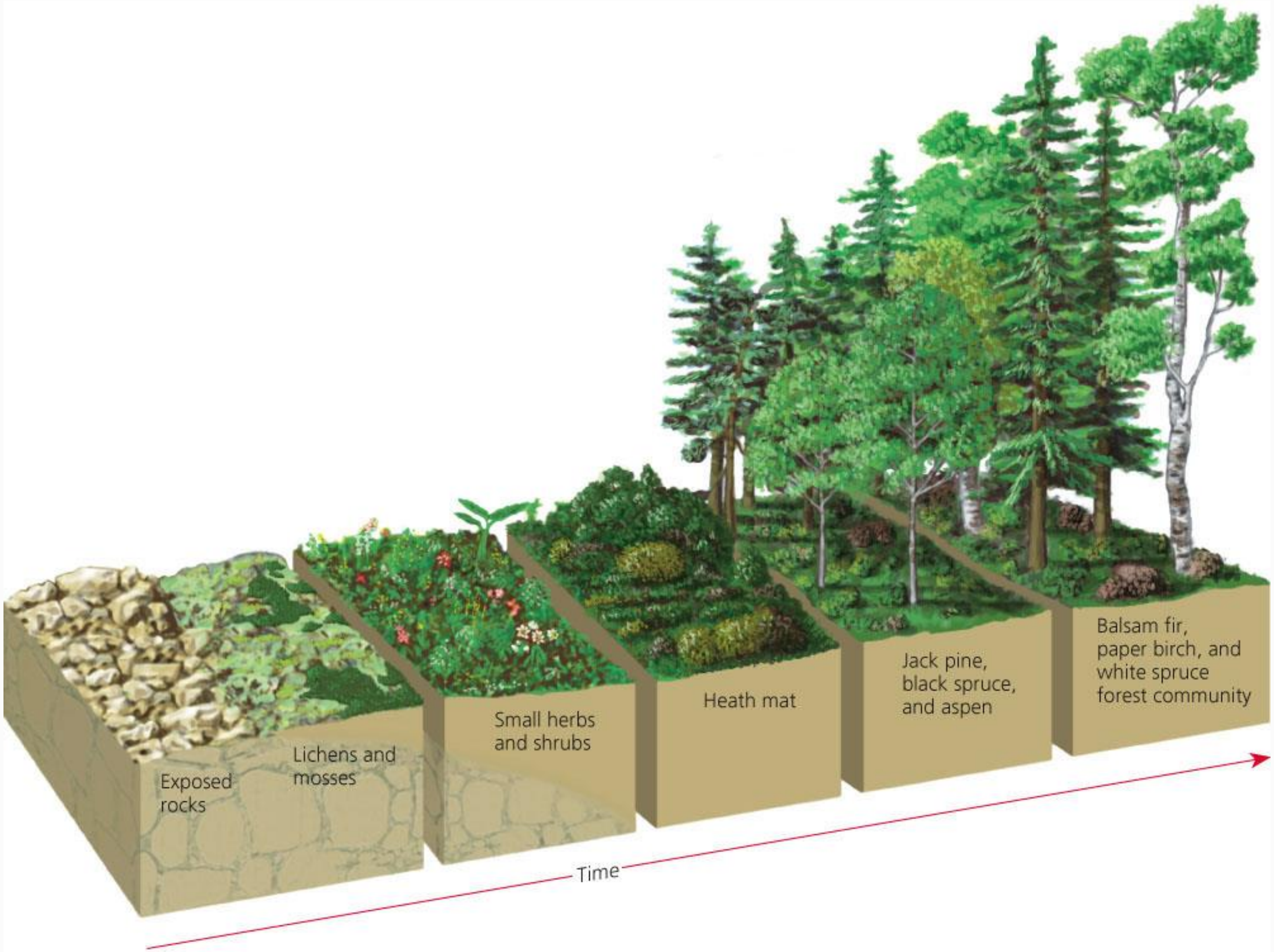
Communities and Ecosystems Change over Time: Ecological Succession

- **Natural ecological restoration**
  - **Primary succession**
  - **Secondary succession**

Some Ecosystems Start from Scratch: Primary Succession

- No soil in a terrestrial system
- No bottom sediment in an aquatic system
- **Early successional plant species, pioneer**
- **Midsuccessional plant species**
- **Late successional plant species**

Primary Ecological Succession



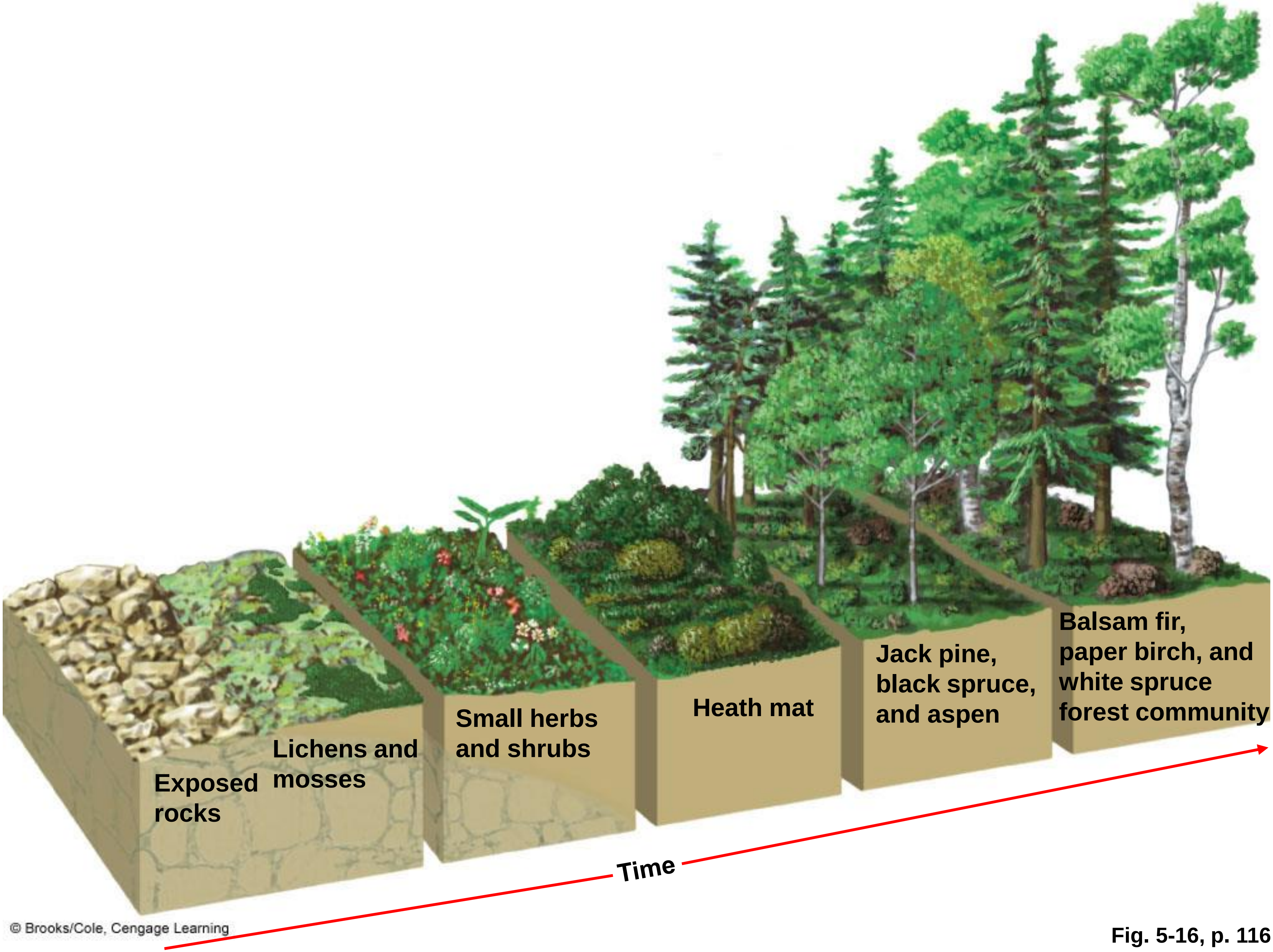
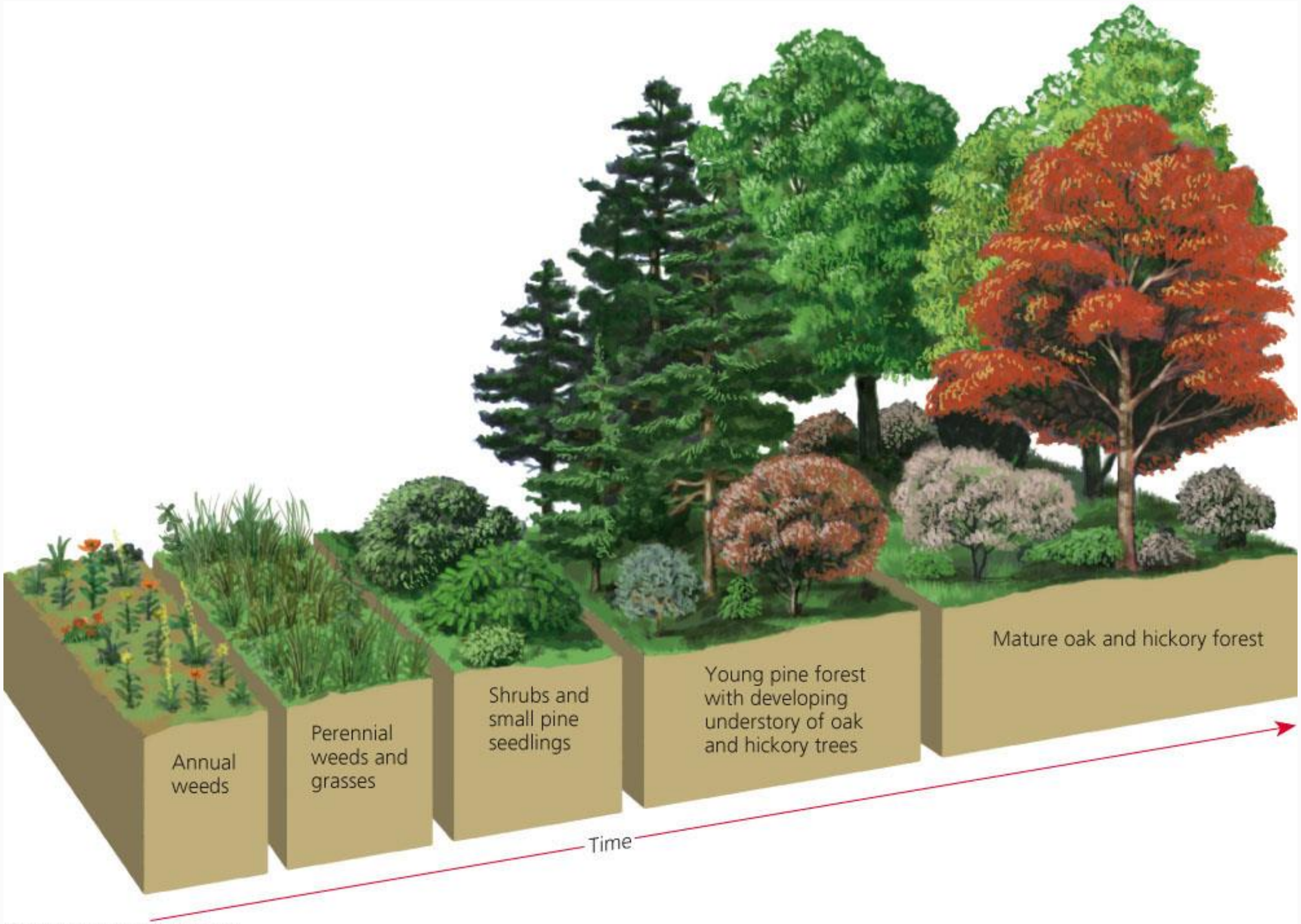

Exposed rocks
Lichens and mosses
Small herbs and shrubs
Heath mat
Jack pine, black spruce, and aspen
Balsam fir, paper birch, and white spruce forest community
Time

Fig. 5-16, p. 116

Some Ecosystems Do Not Have to Start from Scratch: Secondary Succession (1)

- Some soil remains in a terrestrial system
- Some bottom sediment remains in an aquatic system
- Ecosystem has been
  - Disturbed
  - Removed
  - Destroyed

Natural Ecological Restoration of Disturbed Land



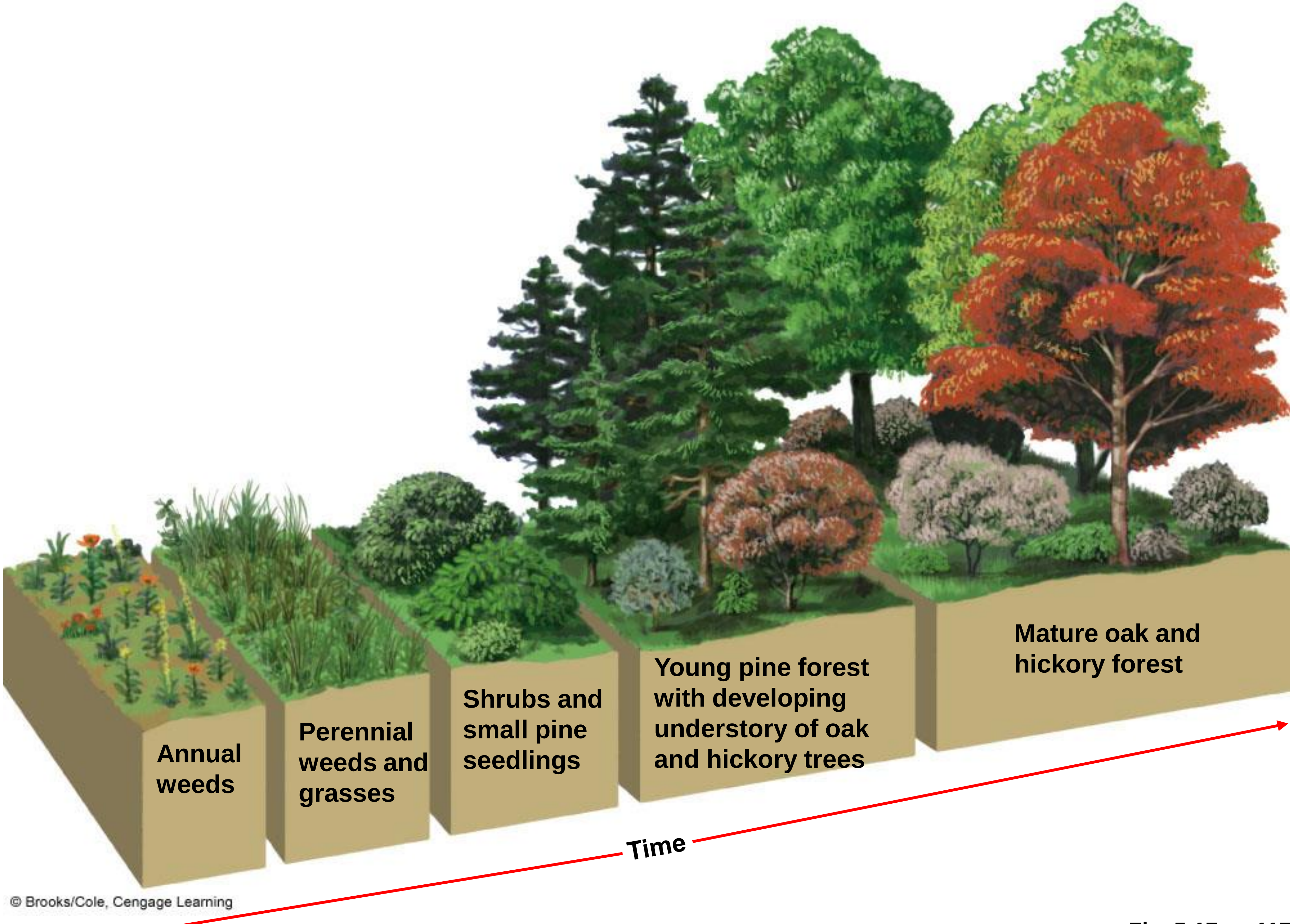

Annual weeds
Perennial weeds and grasses
Shrubs and small pine seedlings
Young pine forest with developing understory of oak and hickory trees
Mature oak and hickory forest
Time

Fig. 5-17, p. 117

Some Ecosystems Do Not Have to Start from Scratch: Secondary Succession (2)

- Primary and secondary succession
  - Tend to increase biodiversity
  - Increase species richness and interactions among species

- Primary and secondary succession can be interrupted by
  - Fires
  - Hurricanes
  - Clear-cutting of forests
  - Plowing of grasslands
  - Invasion by nonnative species

Succession Doesn't Follow a Predictable Path

- Traditional view
  - Balance of nature and a climax community
- Current view
  - Ever-changing mosaic of patches of vegetation
  - Mature late-successional ecosystems
    - State of continual disturbance and change

Living Systems Are Sustained through Constant Change

- **Inertia, persistence**
  - Ability of a living system to survive moderate disturbances
- **Resilience**
  - Ability of a living system to be restored through secondary succession after a moderate disturbance
- **Tipping point**