ENVIRONMENTAL SCIENCE 13e

CHAPTER 5: Biodiversity, Species Interactions, and Population Control

Core Case Study: Endangered Southern Sea Otter (1)

- Santa Cruz to Santa Barbara shallow coast
- Live in kelp forests
- Eat shellfish
- ~16,000 around 1900
- Hunted for fur and because considered competition for abalone and shellfish

Core Case Study: Endangered Southern Sea Otter (2)

- 1938-2008: increase from 50 to ~2760
- 1977: declared an endangered species
- Why should we care?
  1. Cute and cuddly – tourists love them
  2. Ethics – it's wrong to hunt a species to extinction
  3. Keystone species – eat other species that would destroy kelp forests

Fig. 5-1, p. 79

Fig. 5-1, p. 79

5-1 How Do Species Interact?

- ***Concept 5-1*** *Five types of species interactions affect the resource use and population sizes of the species in an ecosystem.*

Species Interact in 5 Major Ways

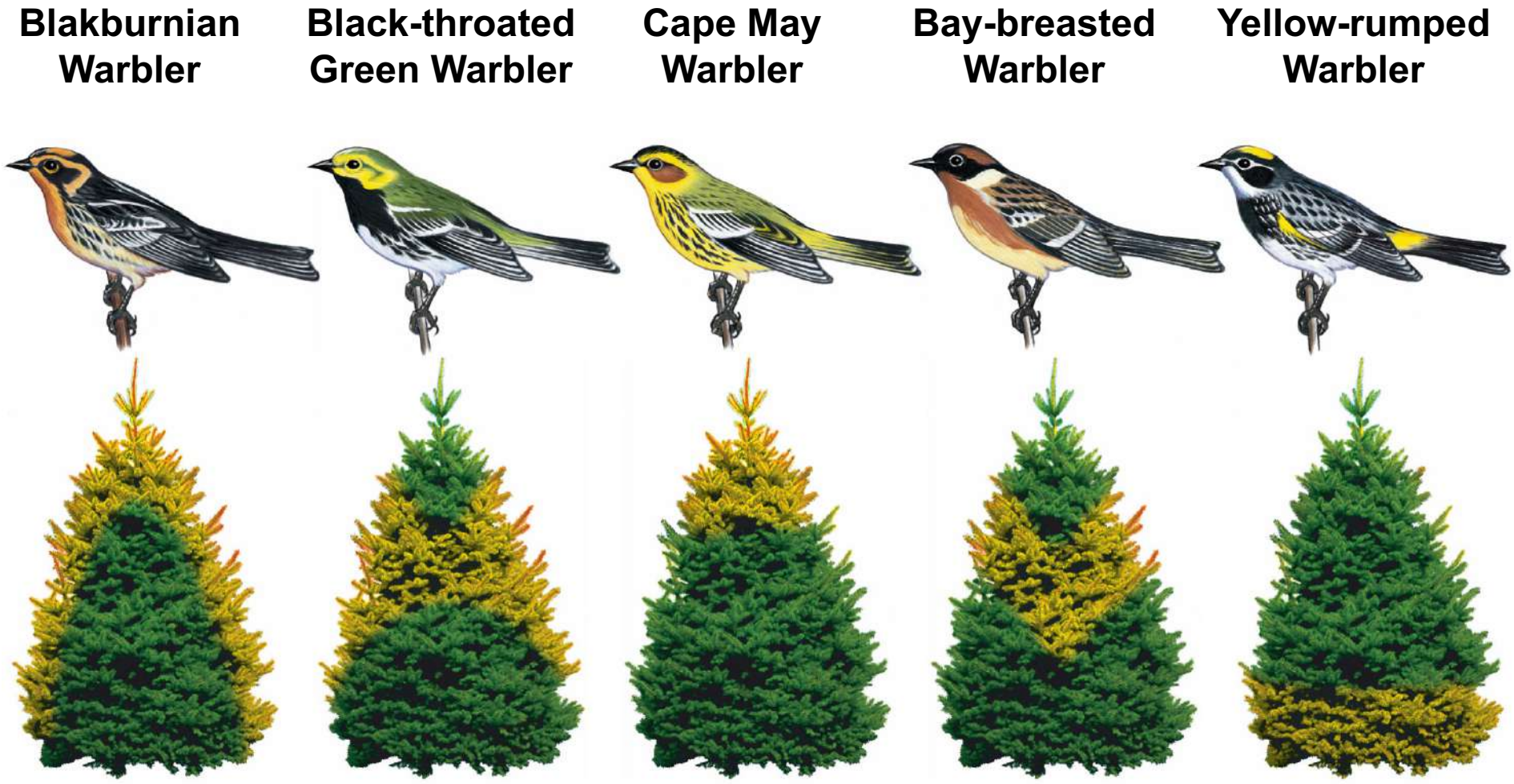
- **Interspecific competition**
- **Predation**
- **Parasitism**
- **Mutualism**
- **Commensalism**

Interspecific Competition

- No two species can share vital limited resources for long
- Resolved by:
  - Migration
  - Shift in feeding habits or behavior
  - Population drop
  - Extinction
- Intense competition leads to **resource partitioning**


Blackburnian Warbler
Black-throated Green Warbler
Cape May Warbler
Bay-breasted Warbler
Yellow-rumped Warbler

Fig. 5-2, p. 81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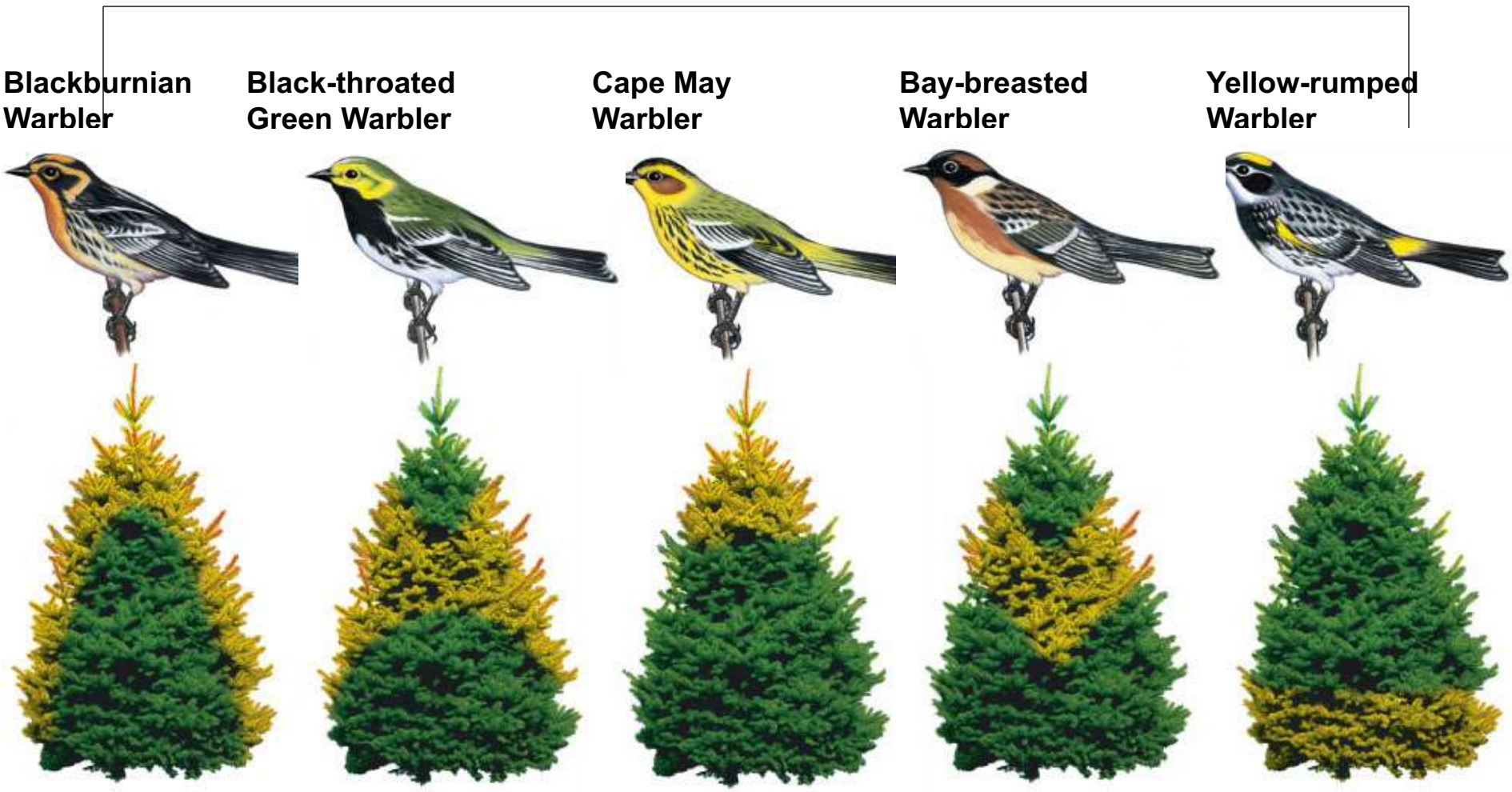

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Fig. 5-2, p. 81

Predation (1)

- **Predator** strategies
  - Herbivores can move to plants
  - Carnivores
    - Pursuit
    - Ambush
  - Camouflage
  - Chemical warfare

Science Focus: Sea Urchins Threaten Kelp Forests (1)

- Kelp forests
  - Can grow two feet per day
  - Require cool water
  - Host many species – high biodiversity
  - Fight beach erosion
  - Algin

Science Focus: Sea Urchins Threaten Kelp Forests (2)

- Kelp forests threatened by
  - Sea urchins
  - Pollution
  - Rising ocean temperatures
- Southern sea otters eat urchins
  - Keystone species

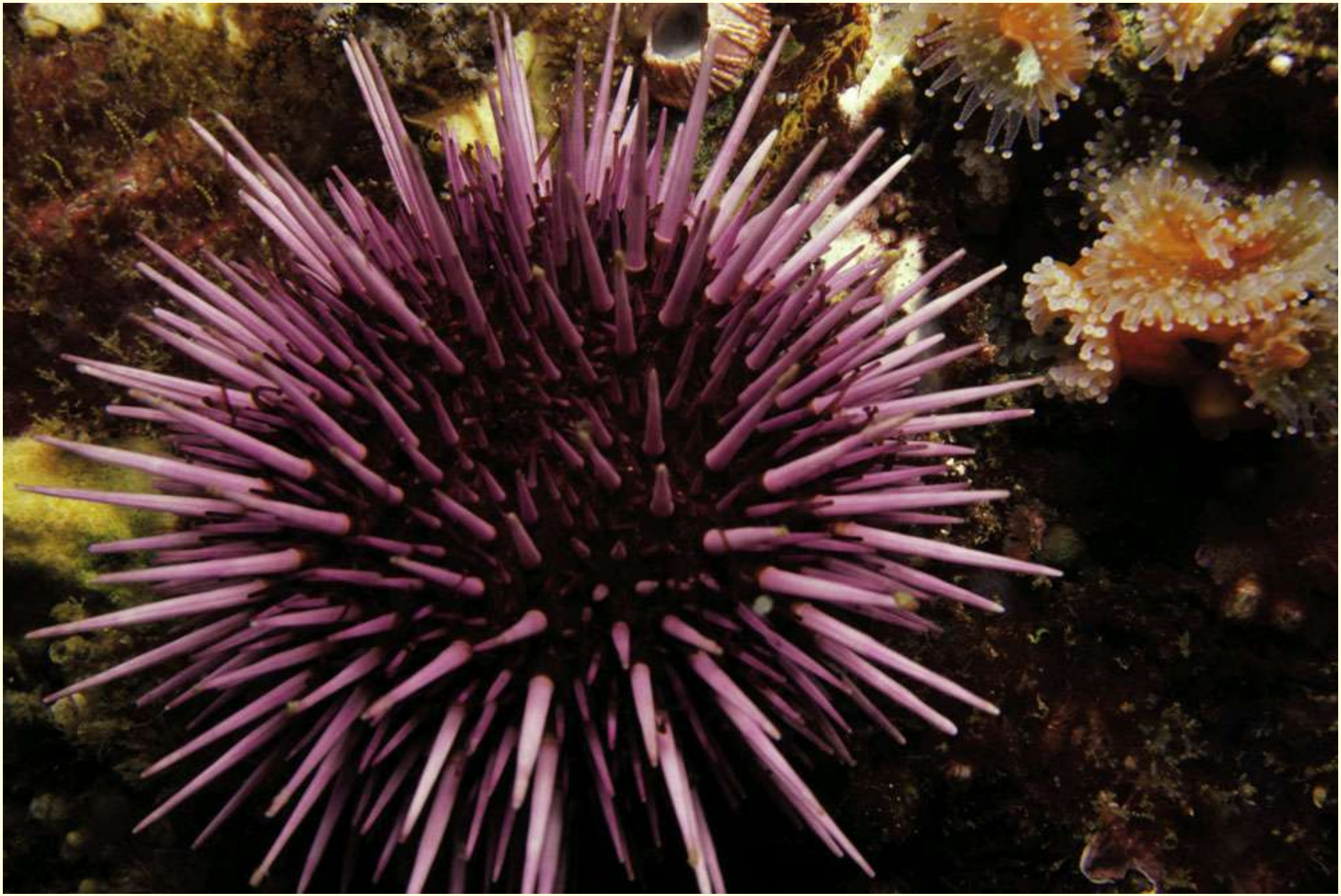


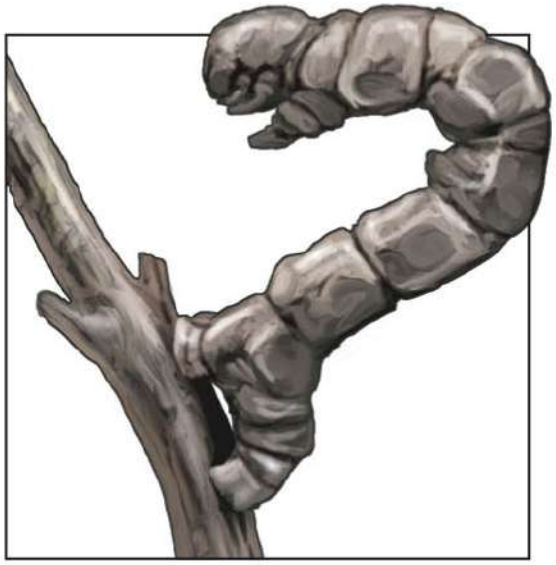
Fig. 5-A, p. 82

Predation (2)

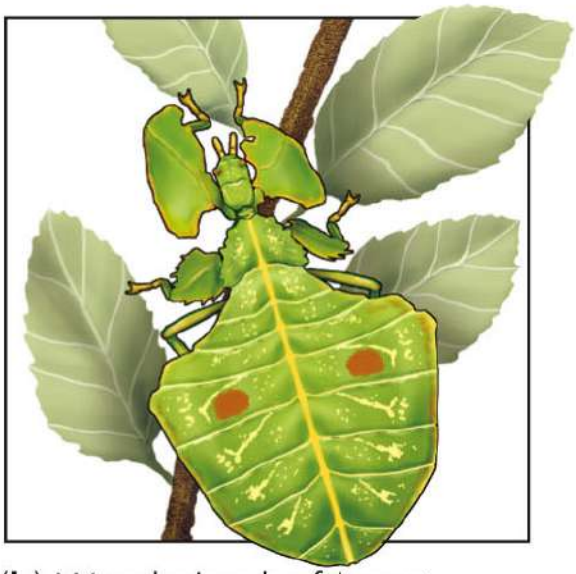
- **Prey** strategies
  - Evasion
  - Alertness – highly developed senses
  - Protection – shells, bark, spines, thorns
  - Camouflage

Predation (3)

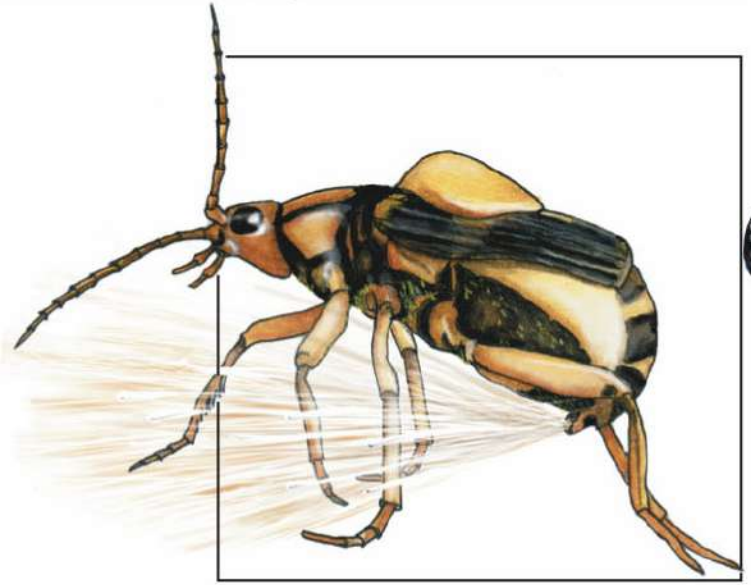
- **Prey** strategies, continued
  - Mimicry
  - Chemical warfare
  - Warning coloration
  - Behavioral strategies – puffing up



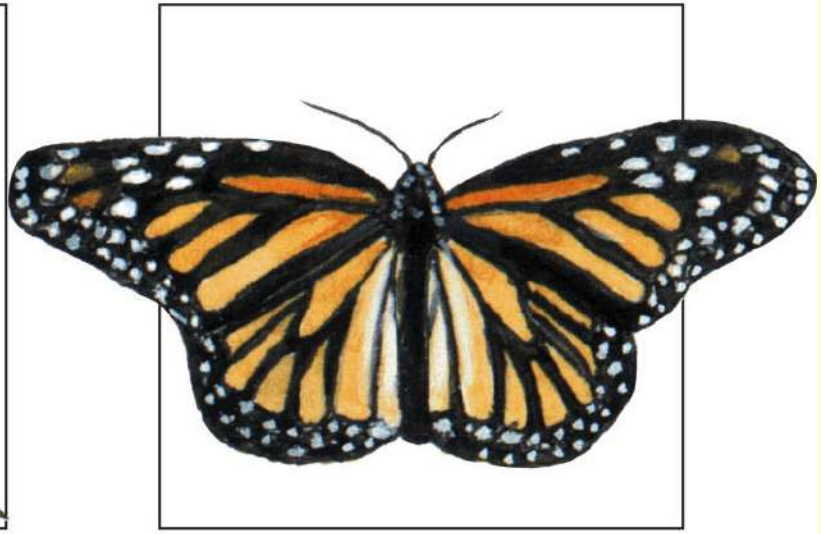
(**a**) Span worm



(**b**) Wandering leaf insect

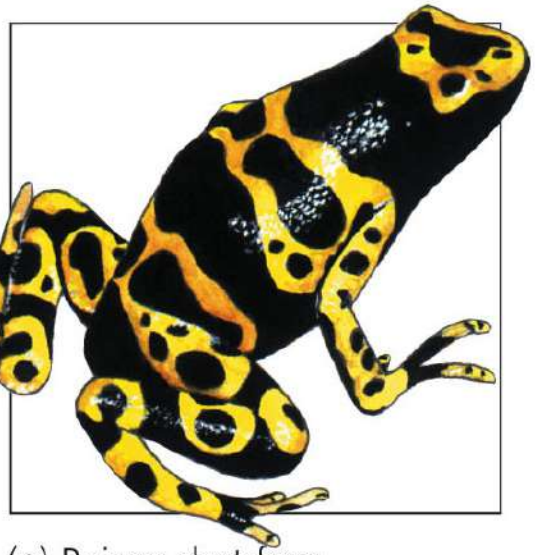


(**c**) Bombardier beetle



(**d**) Foul-tasting monarch butterfly

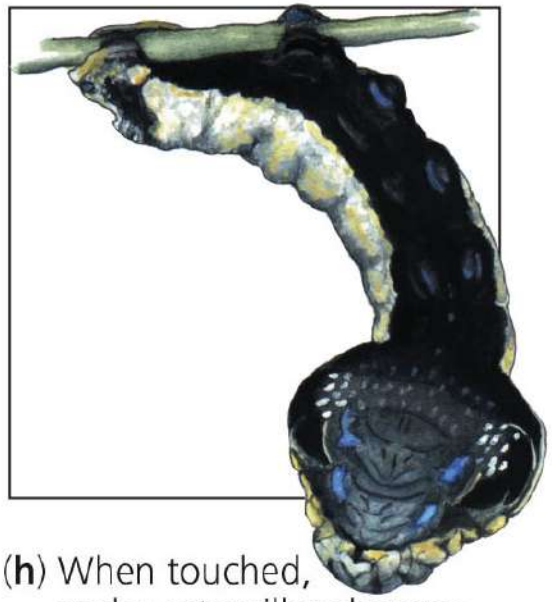
Fig. 5-3, p. 83



(**e**) Poison dart frog

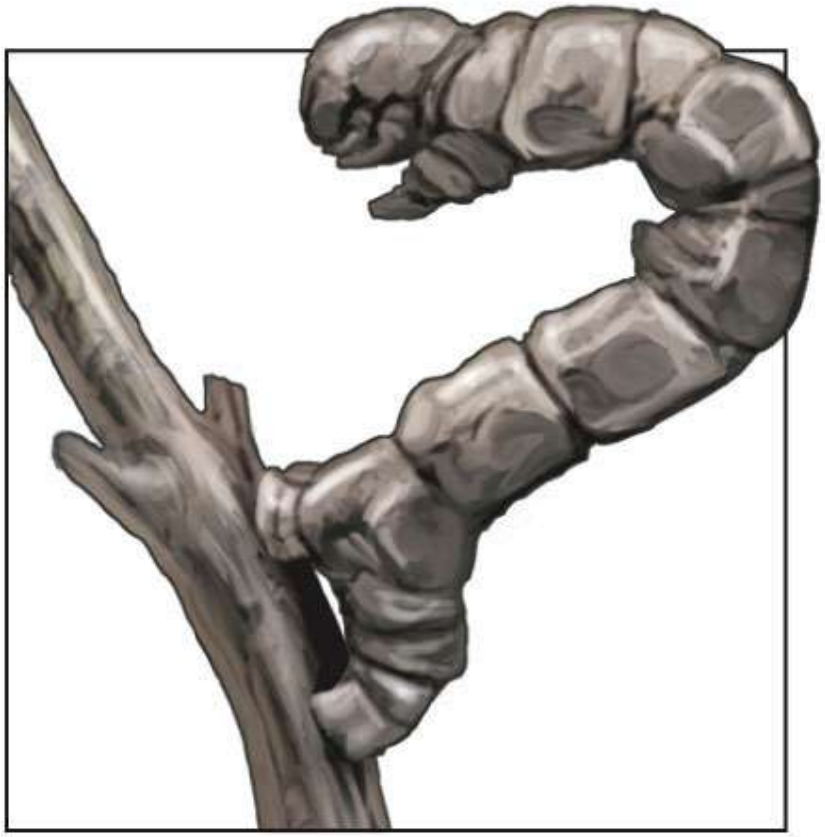
(**f**) Viceroy butterfly mimics monarch butterfly

(**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. 5-3, p. 83



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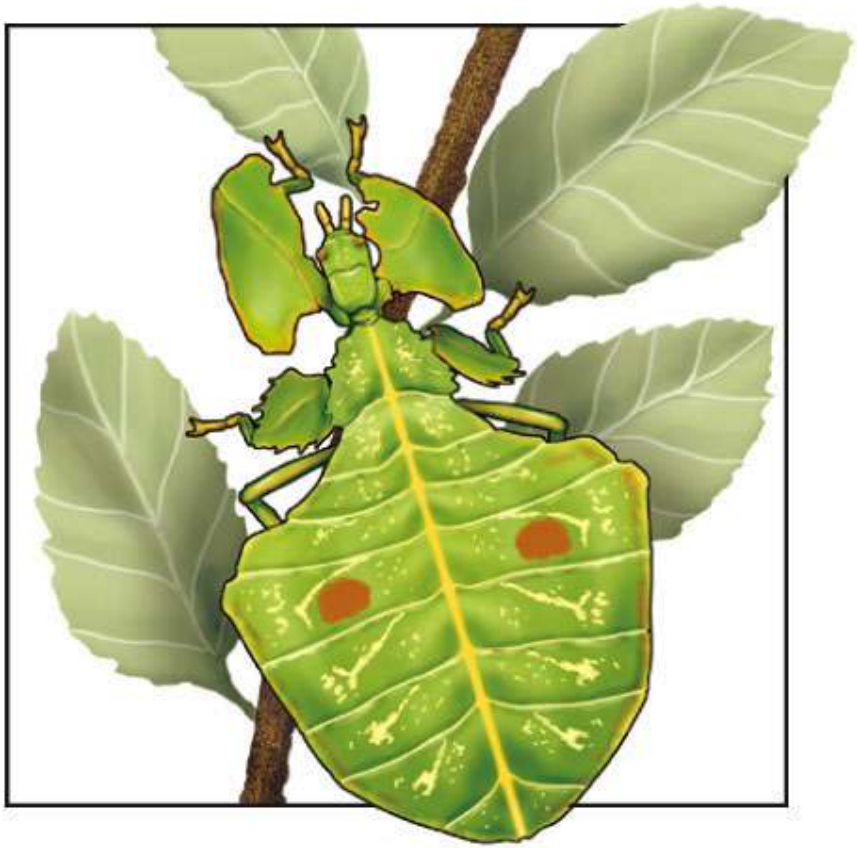

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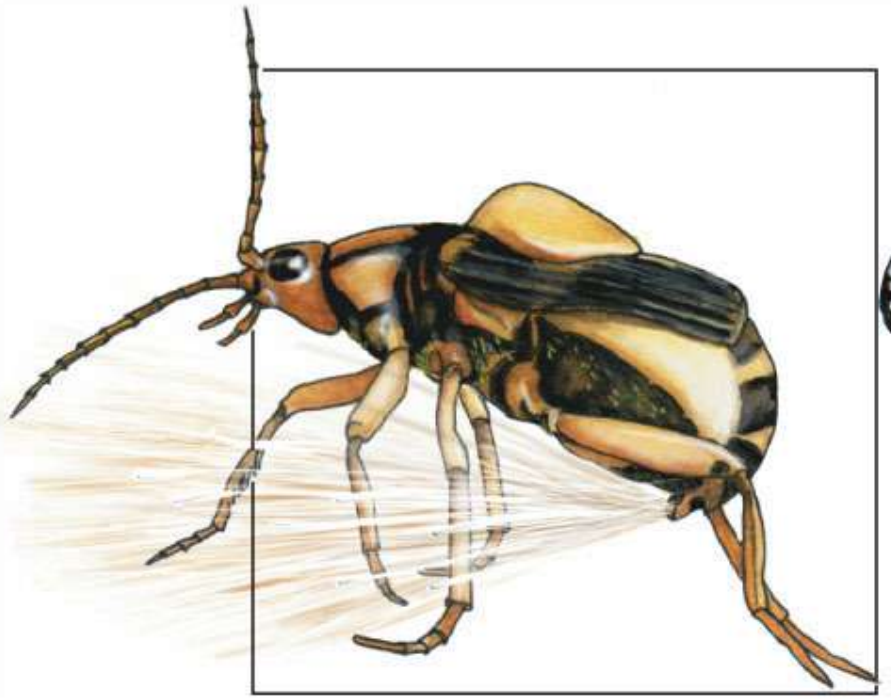

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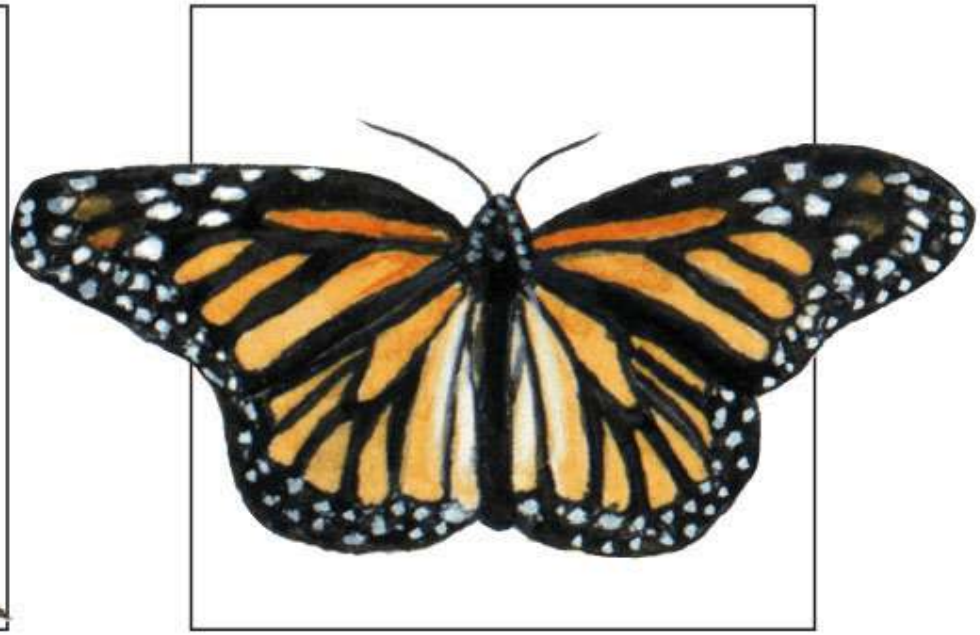

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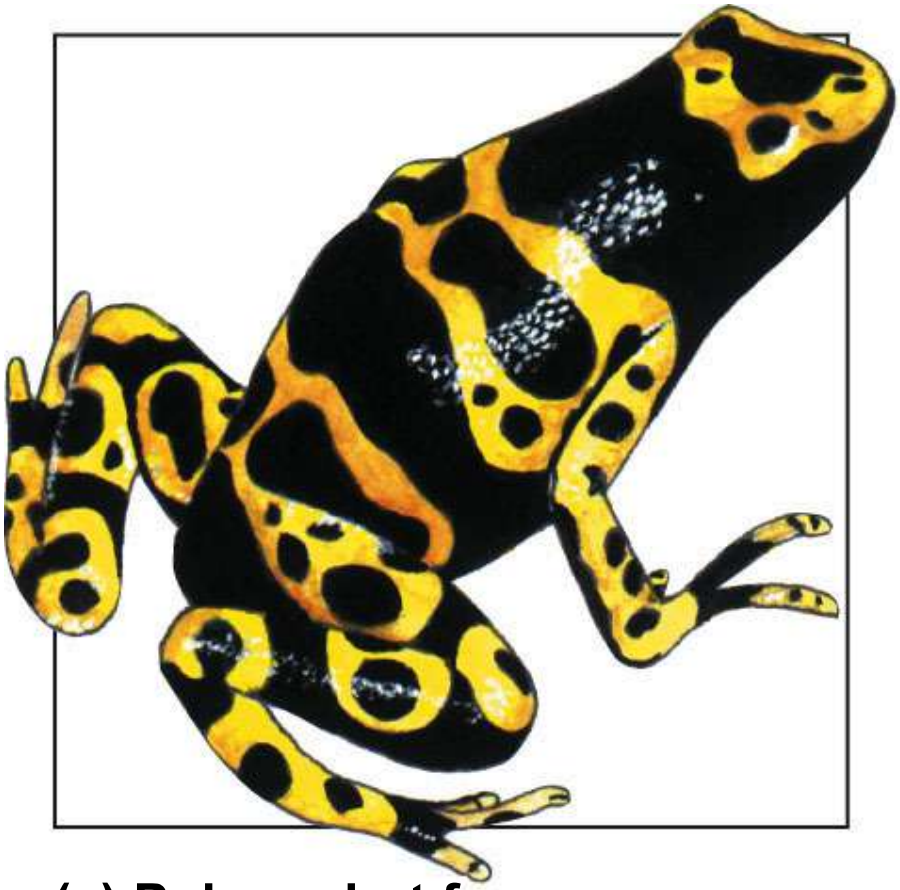

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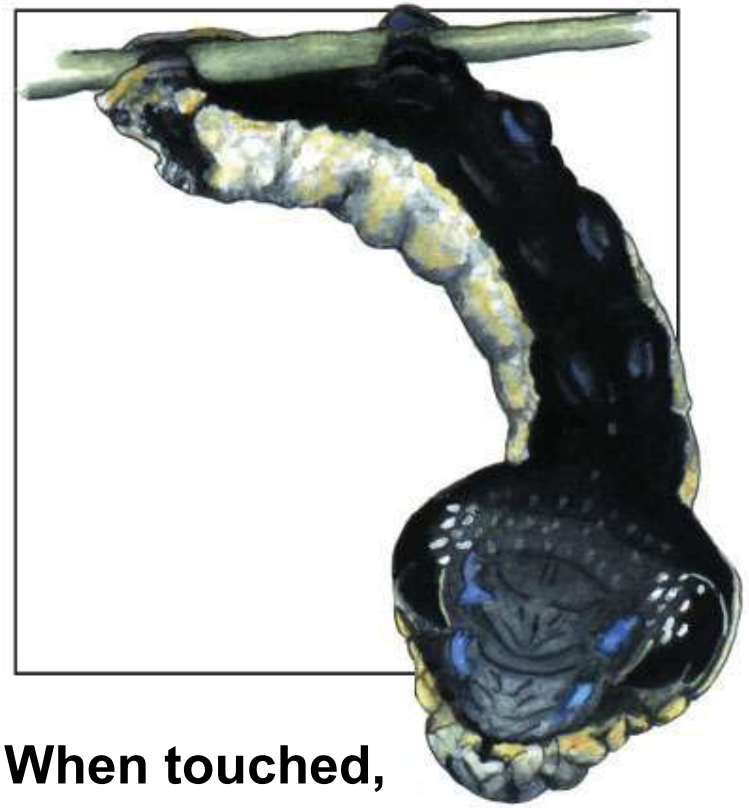

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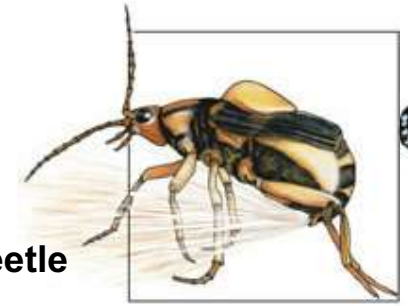

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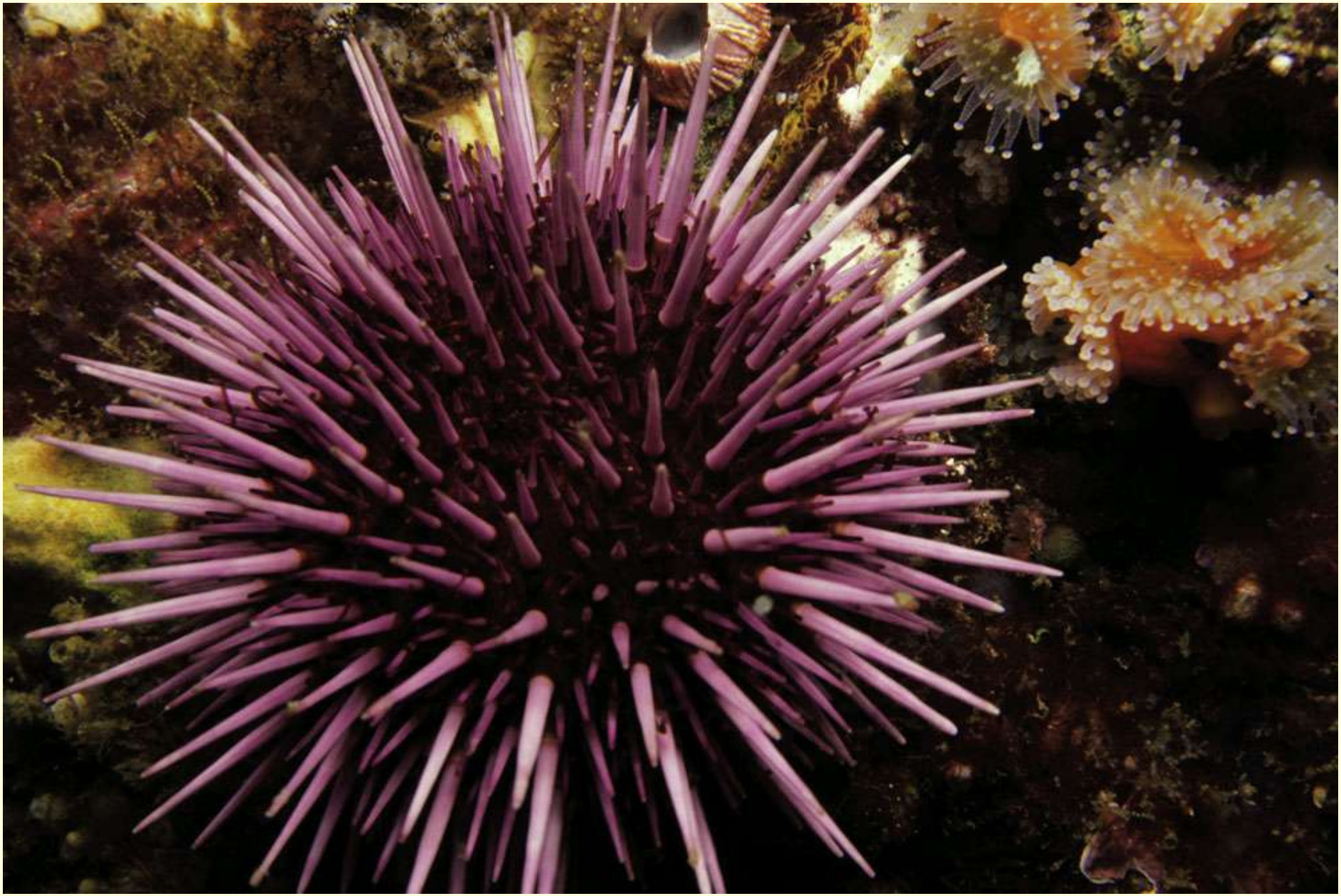


Fig. 5-A, p. 82

Coevolution

- Predator and prey
  - Intense natural selection pressure on each other
  - Each can evolve to counter the advantageous traits the other has developed
  - Bats and moths

Fig. 5-4, p. 83

Parasitism

- Live in or on the host
- Parasite benefits, host harmed
- Parasites promote biodiversity

Fig. 5-5, p. 84

Fig. 5-5, p. 84

Mutualism

- Both species benefit
- Nutrition and protection
- Gut inhabitant mutualism

(a) Oxpeckers and black rhinoceros

Fig. 5-6, p. 85

(b) Clownfish and sea anemone

Fig. 5-6, p. 85

Commensalism

- Benefits one species with little impact on other

Fig. 5-7, p. 85

5-2 What Limits the Growth of Populations?

- ***Concept 5-2*** *No population can continue to grow indefinitely because of limitations on resources and because of competition among species for those resources.*

Population Distribution

- Clumping – most populations
- Uniform dispersion
- Random dispersion

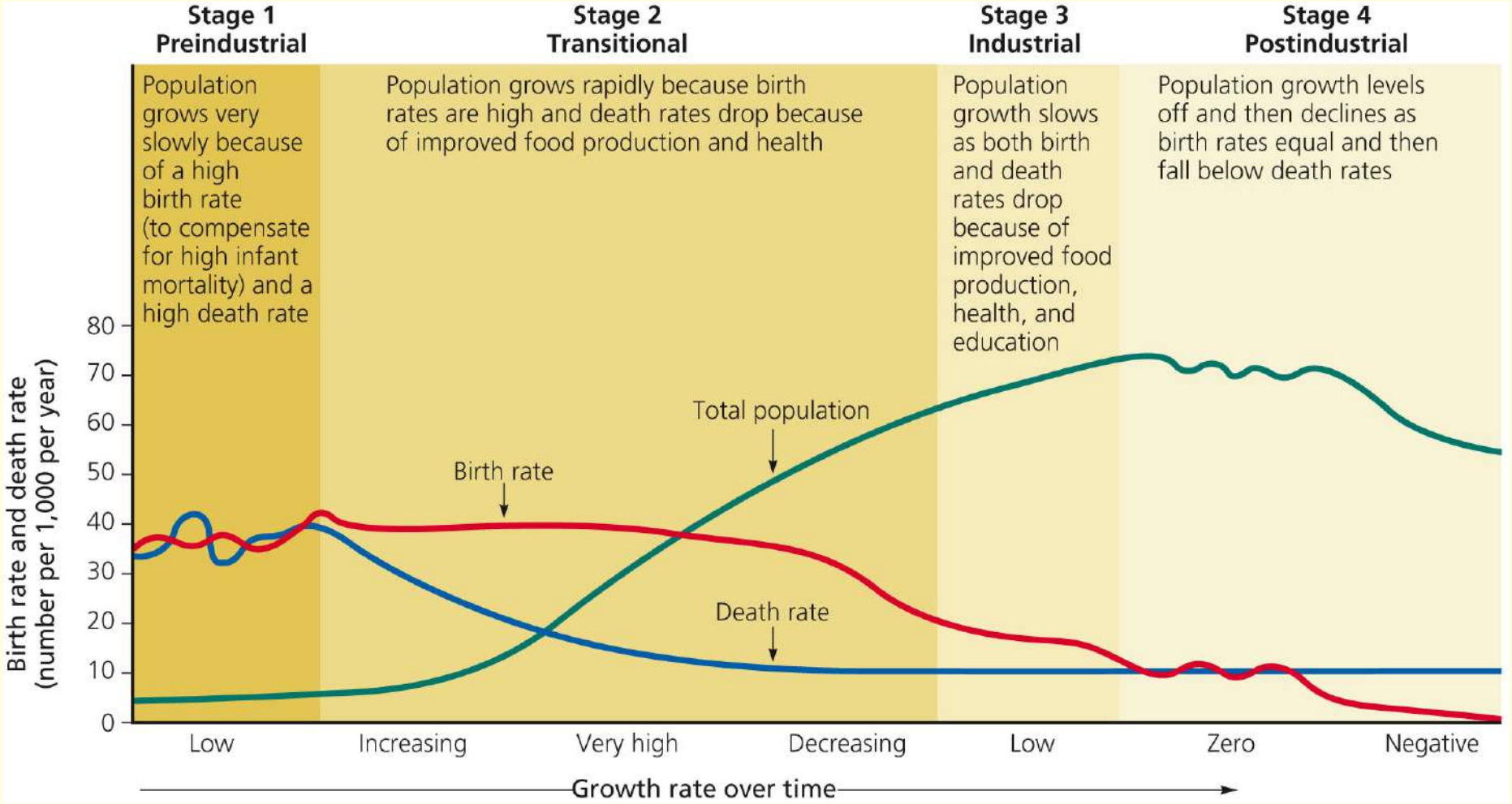
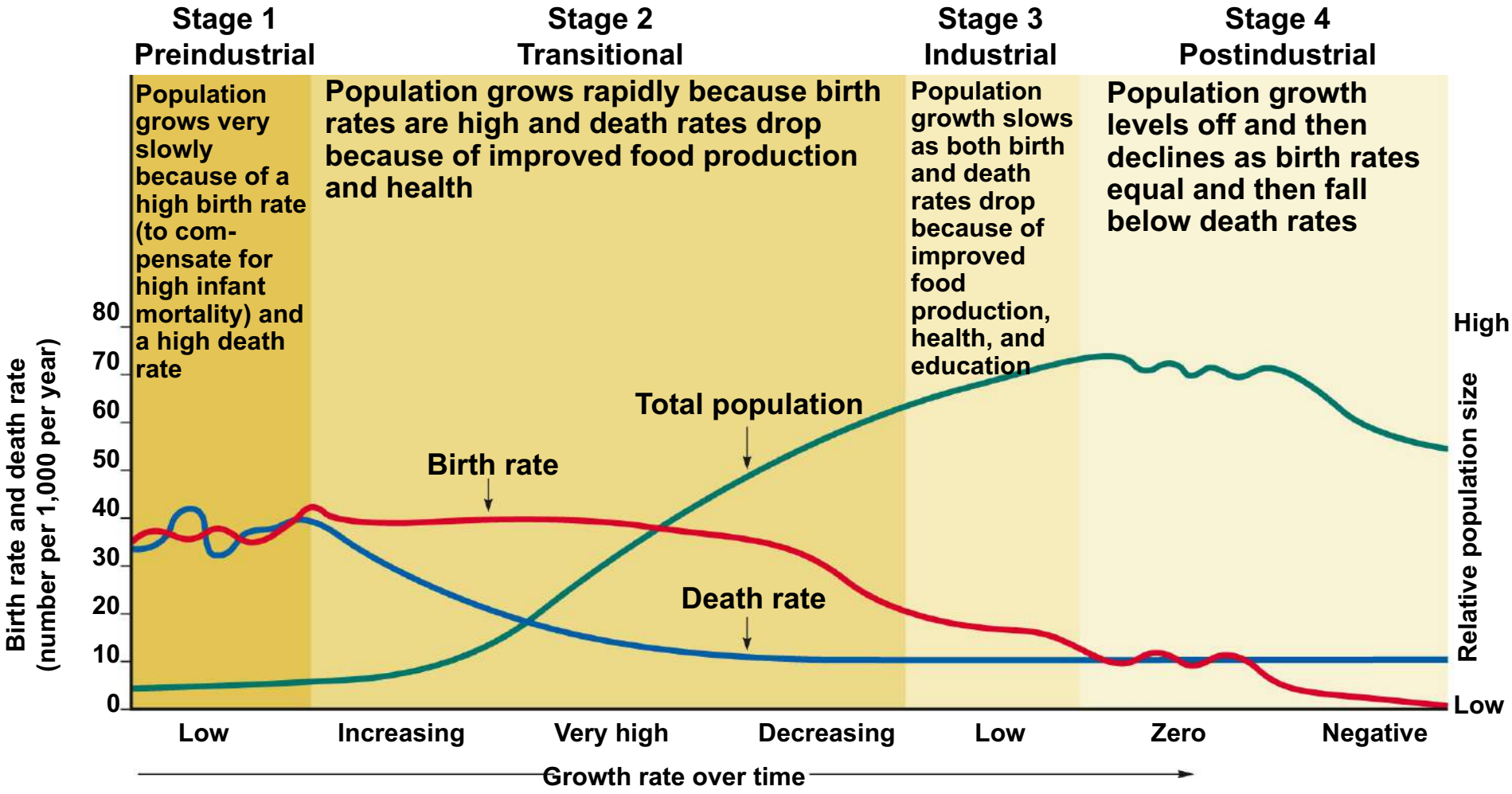

Stage 1
Preindustrial
Stage 2
Transitional
Stage 3
Industrial
Stage 4
Postindustrial
Population grows very slowly because of a high birth rate (to compensate for high infant mortality) and a high death rate
Population grows rapidly because birth rates are high and death rates drop because of improved food production and health
Population growth slows as both birth and death rates drop because of improved food production, health, and education
Population growth levels off and then declines as birth rates equal and then fall below death rates
Total population
Birth rate
Death rate
Birth rate and death rate (number per 1,000 per year)
80
70
60
50
40
30
20
10
0
Low
Increasing
Very high
Decreasing
Low
Zero
Negative
Growth rate over time

Fig. 6-10, p. 105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Total population
Birth rate
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Relative population size
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Growth rate over time

Fig. 6-10, p. 105

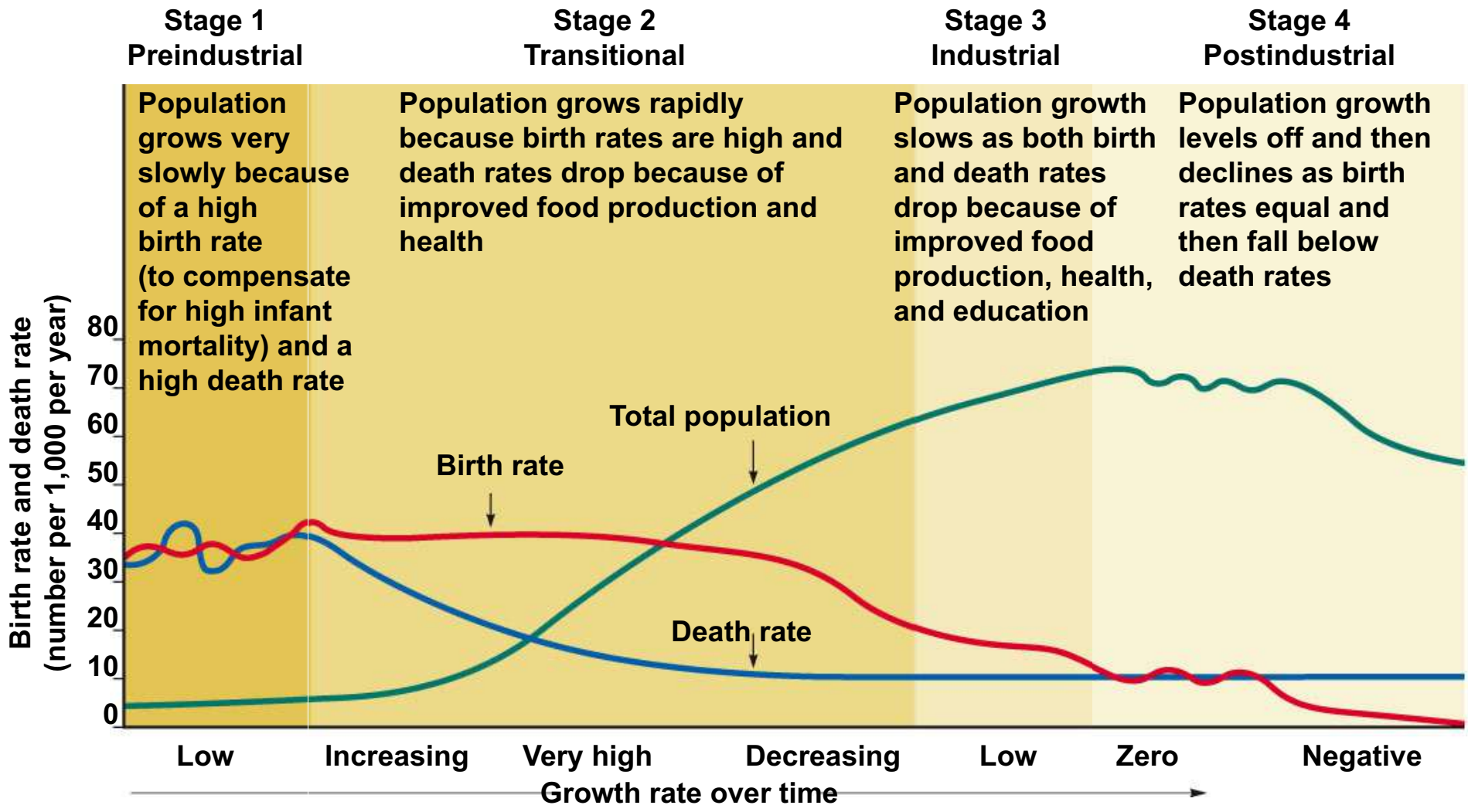

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Fig. 6-10, p. 105

Why Clumping?

- Resources not uniformly distributed
- Protection of the group
- Pack living gives some predators greater success
- Temporary mating or young-rearing groups

Populations Sizes Are Dynamic

- Vary over time

population = (births + immigration) - (deaths + emigration)

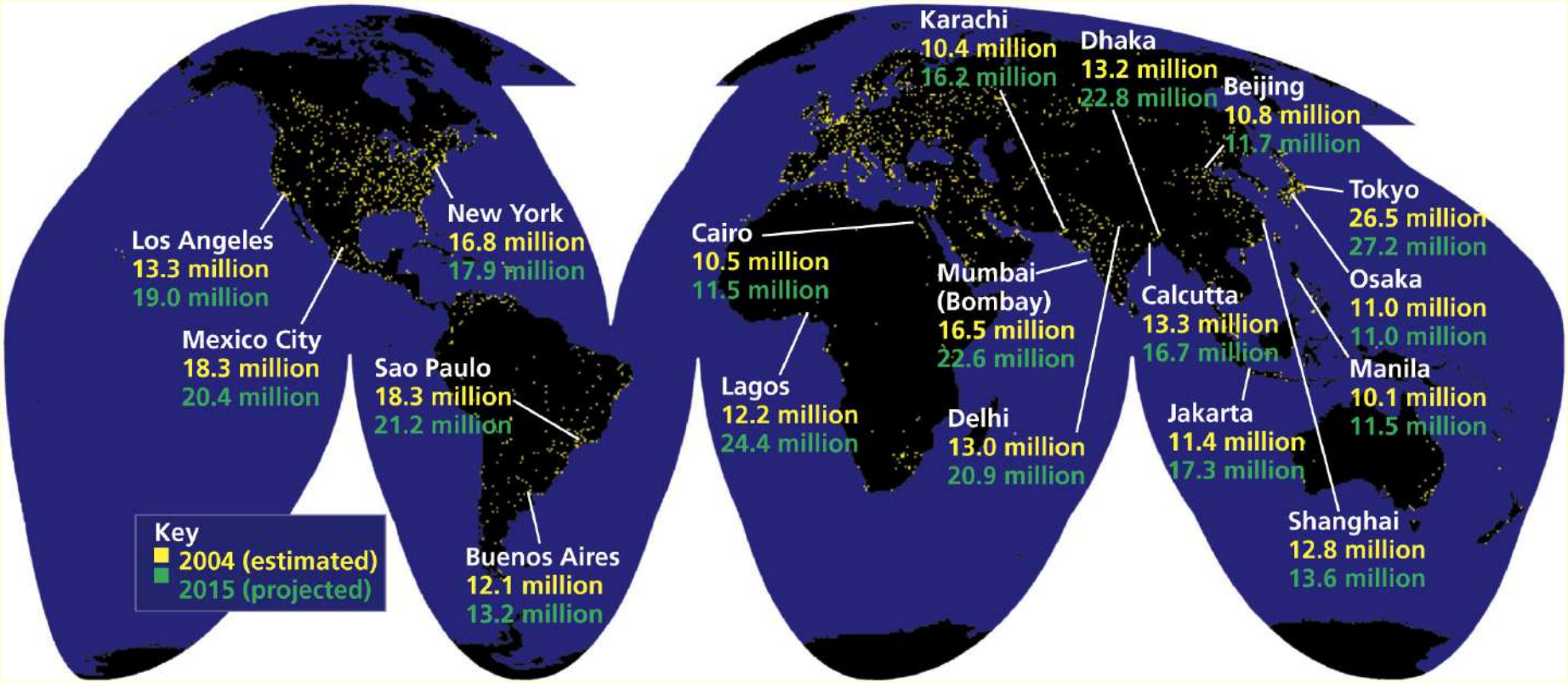
- **Age structure**
  - Pre-reproductive stage
  - Reproductive stage
  - Post-reproductive stage

Limits to Population Growth (1)

- **Biotic potential** is idealized capacity for growth
- **Intrinsic rate of increase (*r*)**
- Nature limits population growth with resource limits and competition
- Environmental resistance

Limits to Population Growth (1)

- **Carrying capacity** – biotic potential and environmental resistance
- Exponential growth
- **Logistic growth**


Karachi
10.4 million
16.2 million
Dhaka
13.2 million
22.8 million
Beijing
10.8 million
11.7 million
Tokyo
26.5 million
27.2 million
Osaka
11.0 million
11.0 million
Manila
10.1 million
11.5 million
Shanghai
12.8 million
13.6 million
Jakarta
11.4 million
17.3 million
Calcutta
13.3 million
16.7 million
Mumbai
(Bombay)
16.5 million
22.6 million
Delhi
13.0 million
20.9 million
Cairo
10.5 million
11.5 million
Lagos
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24.4 million
New York
16.8 million
17.9 million
Los Angeles
13.3 million
19.0 million
Mexico City
18.3 million
20.4 million
Sao Paulo
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21.2 million
Buenos Aires
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13.2 million
Key
2004 (estimated)
2015 (projected)

Fig. 6-11, p. 108

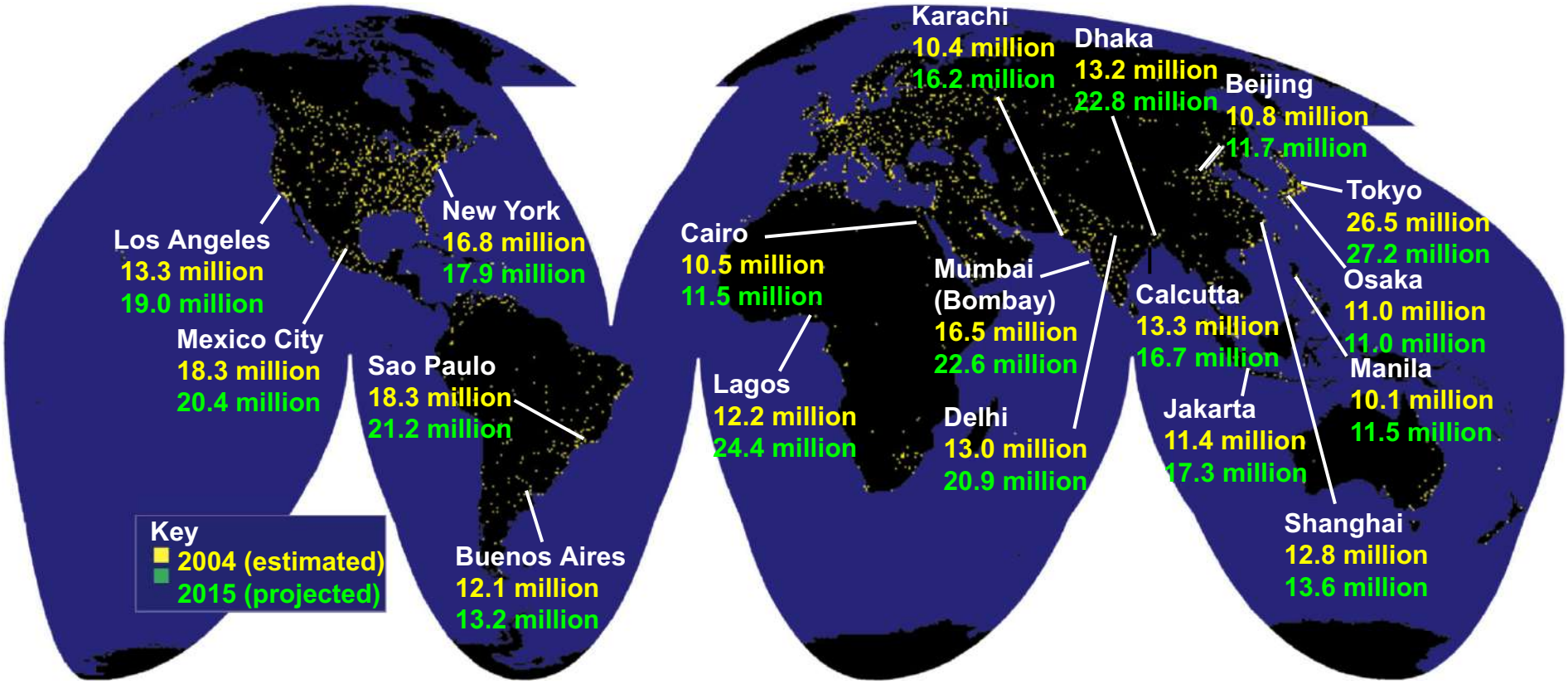
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Fig. 6-11, p. 108


Seattle
Portland
Boise
Salt Lake City
Provo
Minneapolis
Chicago
Boston
New York
Denver
Kansas City
Cincinnati
Washington, D.C.
St. Louis
San Francisco
Fresno
Las Vegas
Nashville
Tulsa
Raleigh
Charlotte
Los Angeles
Memphis
Wilmington
Phoenix
Atlanta
Myrtle Beach
San Diego
Dallas
Tucson
Houston
Austin
Orlando
Laredo
Naples
McAllen

Fig. 6-12, p. 109

Overshoot and Dieback

- Population not transition smoothly from exponential to logistic growth
- **Overshoot** carrying capacity of environment
- Caused by reproductive time lag
- **Dieback**, unless excess individuals switch to new resource

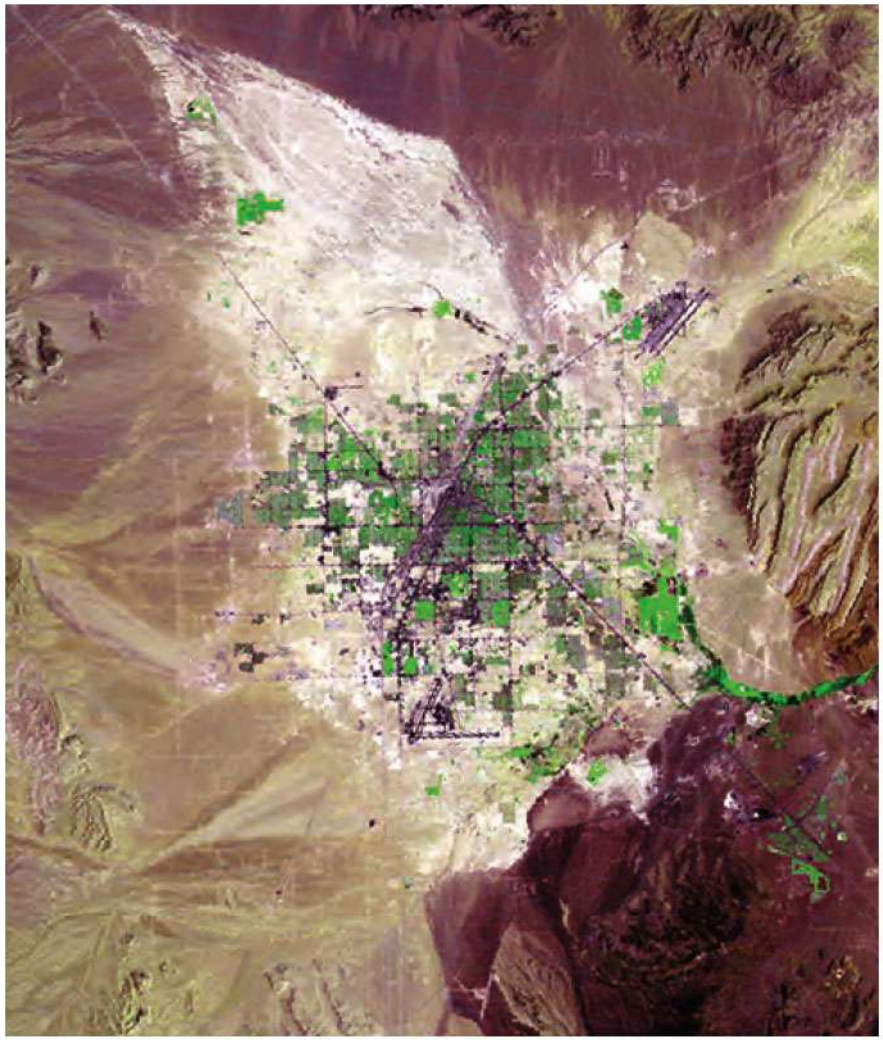

Image courtesy of the U.S. Geological Survey

1973

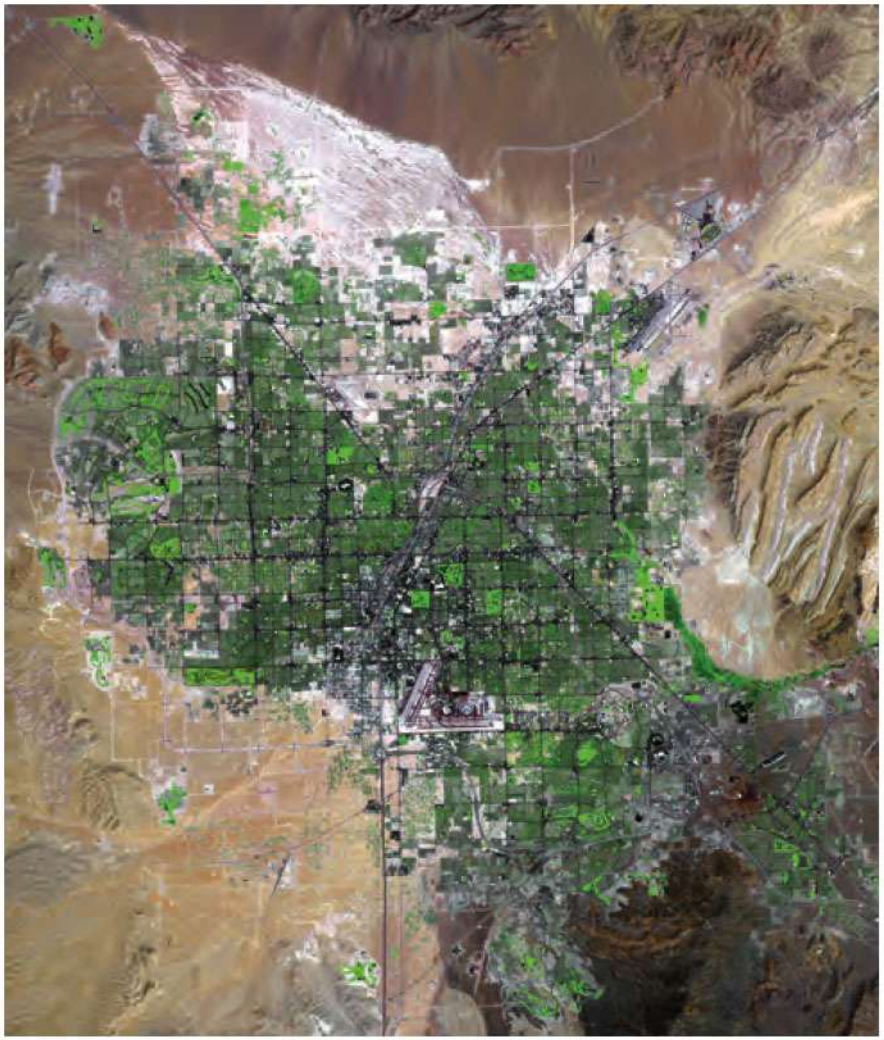

Image courtesy of the U.S. Geological Survey

2003

Different Reproductive Patterns

- *r*-Selected species
  - High rate of population increase
  - Opportunists
- *K*-selected species
  - Competitors
  - Slowly reproducing
- Most species' reproductive cycles between two extremes

Natural Capital Degradation

Urban Sprawl

Land and Biodiversity

Loss of cropland

Loss of forests and grasslands

Loss of wetlands

Loss and fragmentation of wildlife habitats

Water

Increased use of surface water and groundwater

Increased runoff and flooding

Increased surface water and groundwater pollution

Decreased natural sewage treatment

Energy, Air, and Climate

Increased energy use and waste

Increased air pollution

Increased greenhouse gas emissions

Can enhance climate change

Economic Effects

Decline of downtown business districts

Increased unemployment in central city

Loss of tax base in central city

Fig. 6-14, p. 110

Natural Capital Degradation

Urban Sprawl

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Fig. 6-14, p. 110

Humans Not Except from Population Controls

- Bubonic plague (14th century)
- Famine in Ireland (1845)
- AIDS
- Technology, social, and cultural changes extended earth's carrying capacity for humans
- Expand indefinitely or reach carrying capacity?

Case Study: Exploding White-tailed Deer Populations in the United States

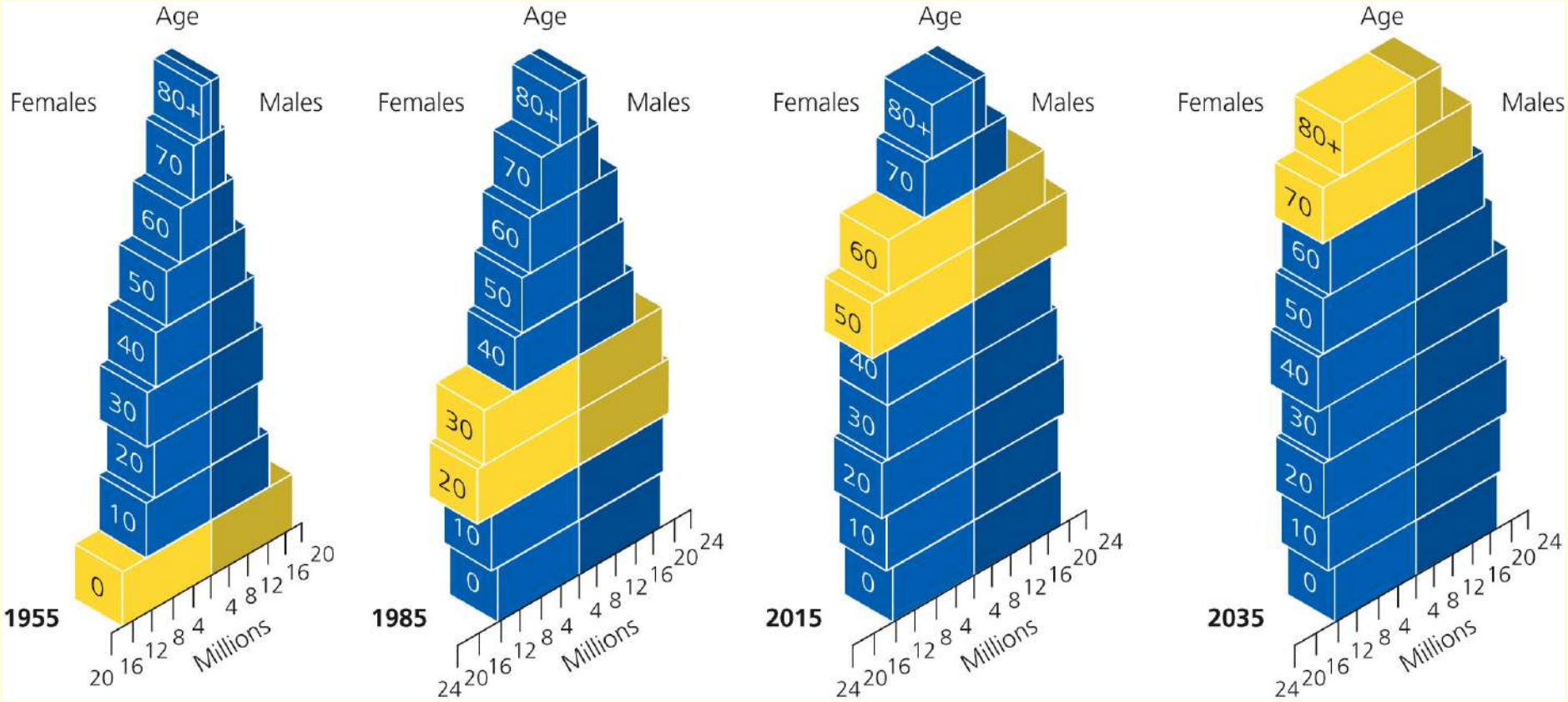
- 1900: population 500,000
- 1920–30s: protection measures
- Today: 25–30 million white-tailed deer in U.S.
- Conflicts with people living in suburbia

5-3 How Do Communities and Ecosystems Respond to Changing Environmental Conditions?

- ***Concept 5-3*** *The structure and species composition of communities and ecosystems change in response to changing environmental conditions through a process called ecological succession.*

Ecological Succession

- **Primary succession**
- **Secondary succession**
- Disturbances create new conditions
- Intermediate disturbance hypothesis


Age
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2015
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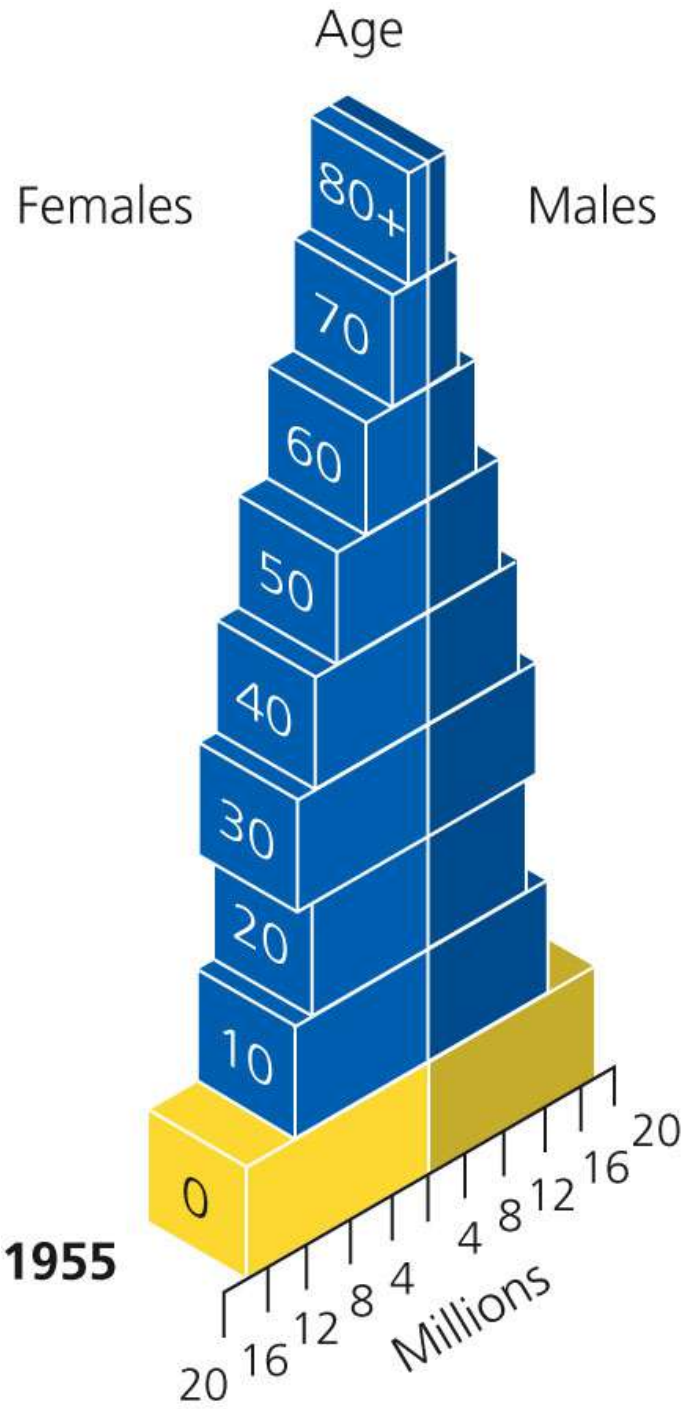
Fig. 6-8, p. 103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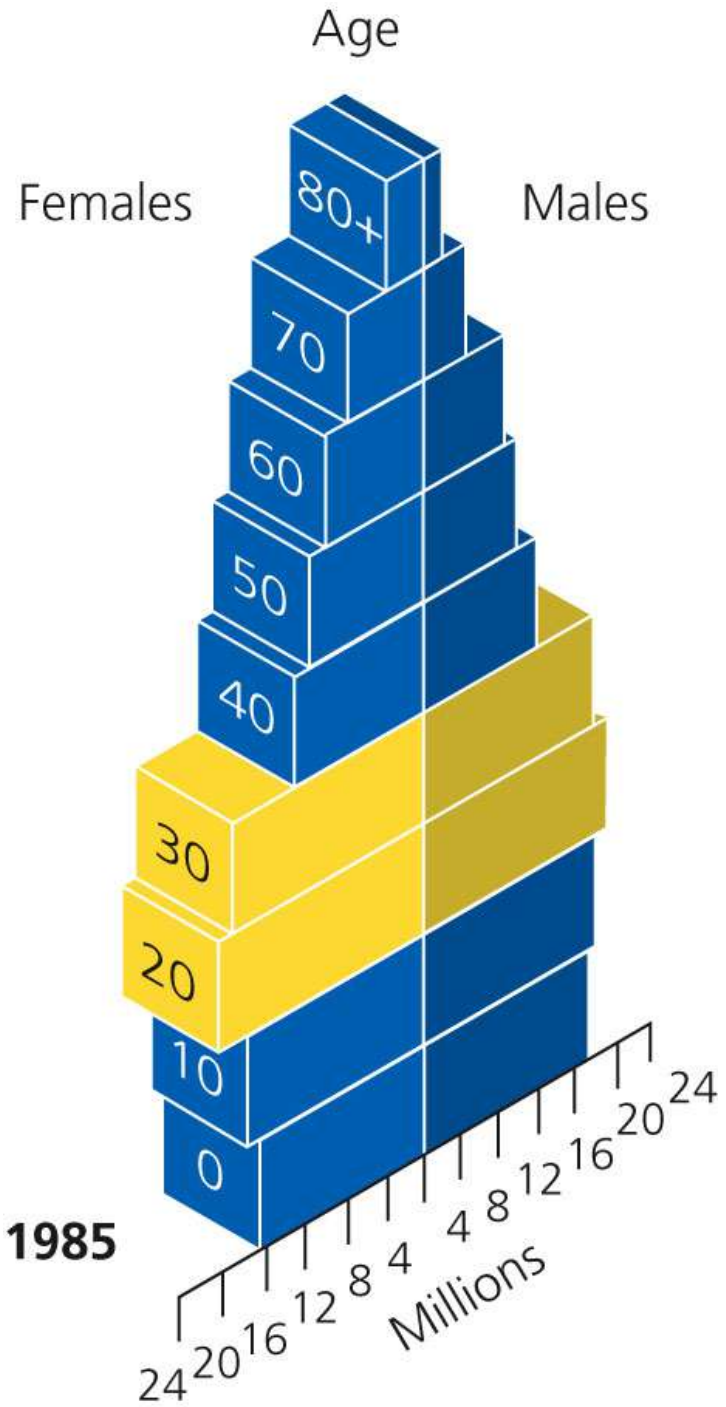
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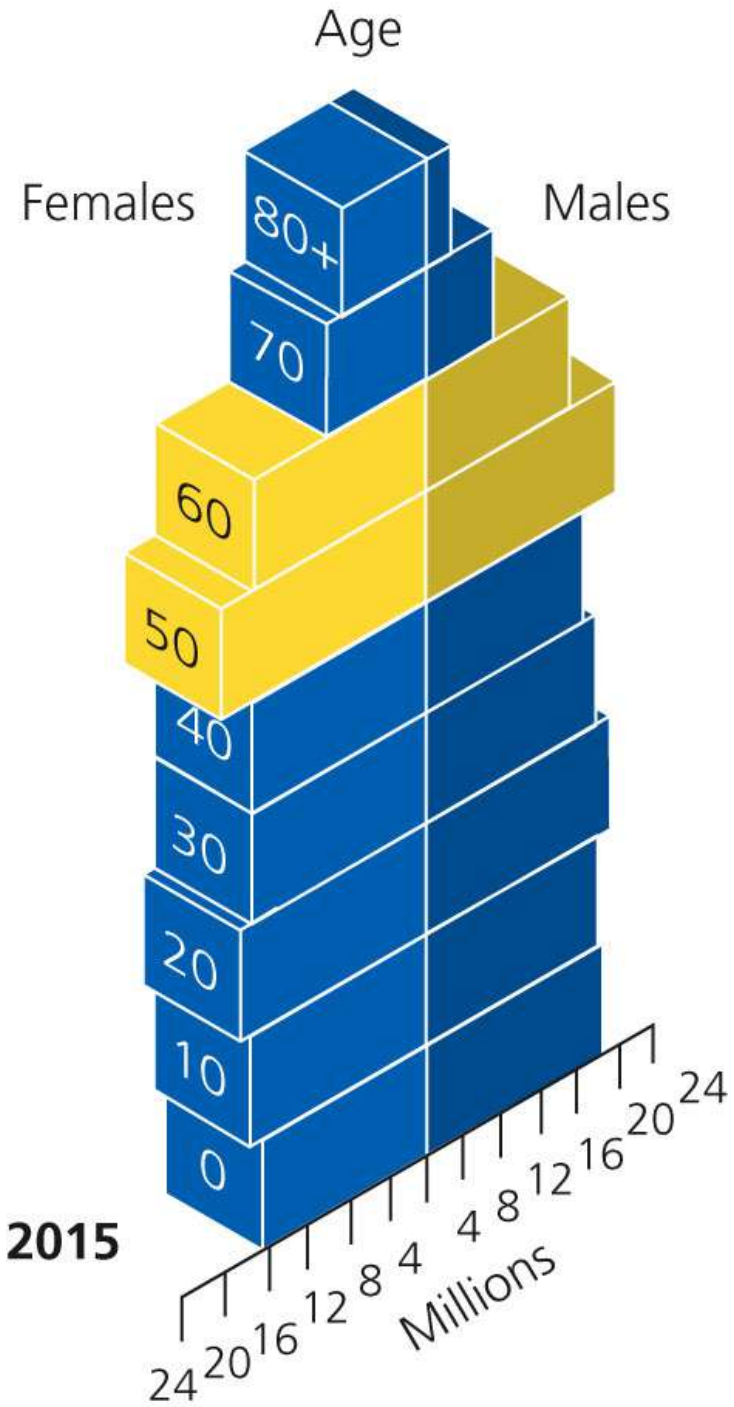
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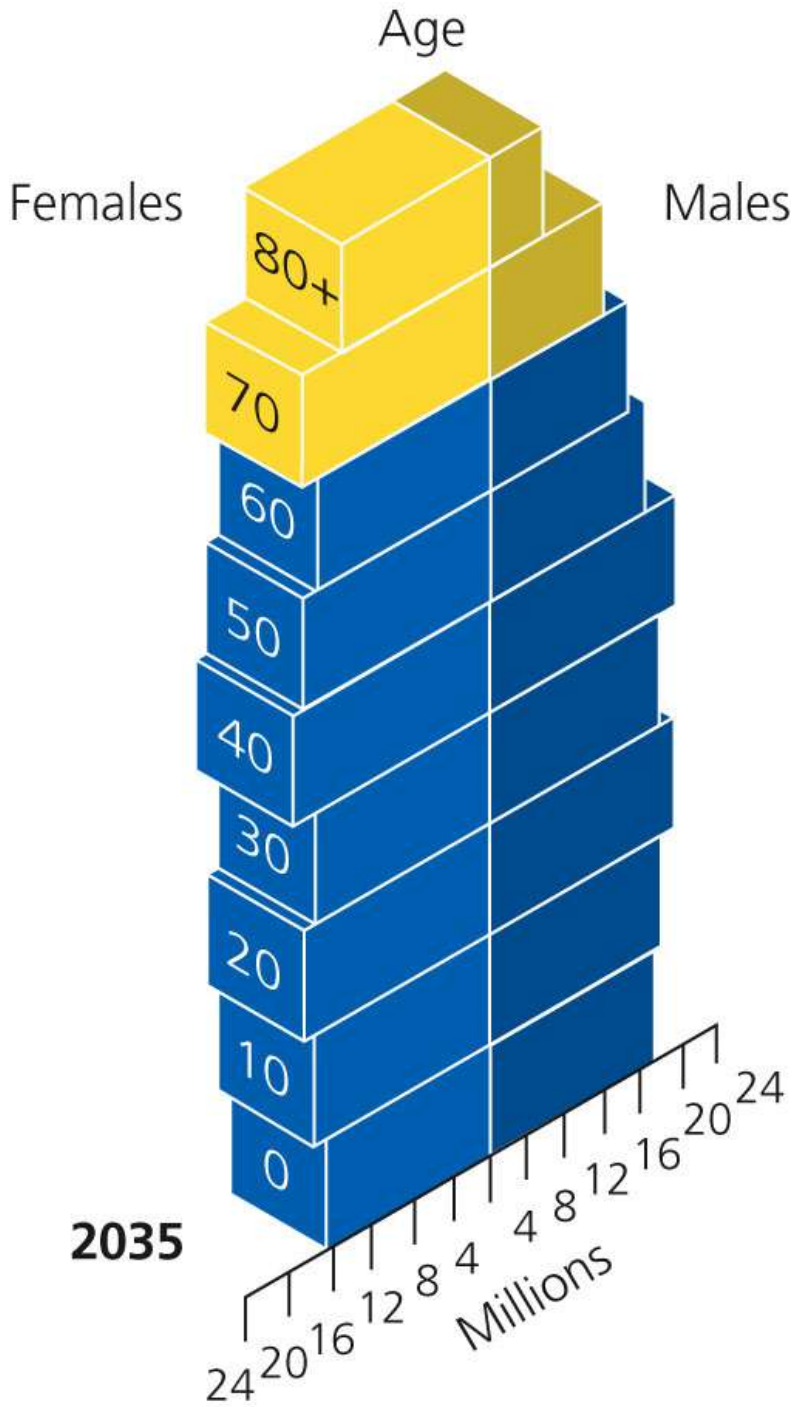
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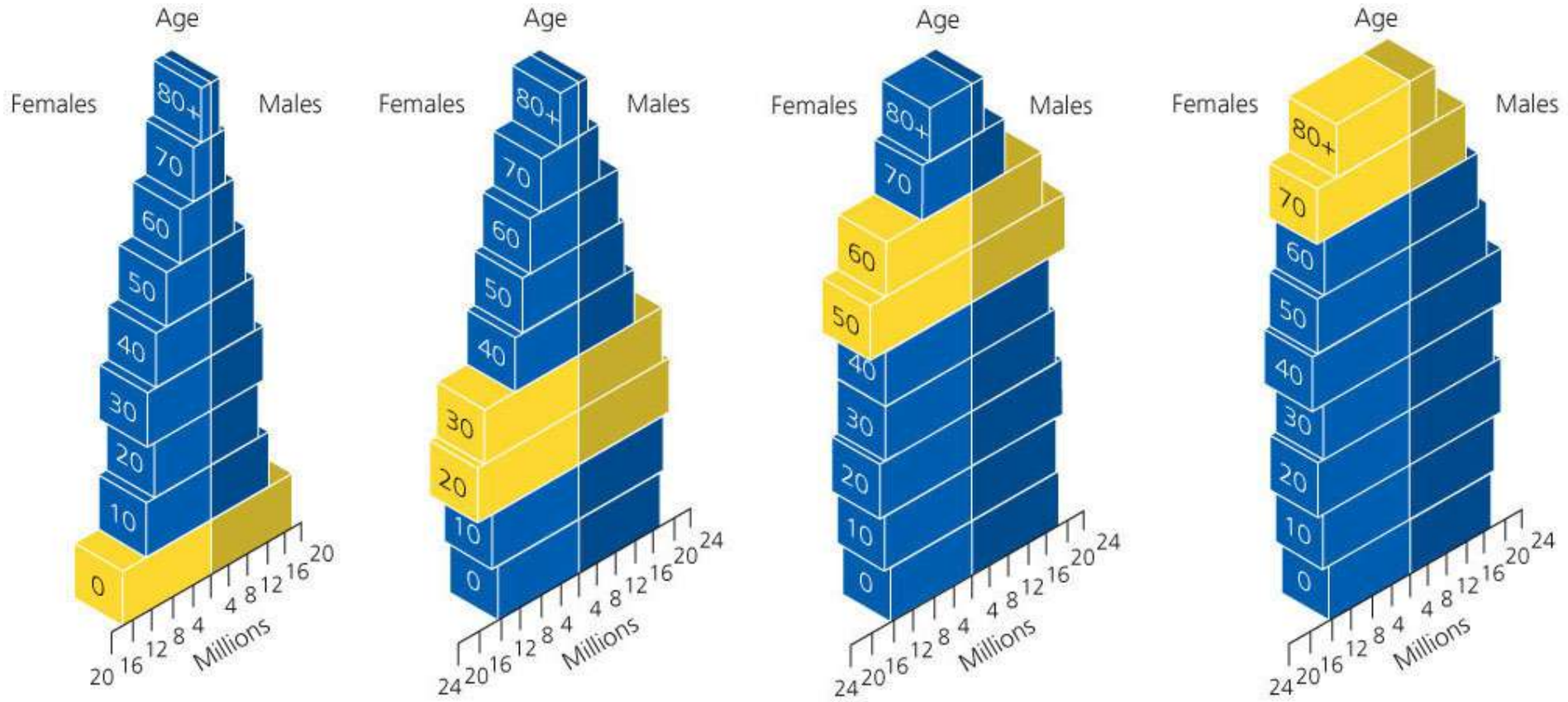


Stepped Art

Fig. 6-8, p. 103

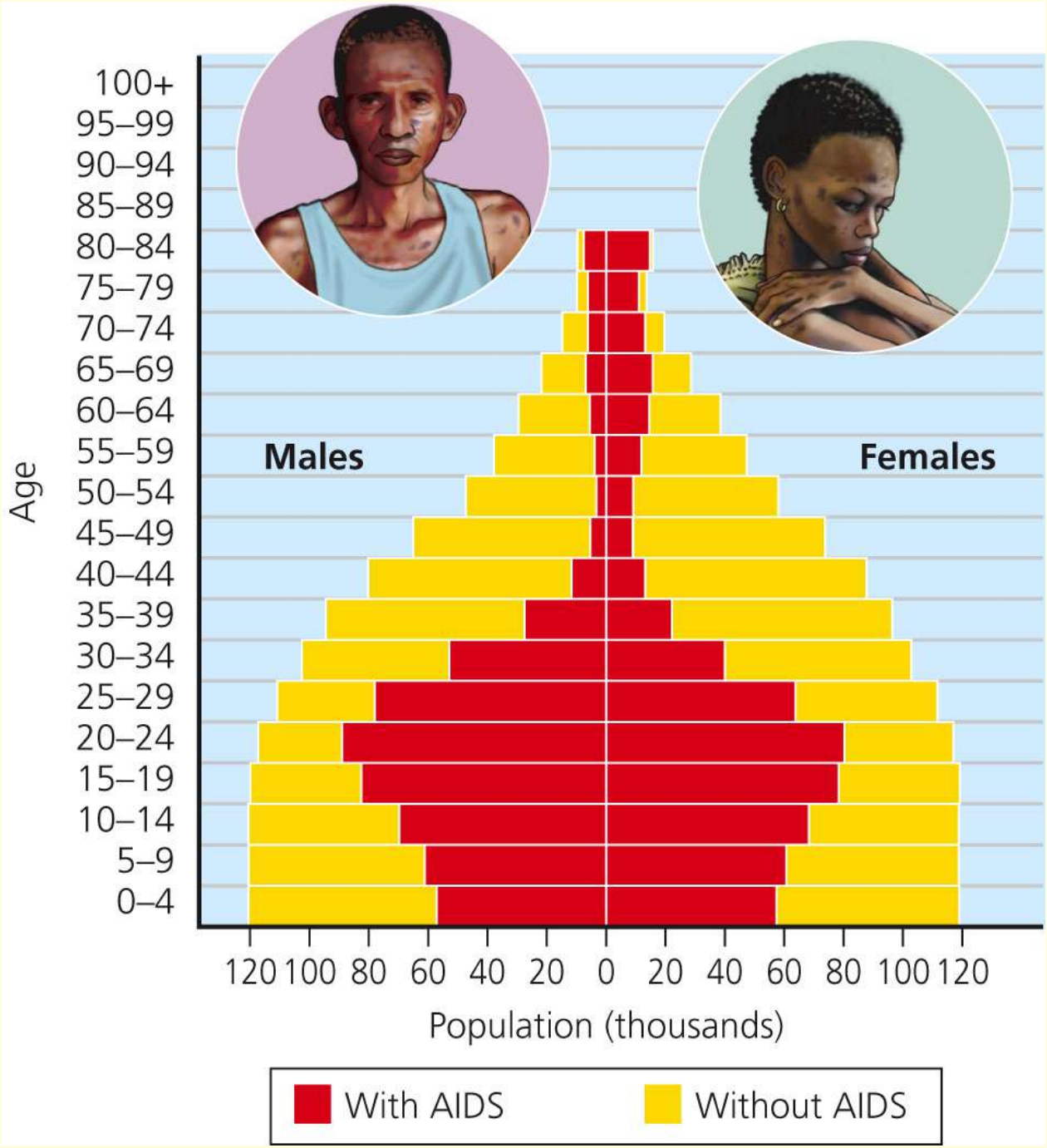

100+
95–99
90–94
85–89
80–84
75–79
70–74
65–69
60–64
55–59
50–54
45–49
40–44
35–39
30–34
25–29
20–24
15–19
10–14
5–9
0–4
Age
Males
Females
120 100 80 60 40 20 0 20 40 60 80 100 120
Population (thousands)
With AIDS
Without AIDS

Fig. 6-9, p. 104

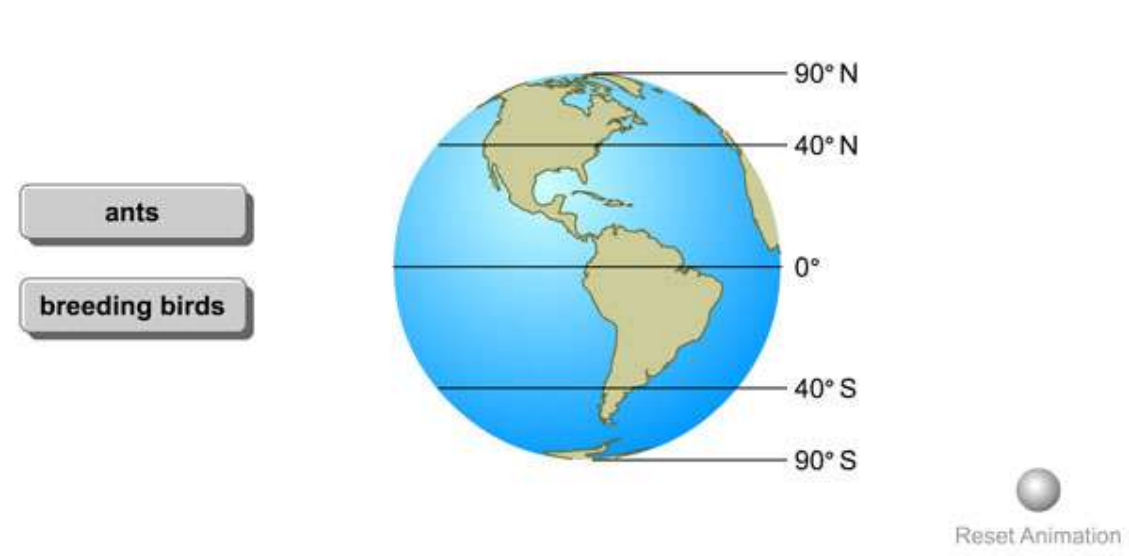
Succession's Unpredictable Path

- Successional path not always predictable toward **climax community**
- Communities are ever-changing mosaics of different stages of succession
- Continual change, not permanent equilibrium

Precautionary Principle

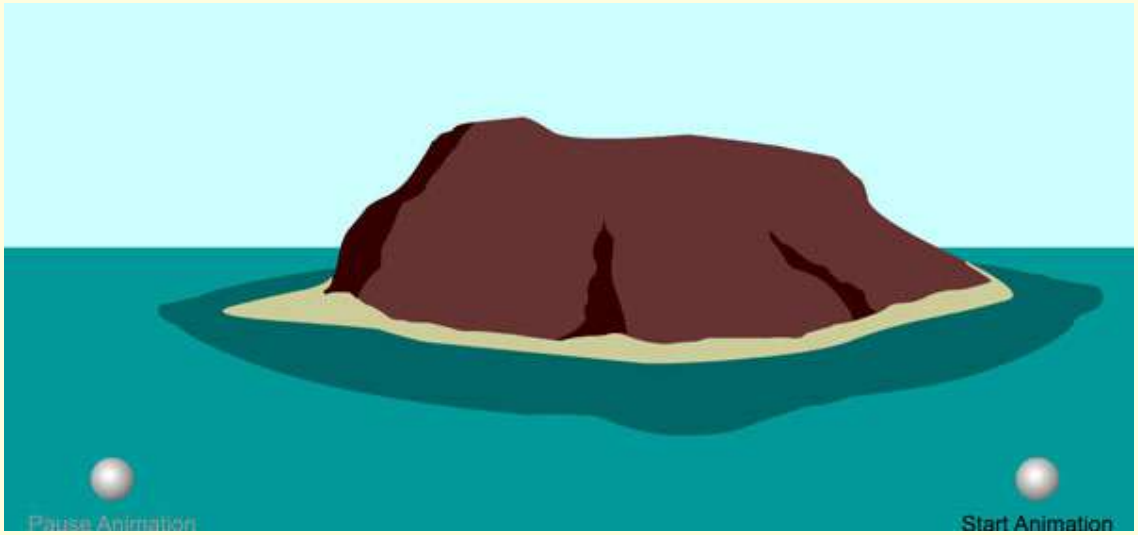
- Lack of predictable succession and equilibrium should not prevent conservation
- Ecological degradation should be avoided
- Better safe than sorry

Animation: Species Diversity By Latitude



PLAY ANIMATION

Animation: Area and Distance Effects



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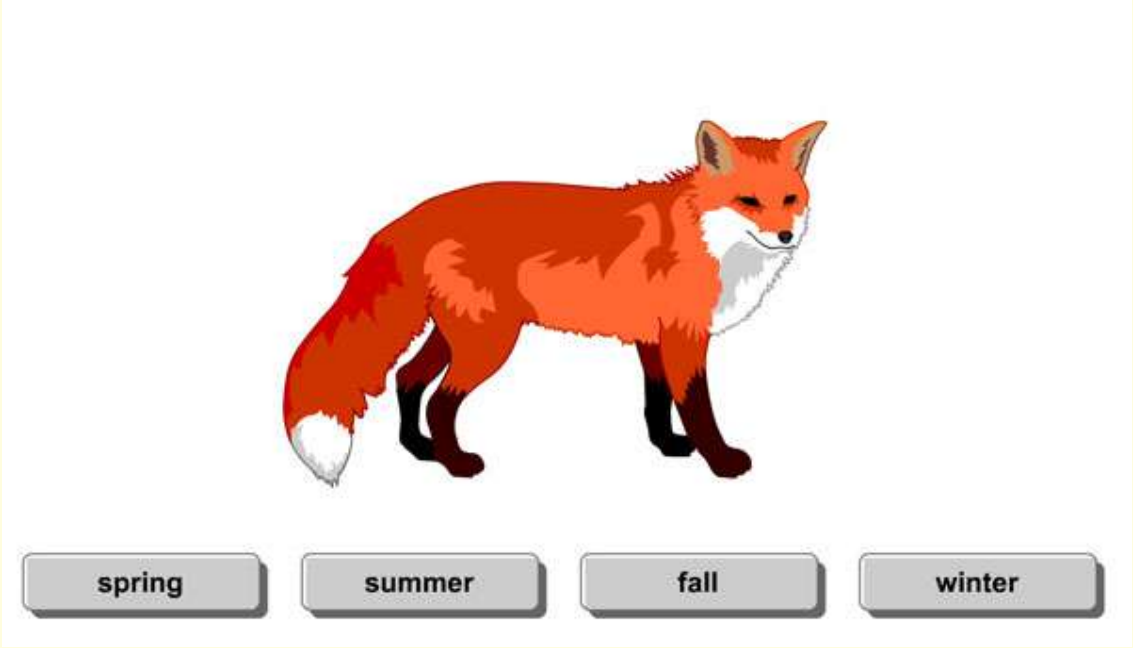
Animation: Diet of a Red Fox



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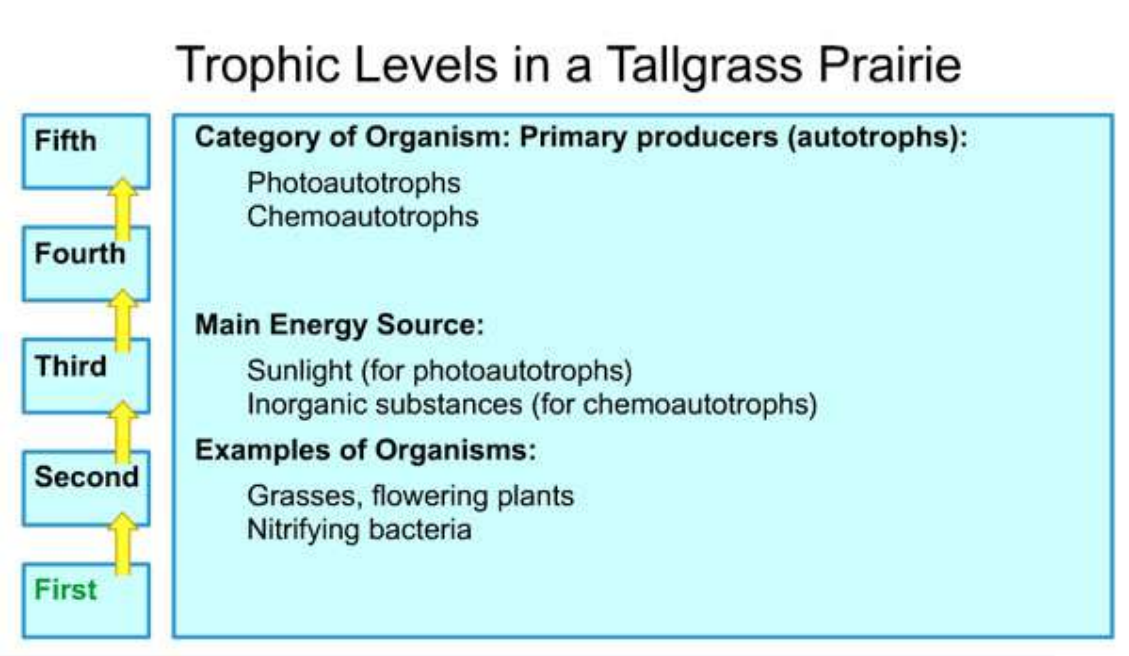
Animation: Prairie Trophic Levels



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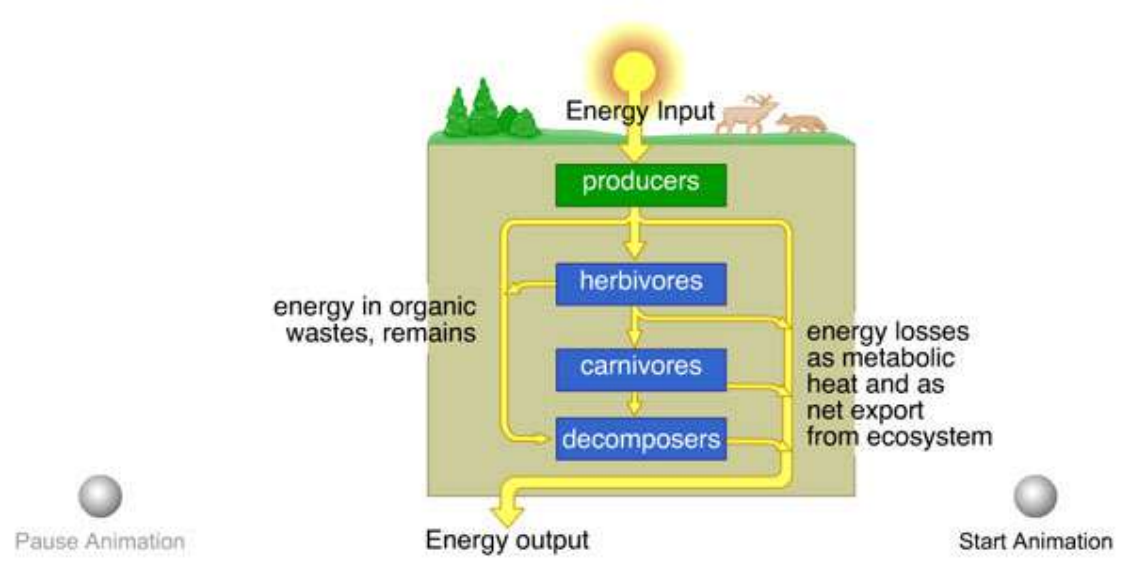
Animation: Categories of Food Webs



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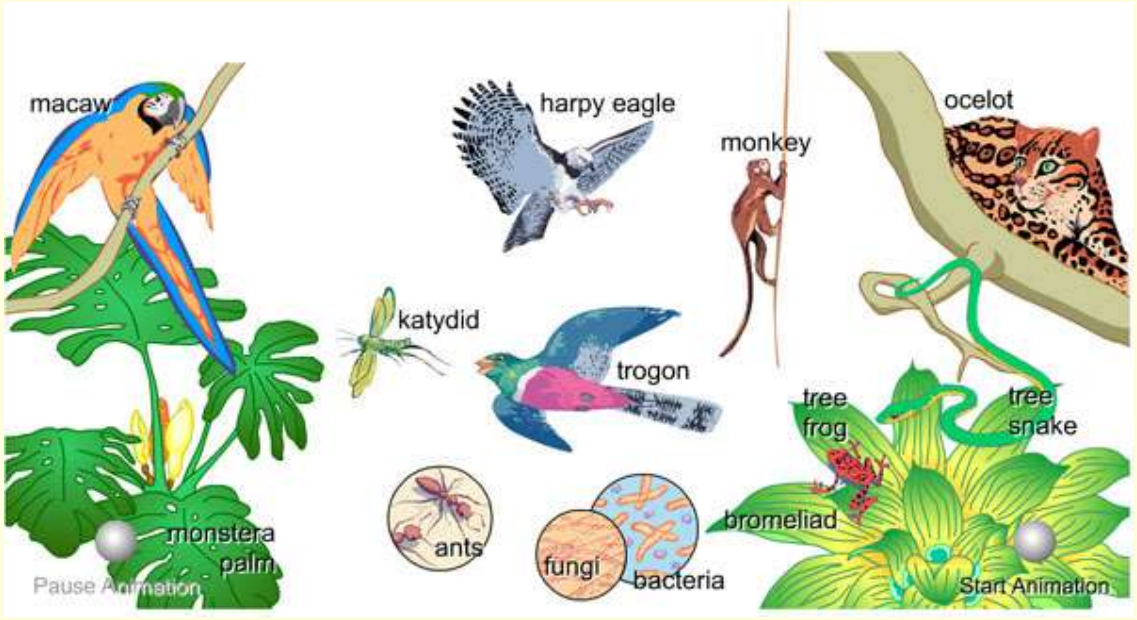
Animation: Rainforest Food Web



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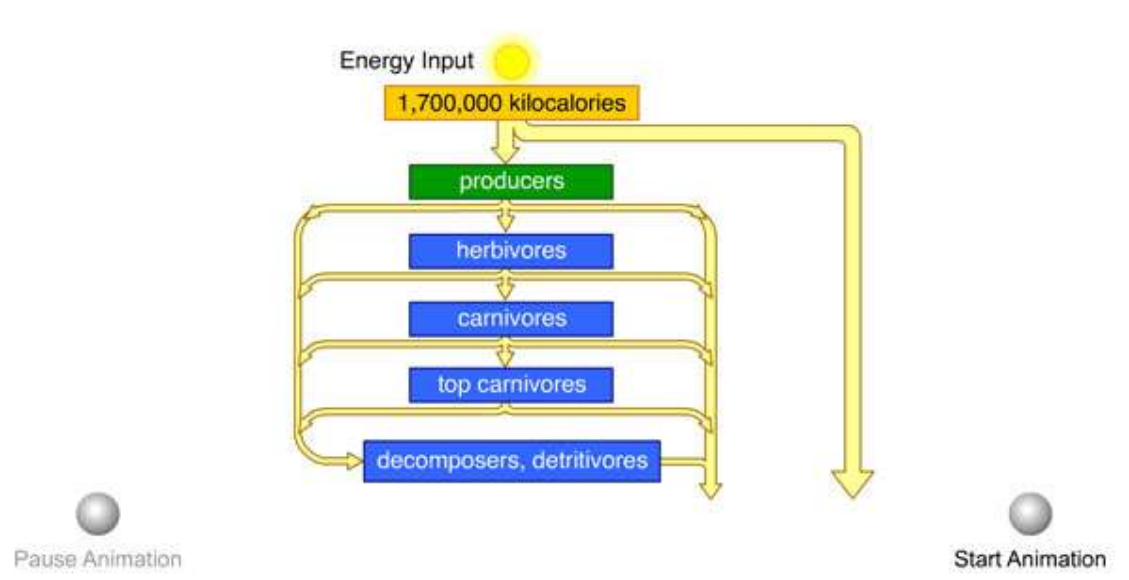
Animation: Energy Flow in Silver Springs



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Animation: Prairie Food Web

secondary to higher level consumer

primary to secondary consumer

producer to primary consumer

all producers and consumers to decomposers

Reset Animation

PLAY ANIMATION

Animation: How Species Interact

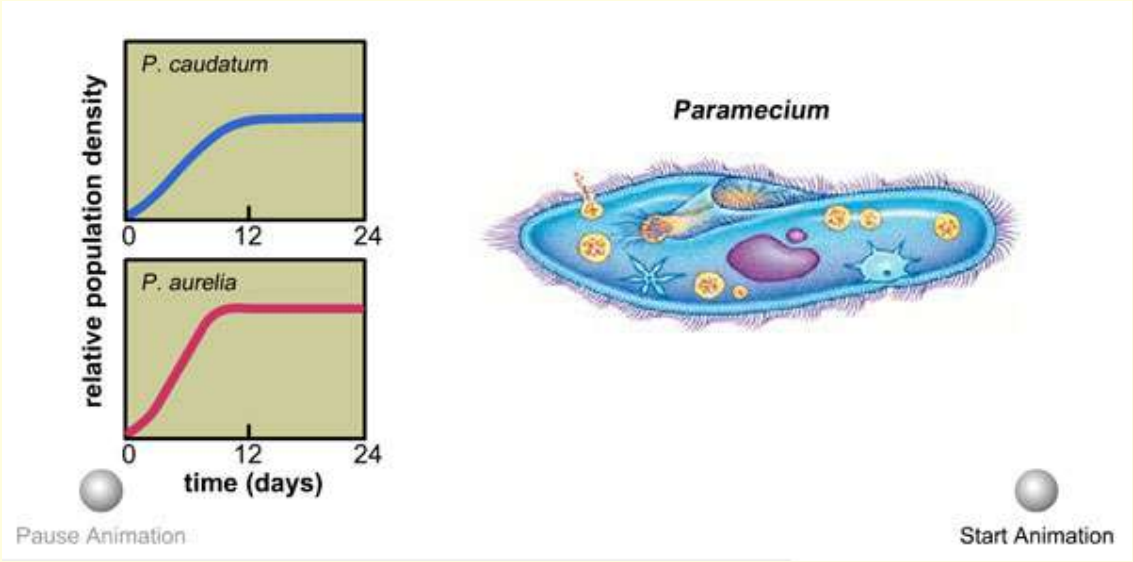
Types of Two Species Interactions		
Type of interaction	Direct effect on Species 1	Direct effect on Species 2
commensalism	+	0
mutualism	+	+
interspecific competition	–	–
predation	+	–
parasitism	+	–

Pause Animation

Reset Animation

PLAY ANIMATION

Animation: Gause's Competition Experiment



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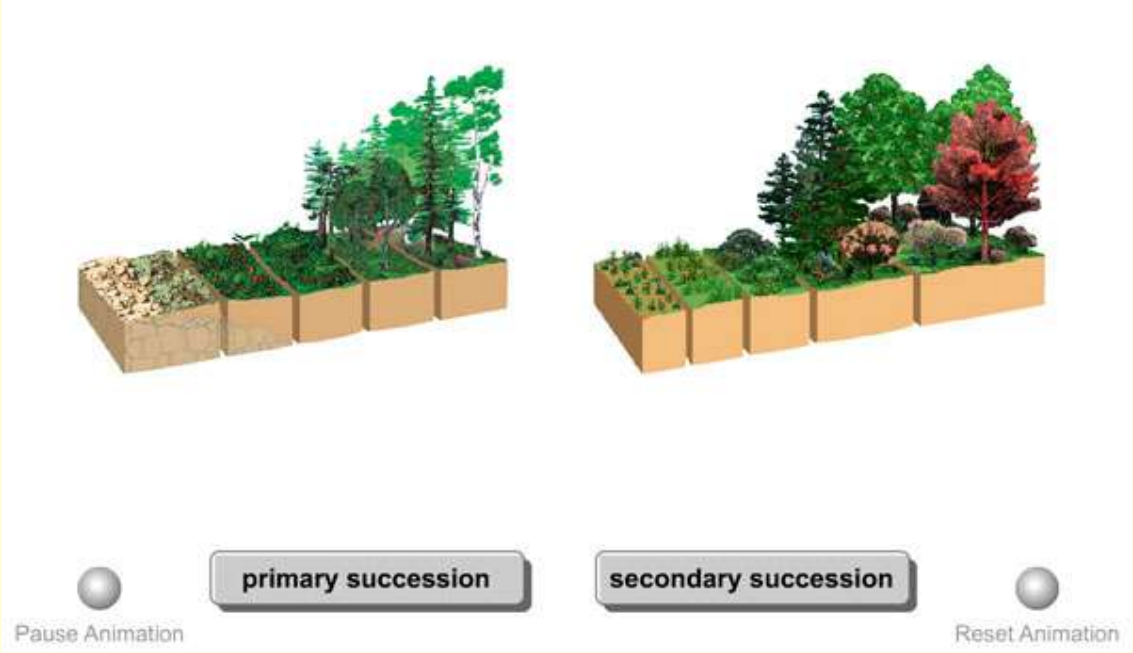
Animation: Succession



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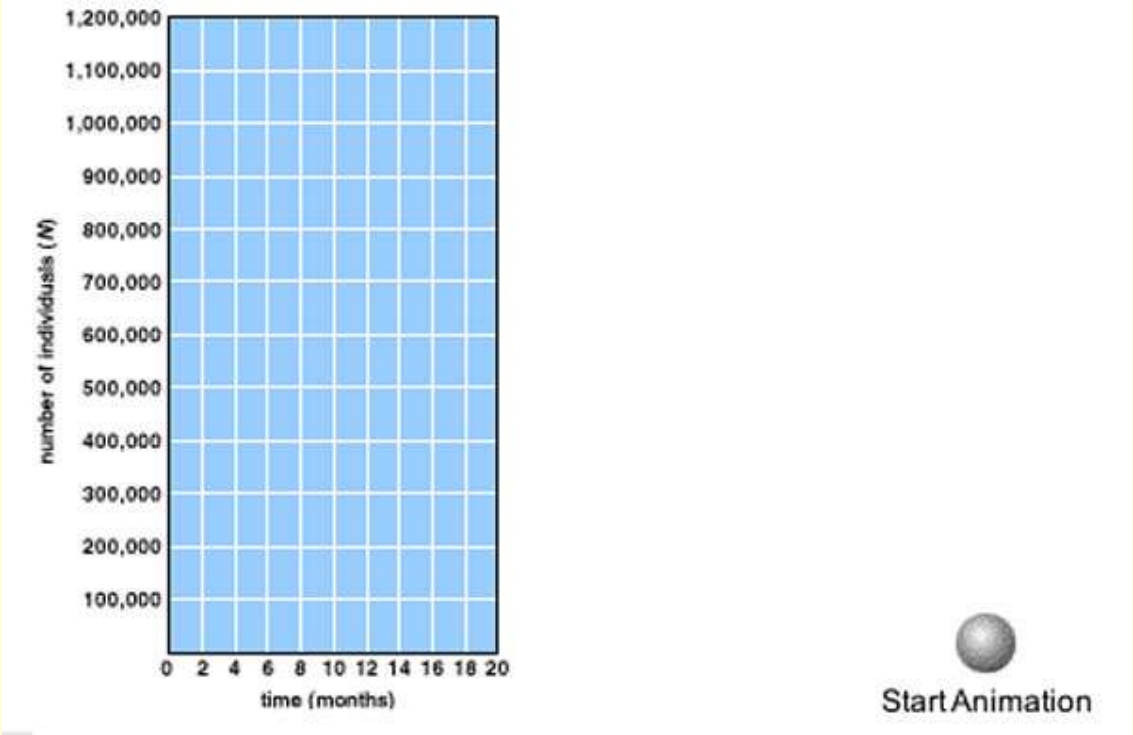
Animation: Exponential Growth



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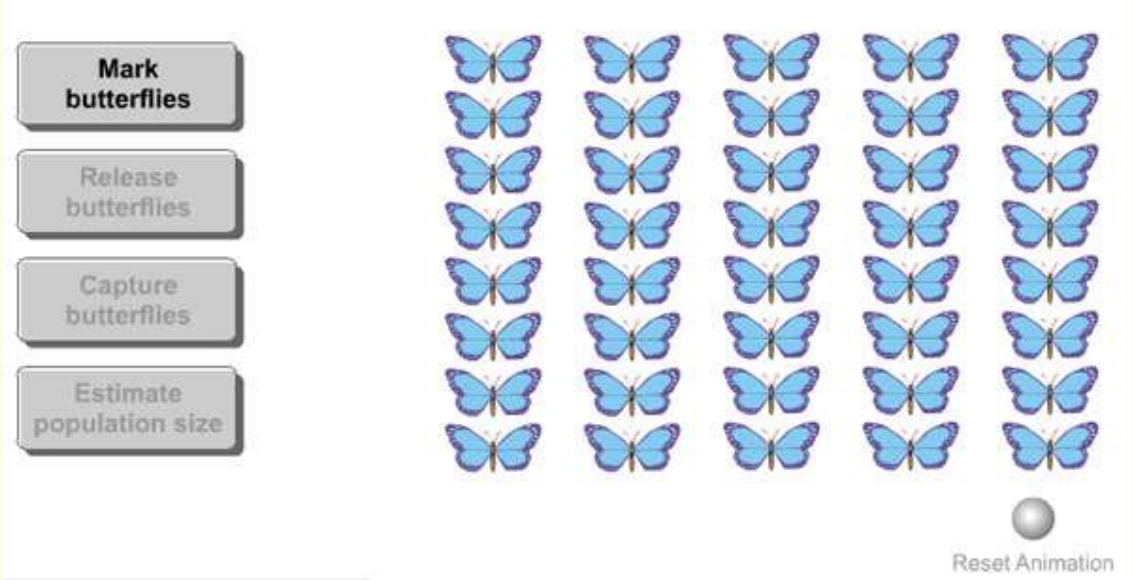
Animation: Capture-Recapture Method



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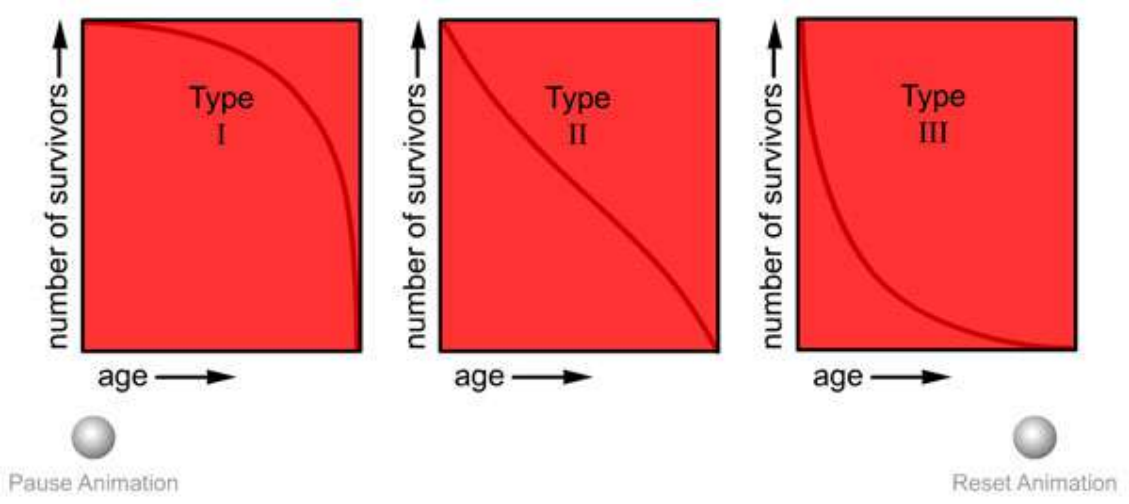
Animation: Life History Patterns



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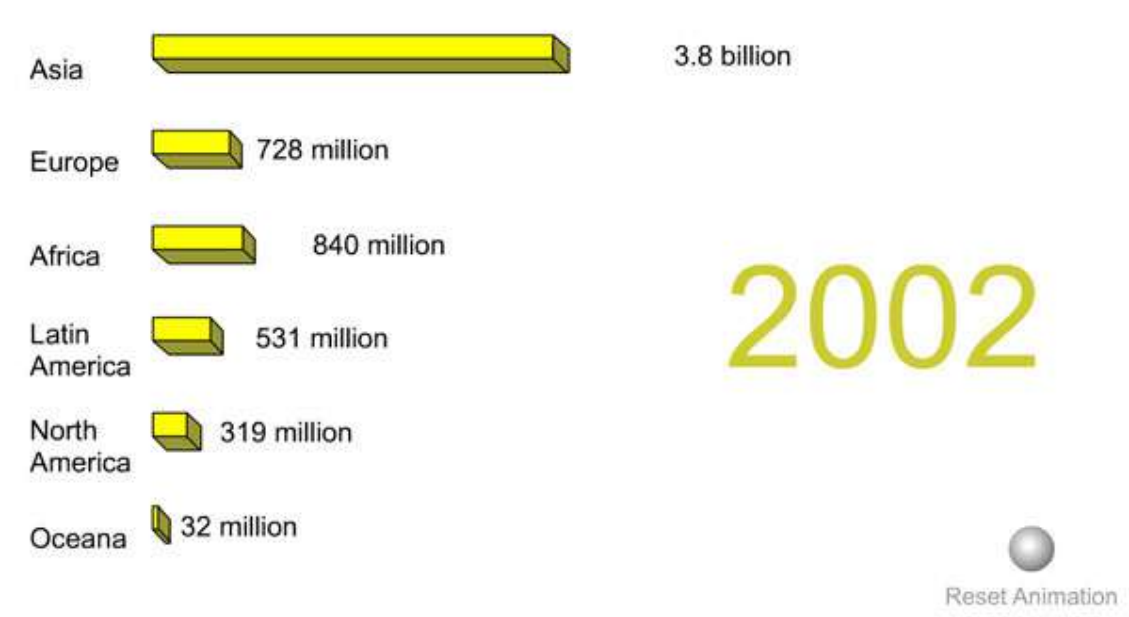
Animation: Current and Projected Population Sizes by Region



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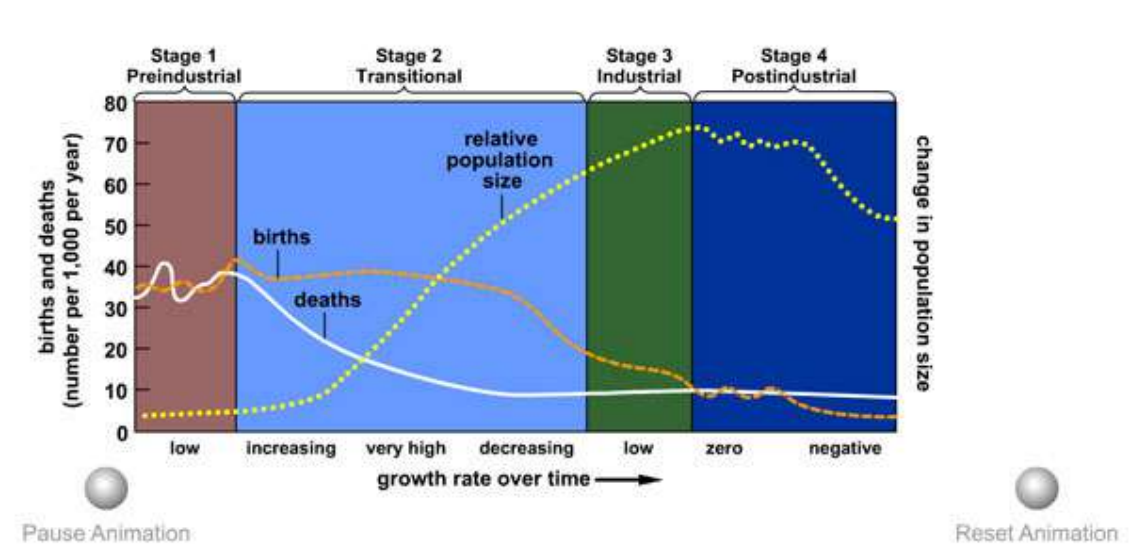
Animation: Demographic Transition Model



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Video: Frogs Galore

PLAY
VIDEO

Video: Bonus for a Baby

PLAY
VIDEO

Video: AIDS Conference in Brazil

PLAY VIDEO

Video: World AIDS Day

PLAY
VIDEO