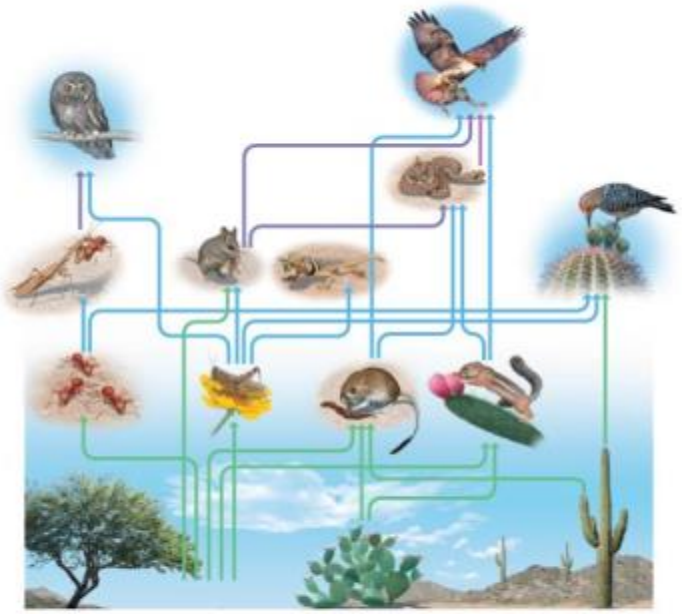
CH 37: Communities and ecosystems

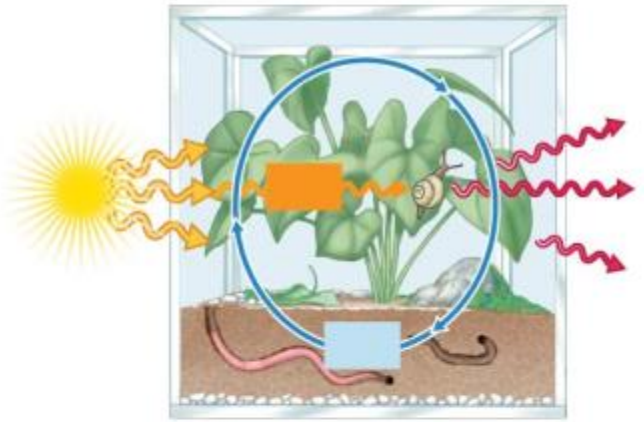
李承叡
生態學與演化生物學研究所
生命科學館 1129

Figure 37.0-2

Chapter 37: Big Ideas



Community Structure and Dynamics



Ecosystem Structure and Dynamics

COMMUNITY STRUCTURE AND DYNAMICS

37.1 A community includes all the organisms inhabiting a particular area

- Biological **community:** an assemblage of all the populations of organisms living close enough together for potential interaction.
- Ecologists define the boundaries of the community according to the research questions they want to investigate.

TABLE 37.2 | INTERSPECIFIC INTERACTIONS

Interspecific Interaction	Effect on Species 1	Effect on Species 2	Example
Competition	−	−	Squirrels/ black bears
Mutualism	+	+	Plants/ mycorrhizae
Predation	+	−	Crocodiles/fish
Herbivory	+	−	Caterpillars/leaves
Parasites and pathogens	+	−	Heartworm/dogs; *Salmonella*/ humans

37.2 Interspecific interactions are fundamental to community structure

- **Interspecific competition** occurs when two different species compete for the same limited resource.
- In **mutualism**, both populations benefit.
- In **predation**, one species (the predator) kills and eats another (the prey).
- In **herbivory**, an animal consumes plant parts or algae.
- In **parasitism**, the host plants or animals are victimized by parasites or pathogens.

37.4 Mutualism benefits both partners

- Reef-building corals and photosynthetic dinoflagellates provide a good example of how mutualists benefit from their relationship.
- Photosynthetic dinoflagellates
  - gain a secure shelter that provides access to light,
  - produce sugars by photosynthesis that provide at least half of the energy used by the coral animals
  - use the coral's waste products, including carbon dioxide (CO_2) and ammonia (NH_3)
  - Coral reef bleaching
  - http://www.bbc.com/zhongwen/trad/science-39550781

37.5 EVOLUTION CONNECTION: Predation leads to diverse adaptations in prey species

- Predation benefits the predator but kills the prey.
- Prey adapt using protective strategies that include
  - camouflage (https://www.youtube.com/watch?v=GFUiCsUSzyw),
  - mechanical defenses, and
  - chemical defenses.

37.6 EVOLUTION CONNECTION: Herbivory leads to diverse adaptations in plants

- Plant defenses against herbivores include
  - spines and thorns and
  - chemical toxins, often the substances that we use medicinally or for other purposes.

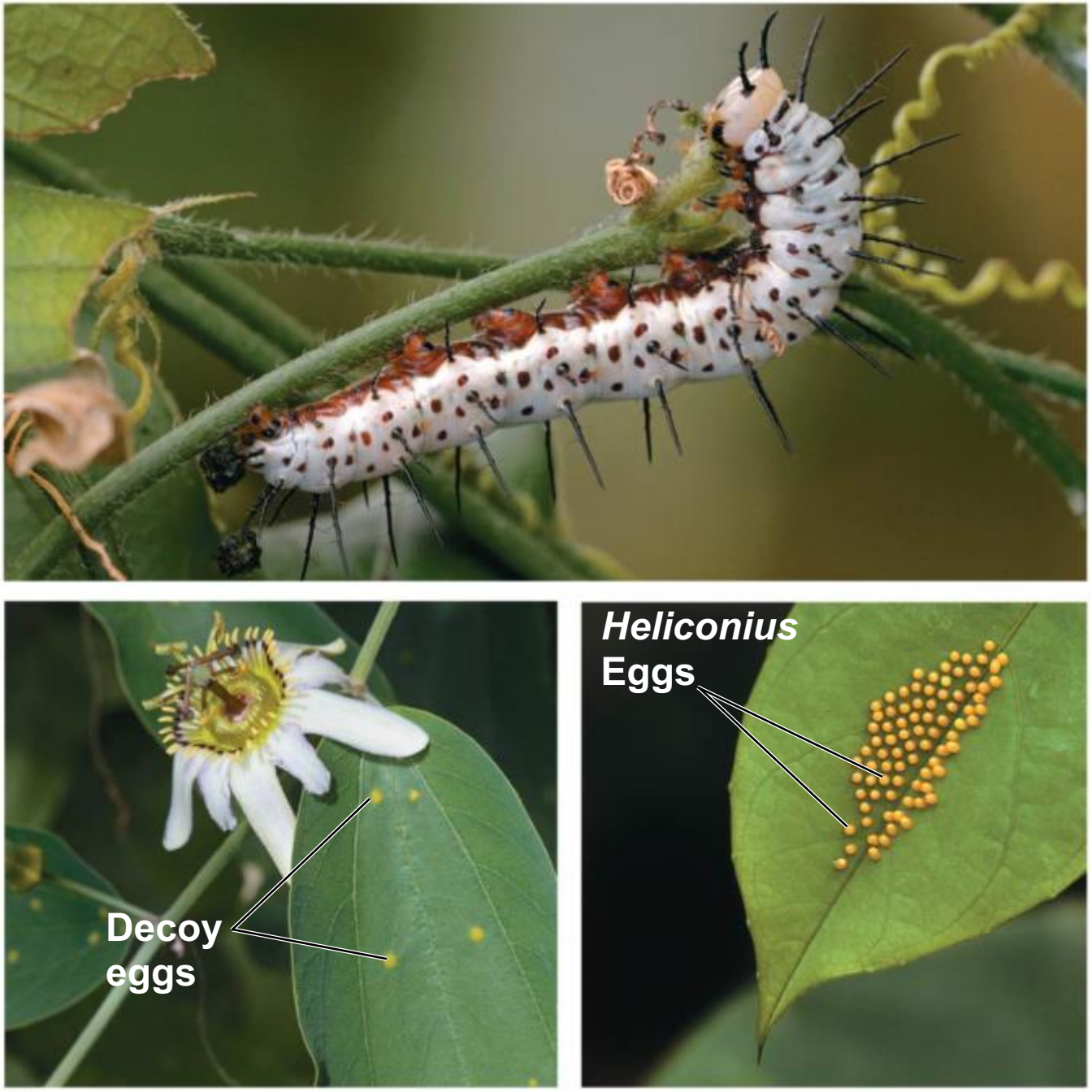
- “Secondary metabolites” (次級代謝物)
- Insect or pathogen resistance
- But human select against them
- A trade-off between crop quality vs. resistance

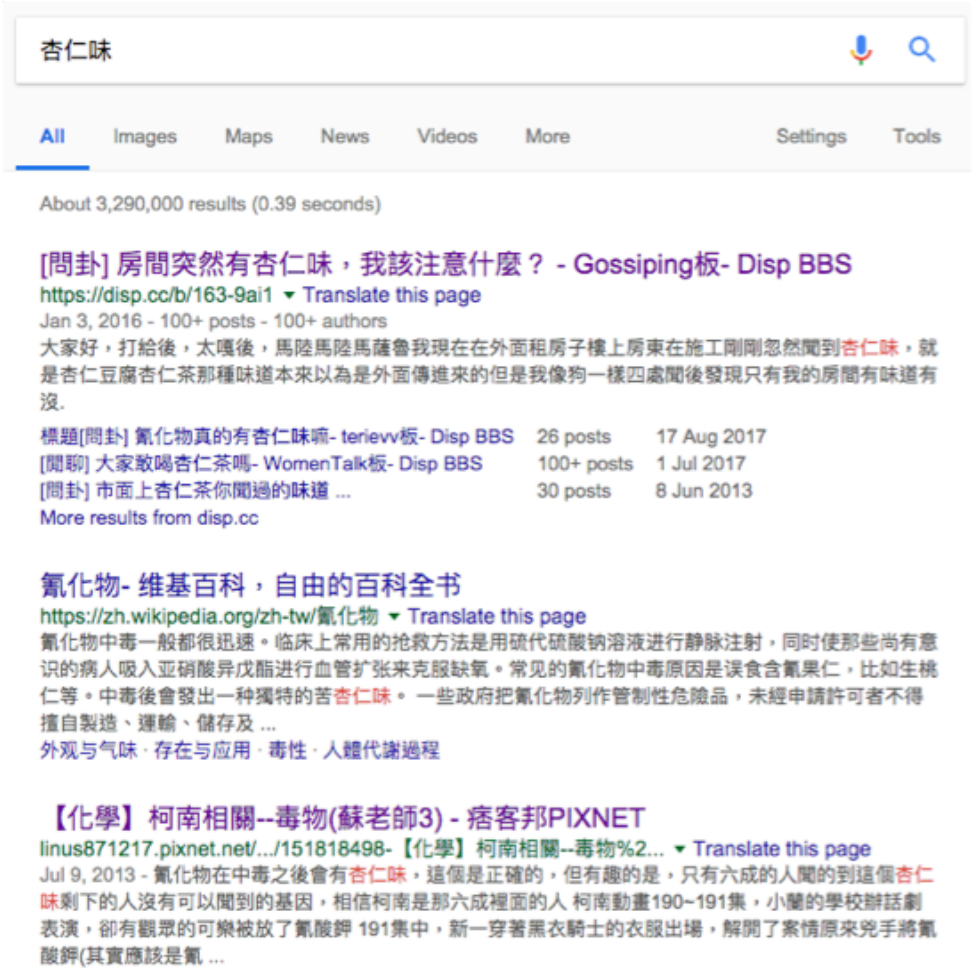
Solanaceae (茄科)

- Many plants are toxic, with alkaloids (生物鹼)
  - Solanine (龍葵鹼 in tomato & potato)
  - Nicotine (尼古丁 in tobacco), etc.
  - Many others…

- Herbivores and plants undergo **coevolution**, a series of reciprocal evolutionary adaptations in two species in which change in one species acts as a new selective force on another species, and the resulting adaptations of the second species in turn affect the selection of individuals in the first species.

Figure 37.6





- Cyanide
  - Bitter almonds
  - Peach
  - Apple
- Story: *Heliconius* and passionflower
- https://www.youtube.com/watch?v=1ZRMpqw7Ak0
- Related topic: Mimicry

Mimicry

***EVOLUTION 3e,* Figure 12.20**

Up: *Heliconius melpomene*
Down: *Heliconius erato*

Figure 37.7

Parasites

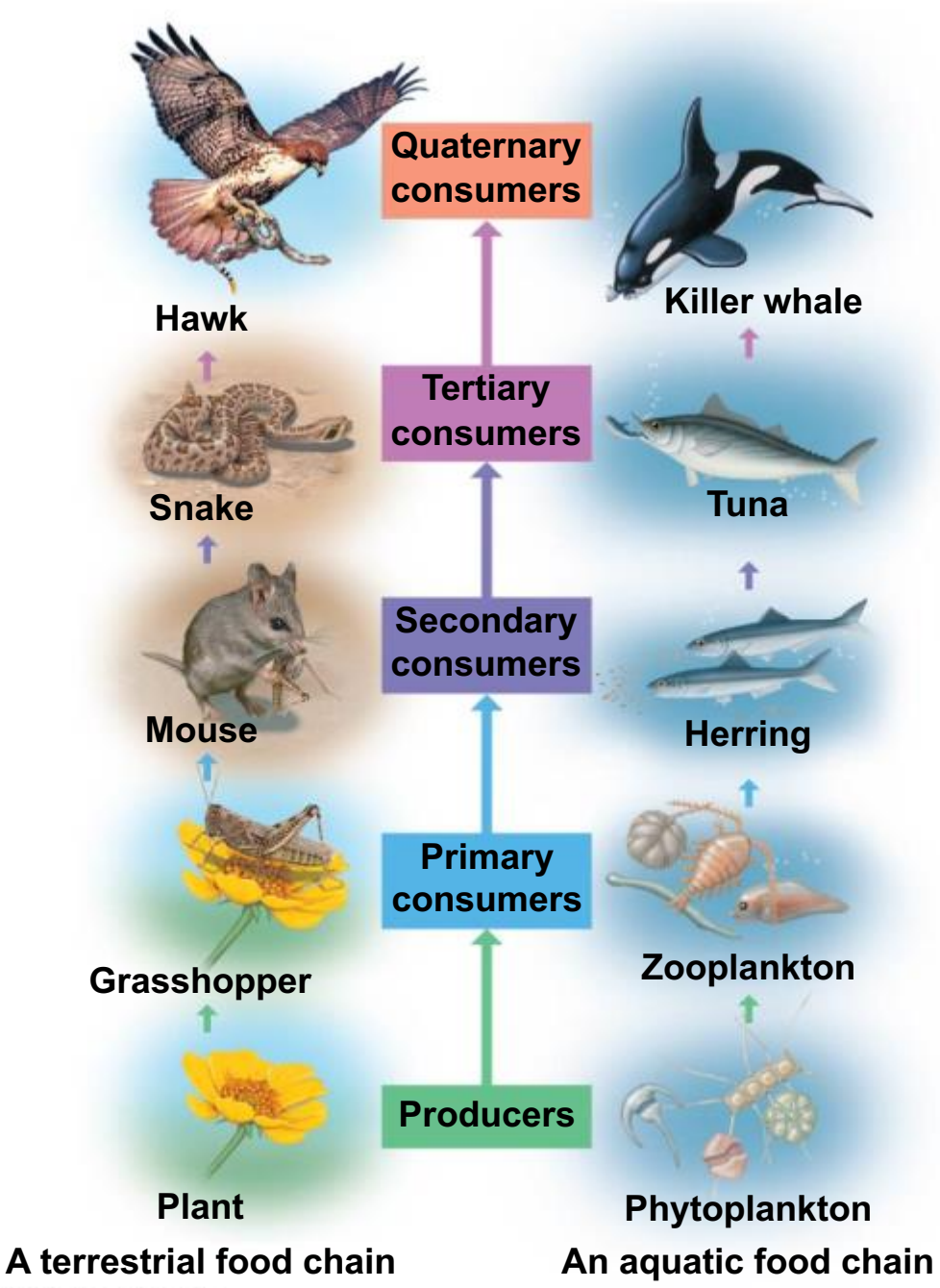
37.7 Parasites and pathogens can affect community composition

- Non-native pathogens can have rapid and dramatic impacts.
- Why?
  - The American chestnut was devastated by the chestnut blight protist.
  - A fungus-like pathogen is currently causing sudden oak death on the West Coast.

37.8 Trophic structure is a key factor in community dynamics

- Every community has a **trophic structure**, a pattern of feeding relationships consisting of several different levels.
  - The sequence of food transfer up the trophic levels is known as a **food chain**.
  - This transfer of food moves chemical nutrients and energy from producers up through the trophic levels in a community.

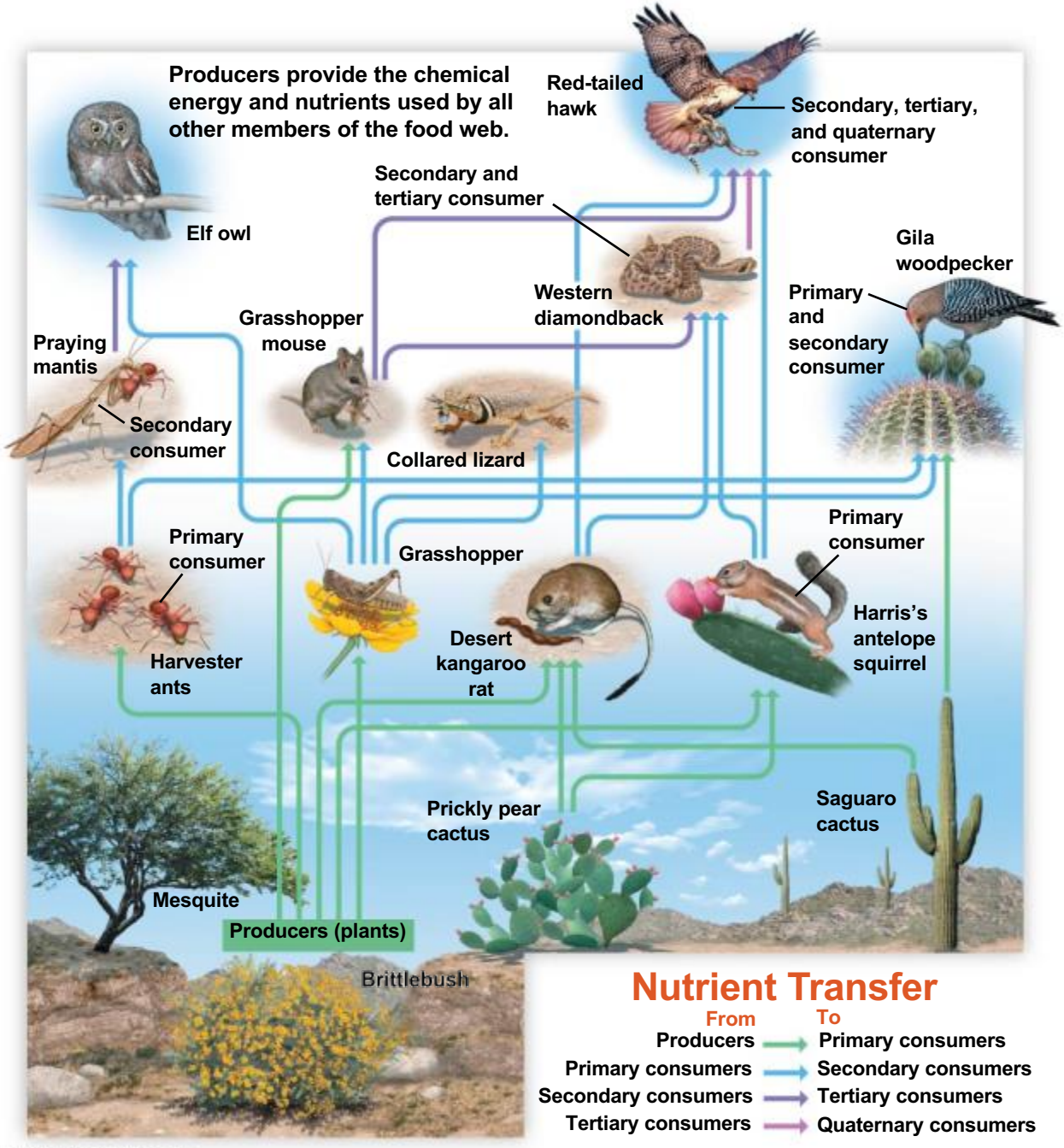
Figure 37.8



Don’t forget: decomposers

Figure 37.9-4

Food web



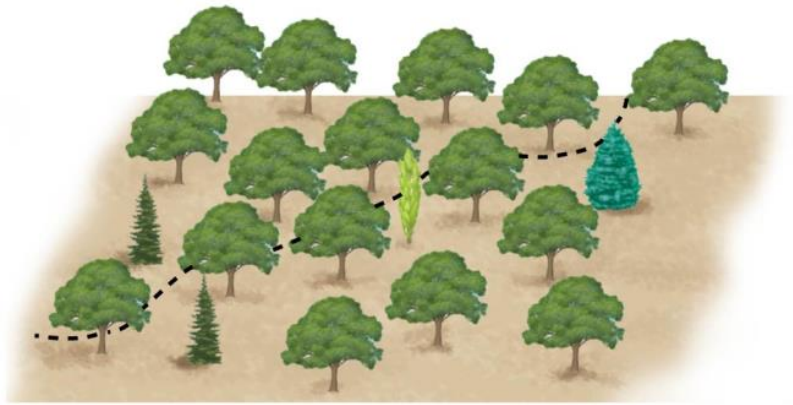
37.10 Species diversity includes relative abundance and species richness

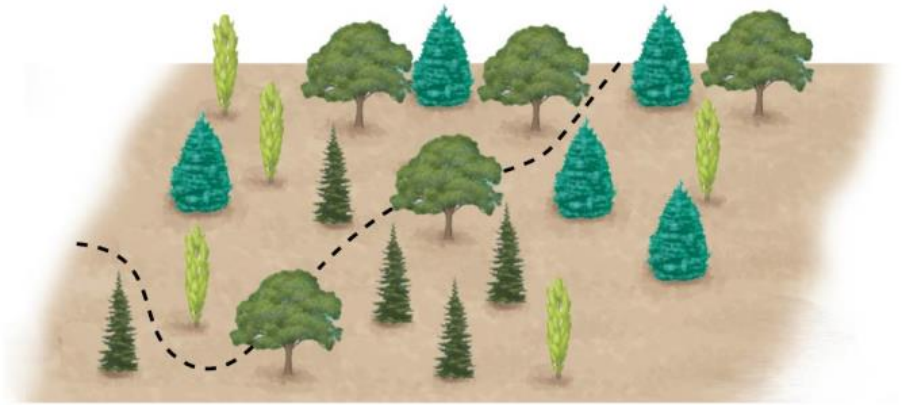
- **Species diversity** is defined by two components:
  1. species richness, the number of species in a community, and
  2. relative abundance, the proportional representation of a species in a community.

Table 37.10

TABLE 37.10 | RELATIVE ABUNDANCE OF TREE SPECIES IN WOODLOTS A AND B

Species	Relative Abundance in Woodlot A (%)	Relative Abundance in Woodlot B (%)
	80	25
	10	25
	5	25
	5	25



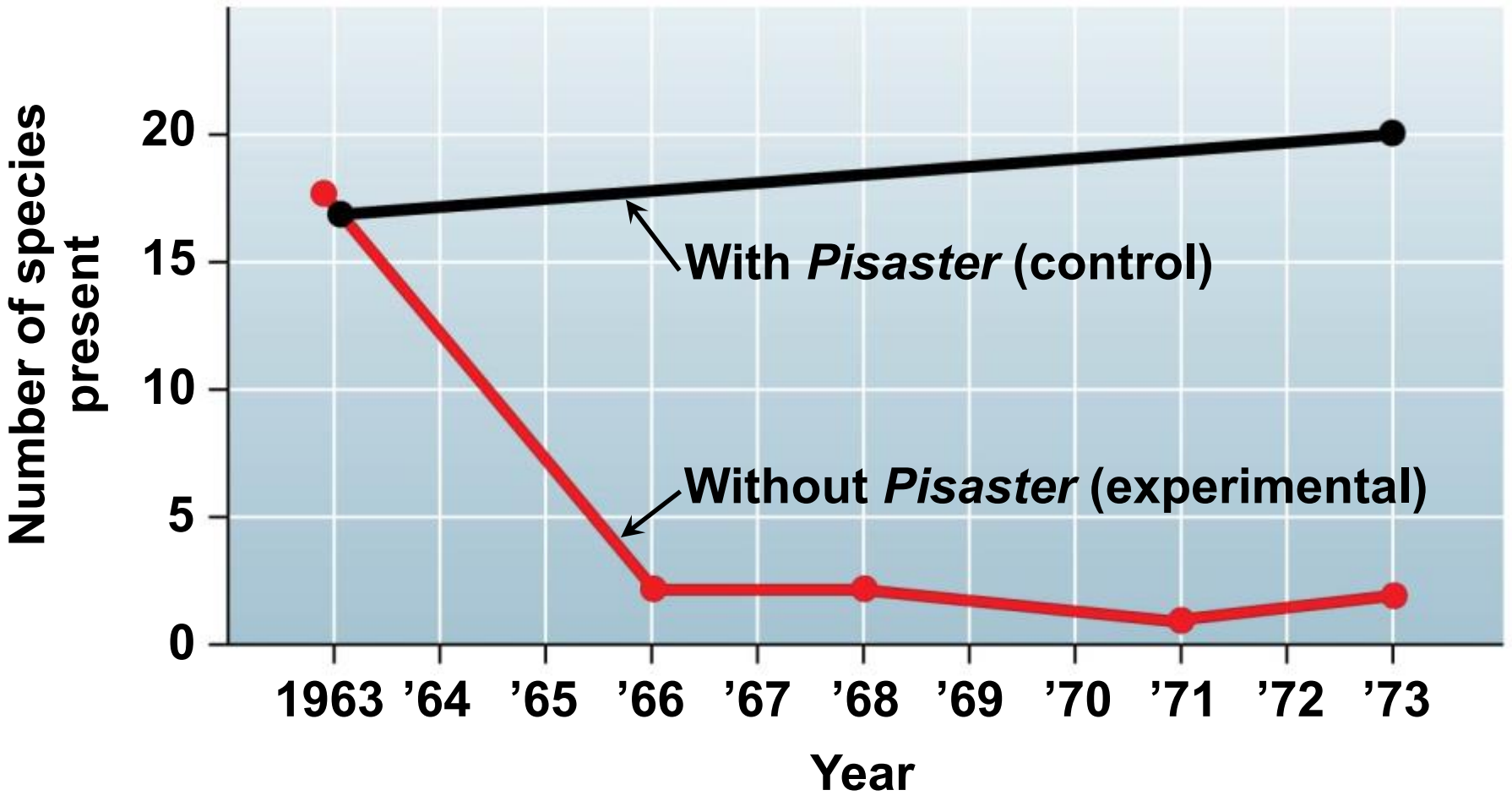


37.11 SCIENTIFIC THINKING: Some species have a disproportionate impact on diversity

- Ecologist Robert Paine hypothesized that the species diversity of a community is directly related to the ability of predators to prevent any one species from monopolizing local resources.
- To test this hypothesis, Paine
  - manually removed a predatory sea star known as *Pisaster* from certain areas of the intertidal zone,
  - left comparable areas intact as controls, and
  - determined the species richness of these experimental and control areas

Figure 37.11a

Figure 37.11b



Data from R.T. Paine, Food web complexity and species diversity, *American Naturalist* 100:65–75 (1996).

37.11 SCIENTIFIC THINKING: Some species have a disproportionate impact on diversity

- What accounted for the dramatic change?
  - A mussel of the genus *Mytilus* proved to be a superior competitor for the available space, eliminating most other invertebrates and algae.
  - In the control areas, population growth of *Mytilus* was suppressed by *Pisaster*.
  - Thus, interspecific interactions can be an important factor in the species diversity of a community.

Figure 37.11c

37.11 SCIENTIFIC THINKING: Some species have a disproportionate impact on diversity

- Paine's experiment and others like it gave rise to the concept of a **keystone species**, defined as a species
  - whose impact on its community is larger than its biomass or abundance indicates and
  - that occupies a niche that holds the rest of its community in place.

How wolves change rivers

- https://www.youtube.com/watch?v=ysa5OBhXz-Q
- https://dq.yam.com/post.php?id=6795
- https://www.nature.com/news/rethinking-predators-legend-of-the-wolf-1.14841
- https://www.nytimes.com/2014/03/10/opinion/is-the-wolf-a-real-american-hero.html

37.12 Disturbance is a prominent feature of most communities

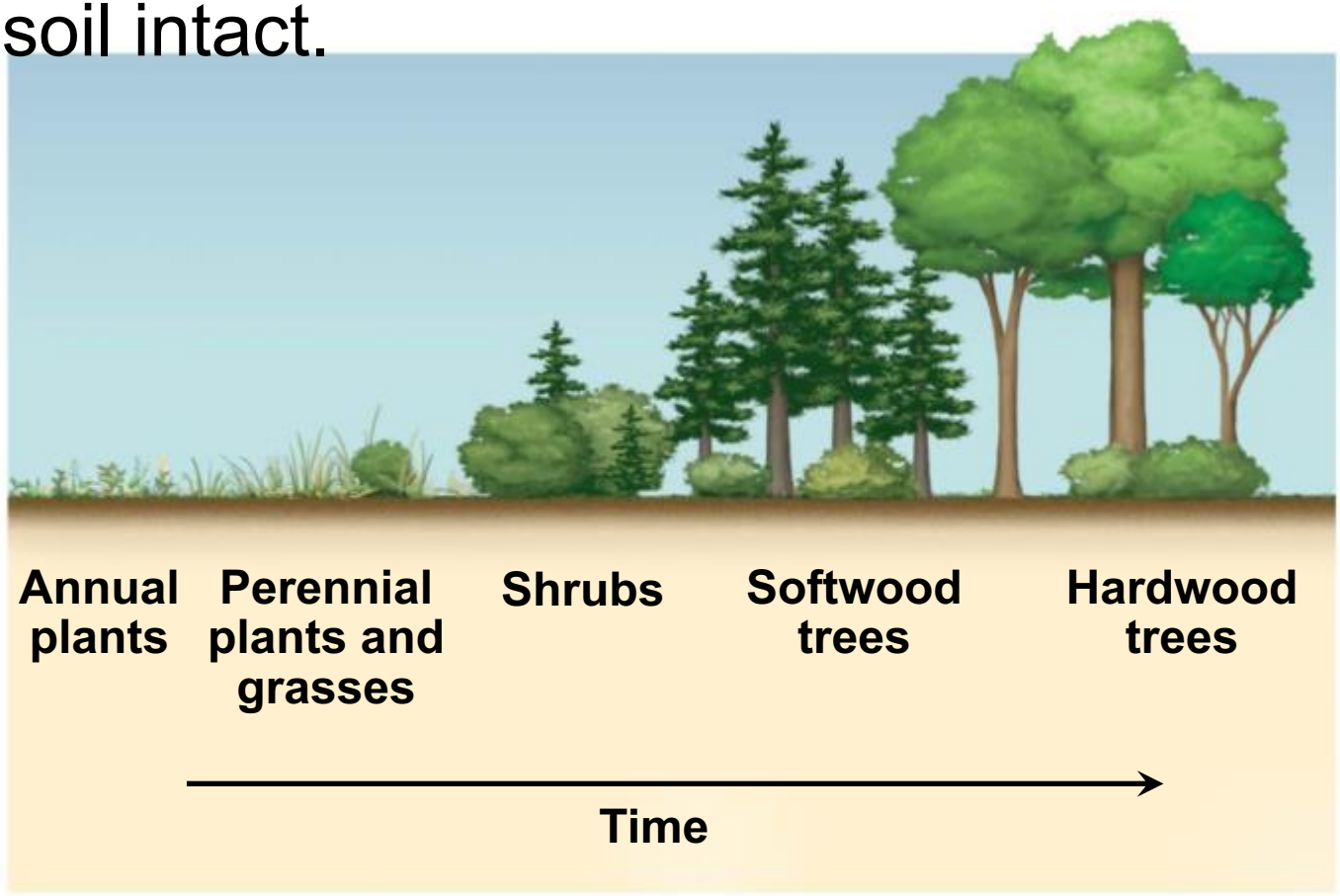
- **Disturbances**
  - are events that damage biological communities and
  - include storms, fires, floods, drought, and human activity.
- The disturbed area may be colonized by a variety of species, which are gradually replaced by a succession of other species, in a process called **ecological succession**.

37.12 Disturbance is a prominent feature of most communities

- **Primary succession** begins in a virtually lifeless area with no soil.

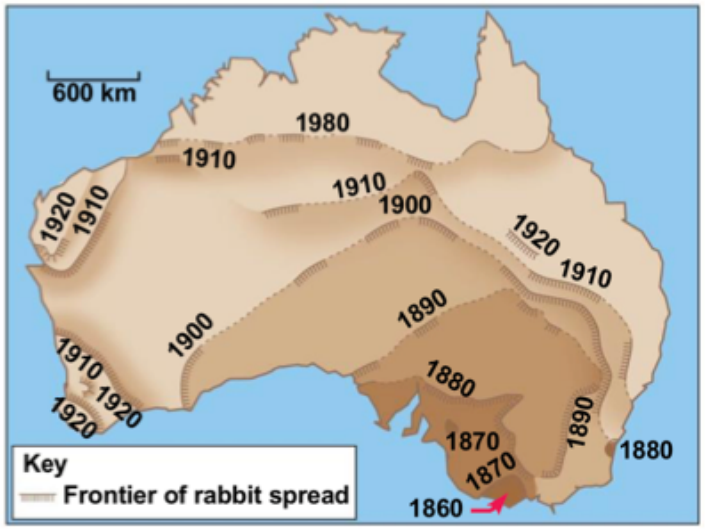
37.12 Disturbance is a prominent feature of most communities

- **Secondary succession** occurs when a disturbance destroys an existing community but leaves the soil intact.



37.13 CONNECTION: Invasive species can devastate communities

- **Invasive species**
  - are organisms that have been introduced into non-native habitats by human actions and
- The absence of natural enemies often allows rapid population growth of invasive species.

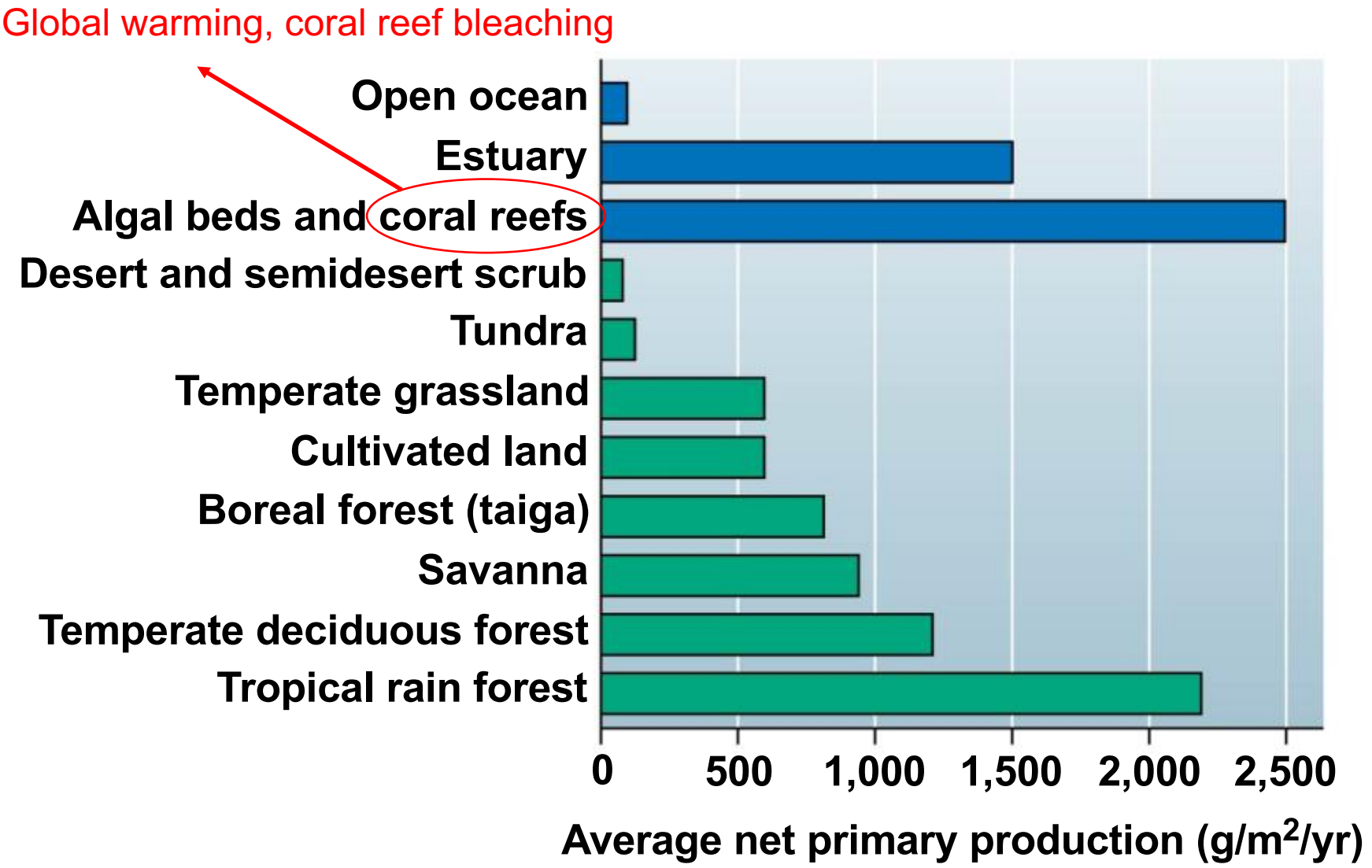


Ecosystem Structure and Dynamics

37.14 Ecosystem ecology emphasizes energy flow and chemical cycling

- An **ecosystem** consists of
  - all the organisms in a community and
  - the abiotic environment with which the organisms interact.
- In an ecosystem,
  - **energy flow** moves *through* the components of an ecosystem and
  - **chemical cycling** is the transfer of materials *within* the ecosystem.

Figure 37.15



Data from R.H. Whittaker, *Communities and Ecosystems*, second edition, New York: Macmillan (1975).

Figure 37.16a

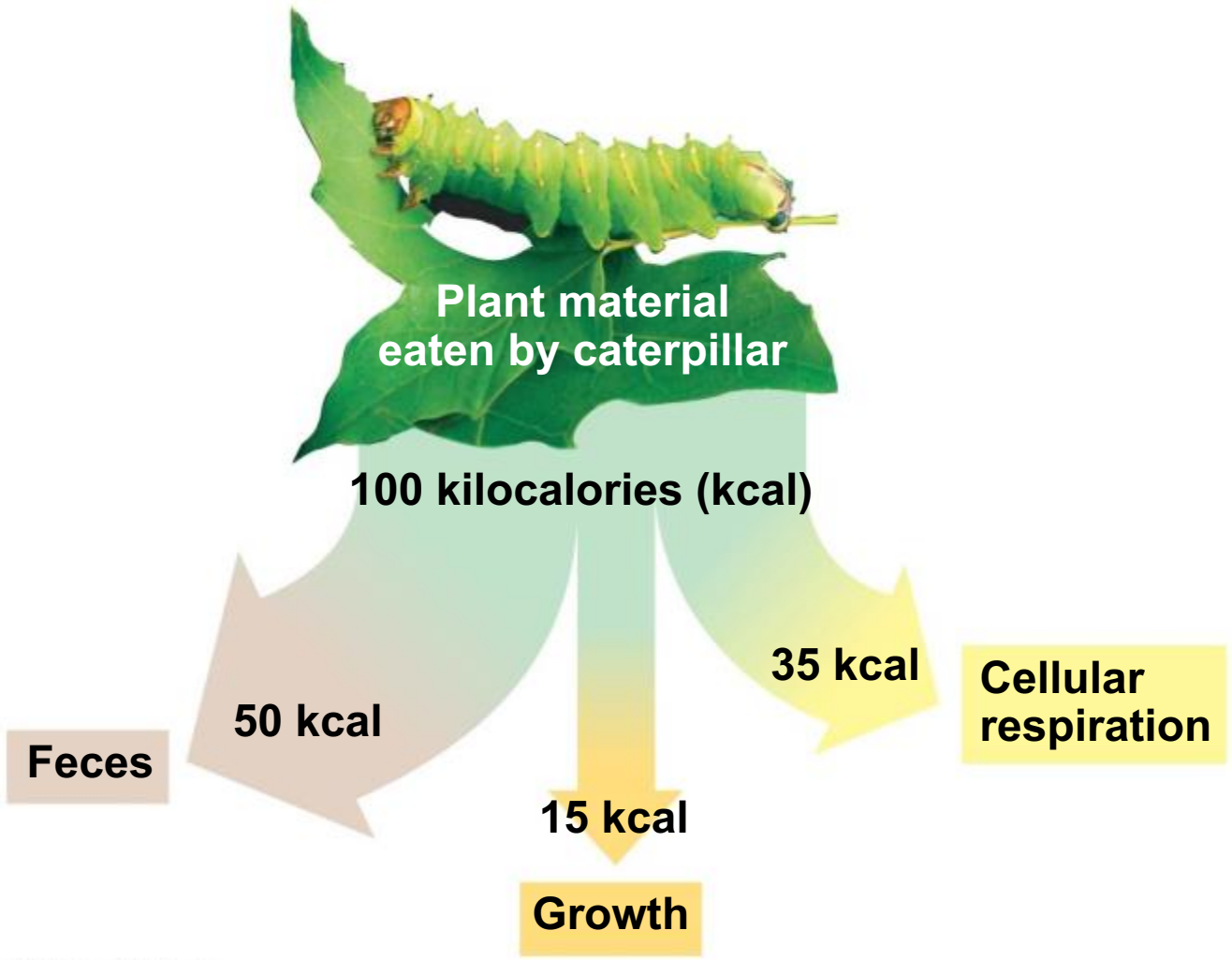


Figure 37.16b

The 10% rule

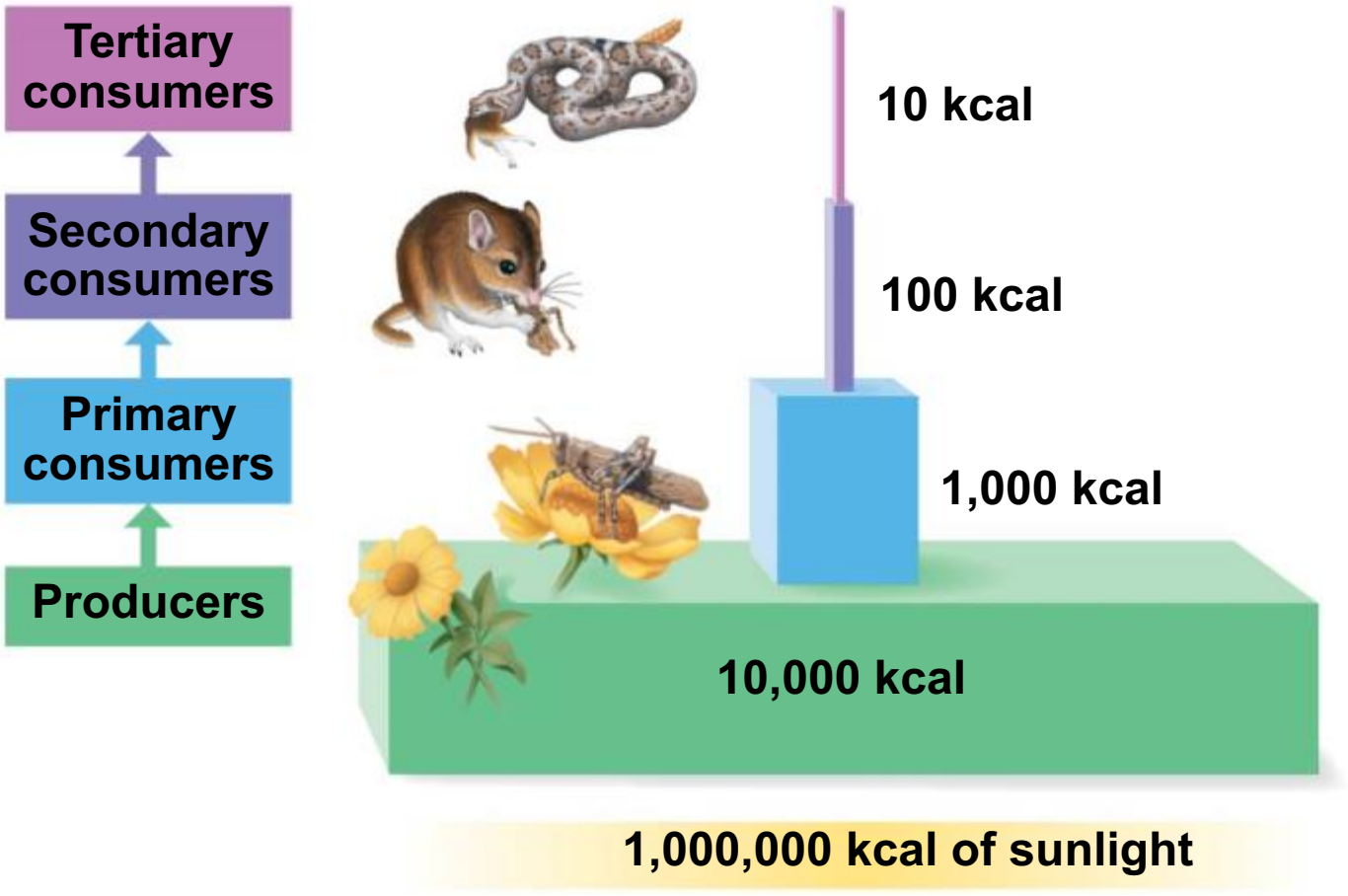


Figure 37.19

Biogeochemical cycles

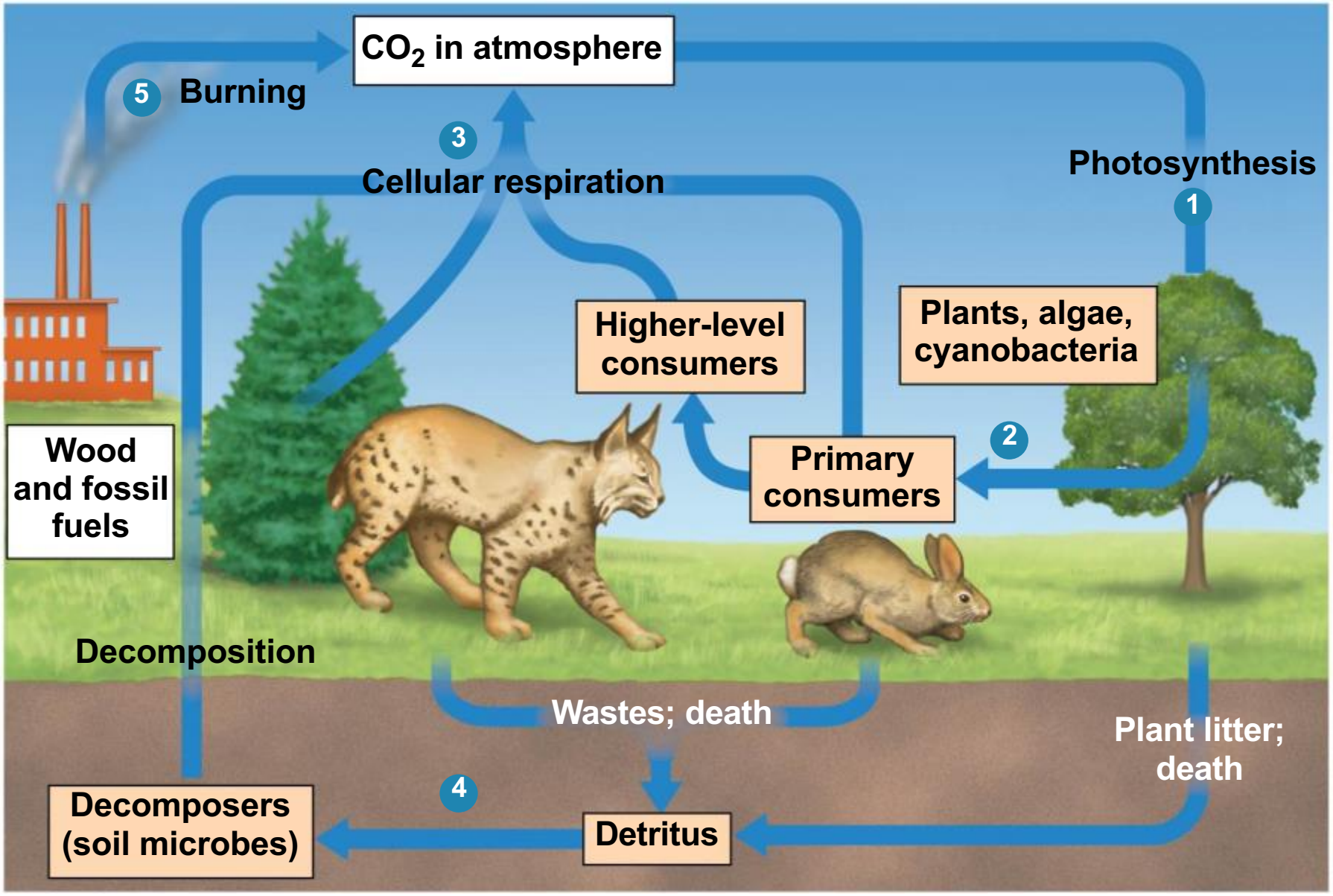
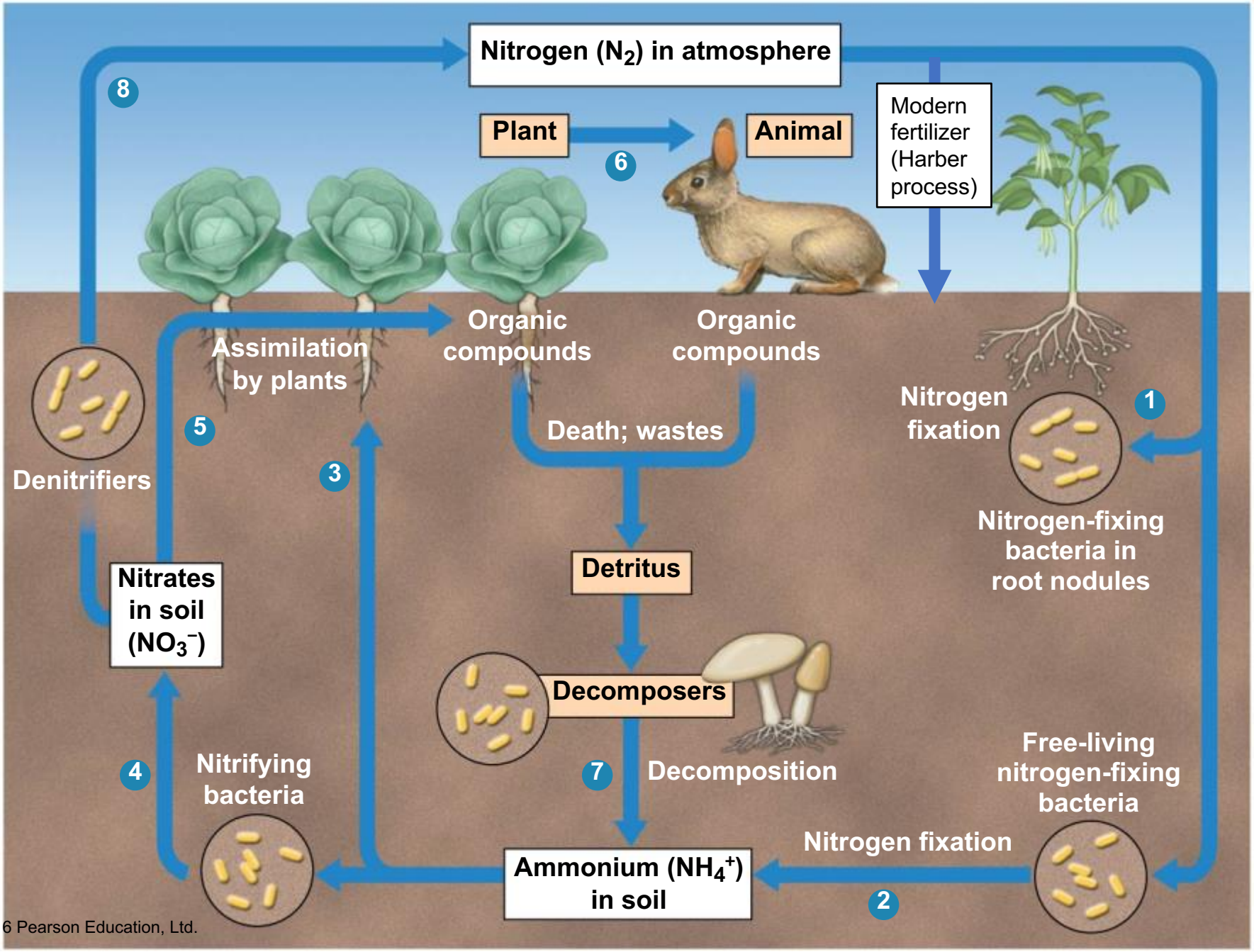


Figure 37.21

Biogeochemical cycles

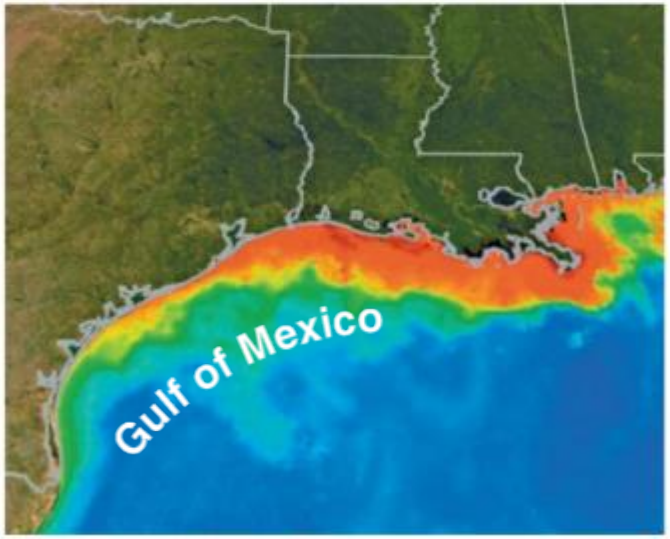


37.22 CONNECTION: A rapid inflow of nutrients degrades aquatic ecosystems

- In aquatic ecosystems, primary production is limited by low nutrient levels of
  - phosphorus (P)
  - Nitrogen (N)
- Too much P and N ? Eutrophication
- Eutrophication of lakes, rivers, and coastal waters
  - depletes oxygen levels and
  - decreases species diversity.

Figure 37.22b

Winter



Summer

Nitrogen runoff from Midwestern farm fields

Color: Concentrations of phytoplankton