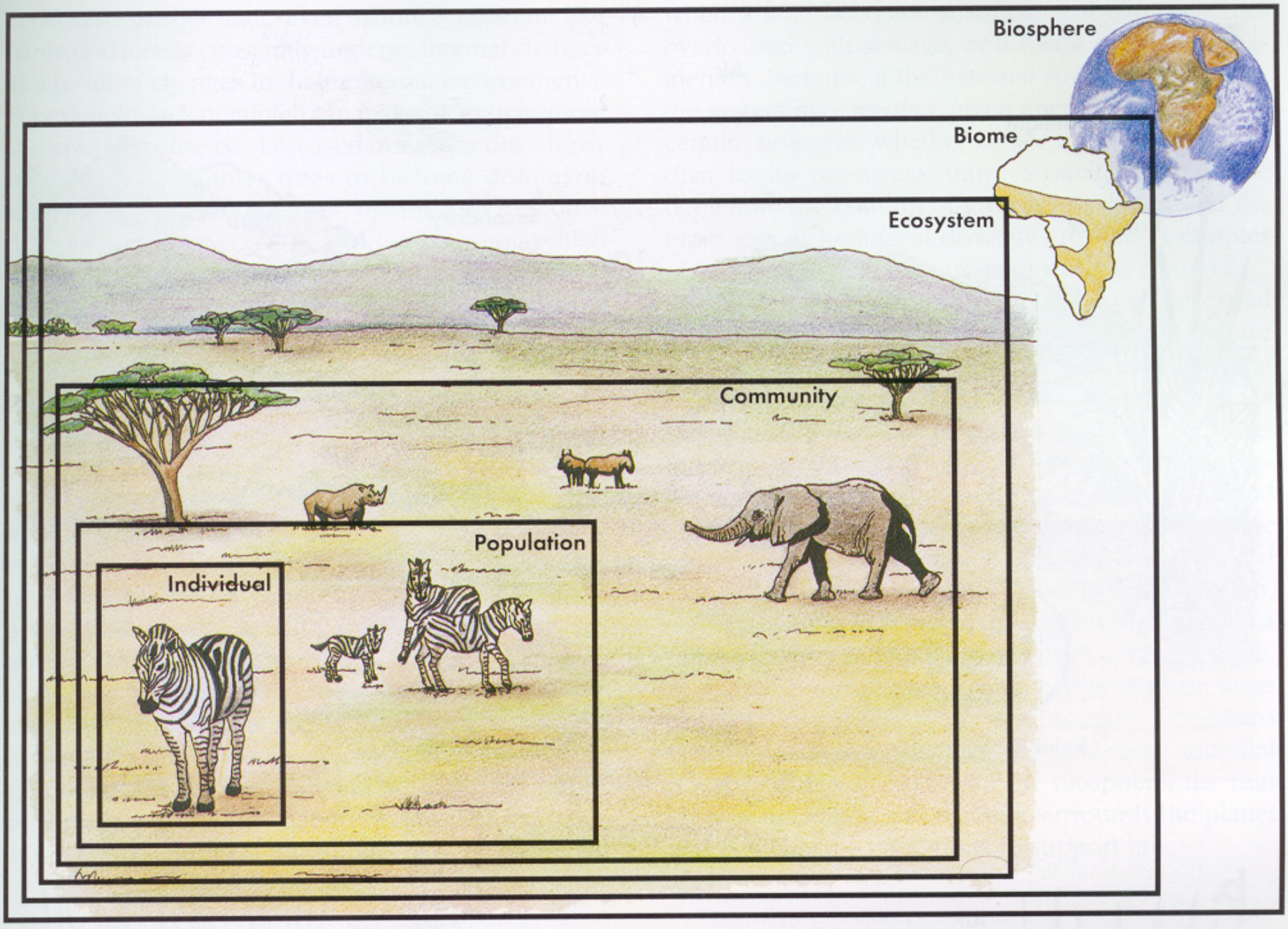
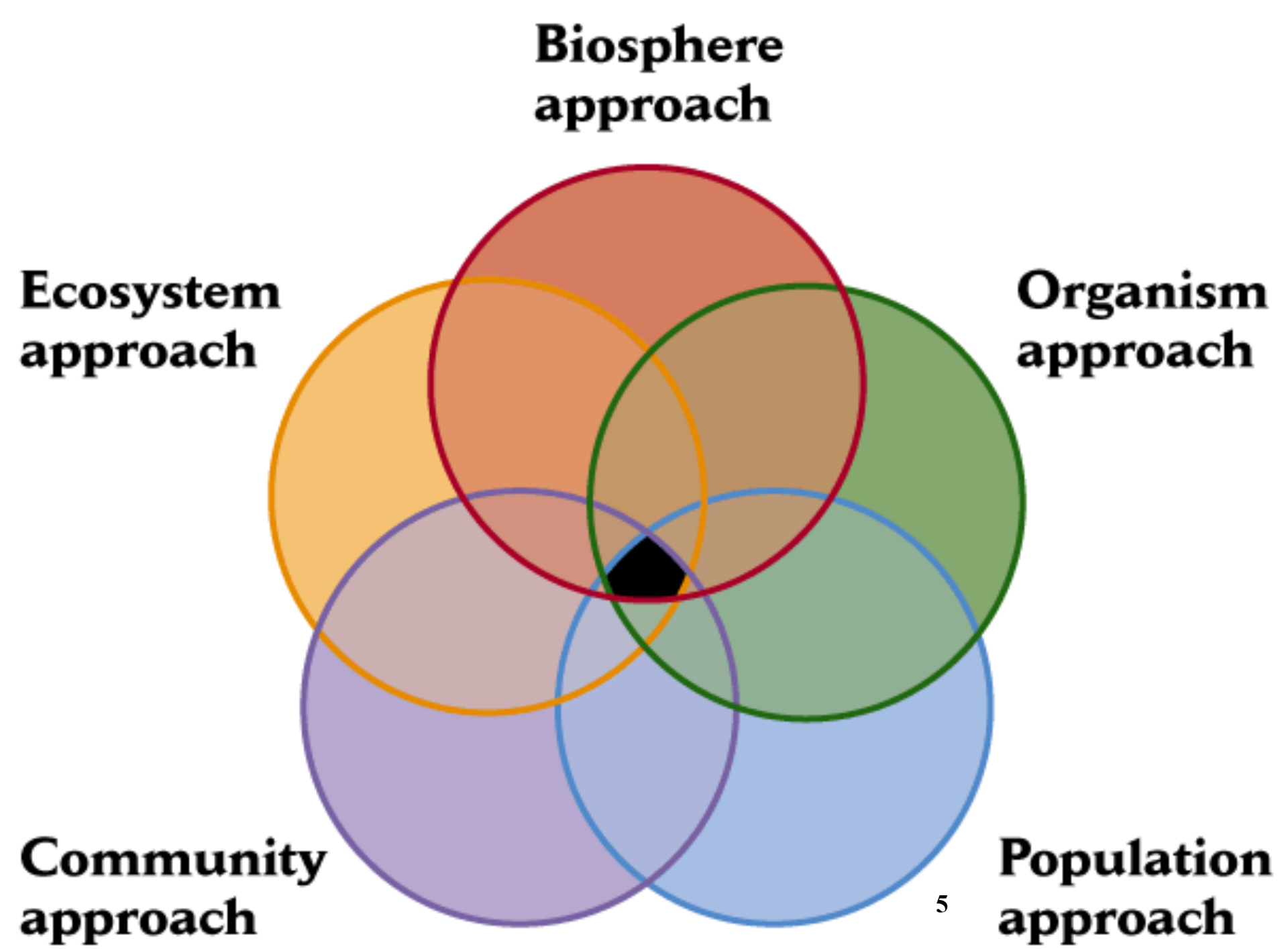
Robert Paine

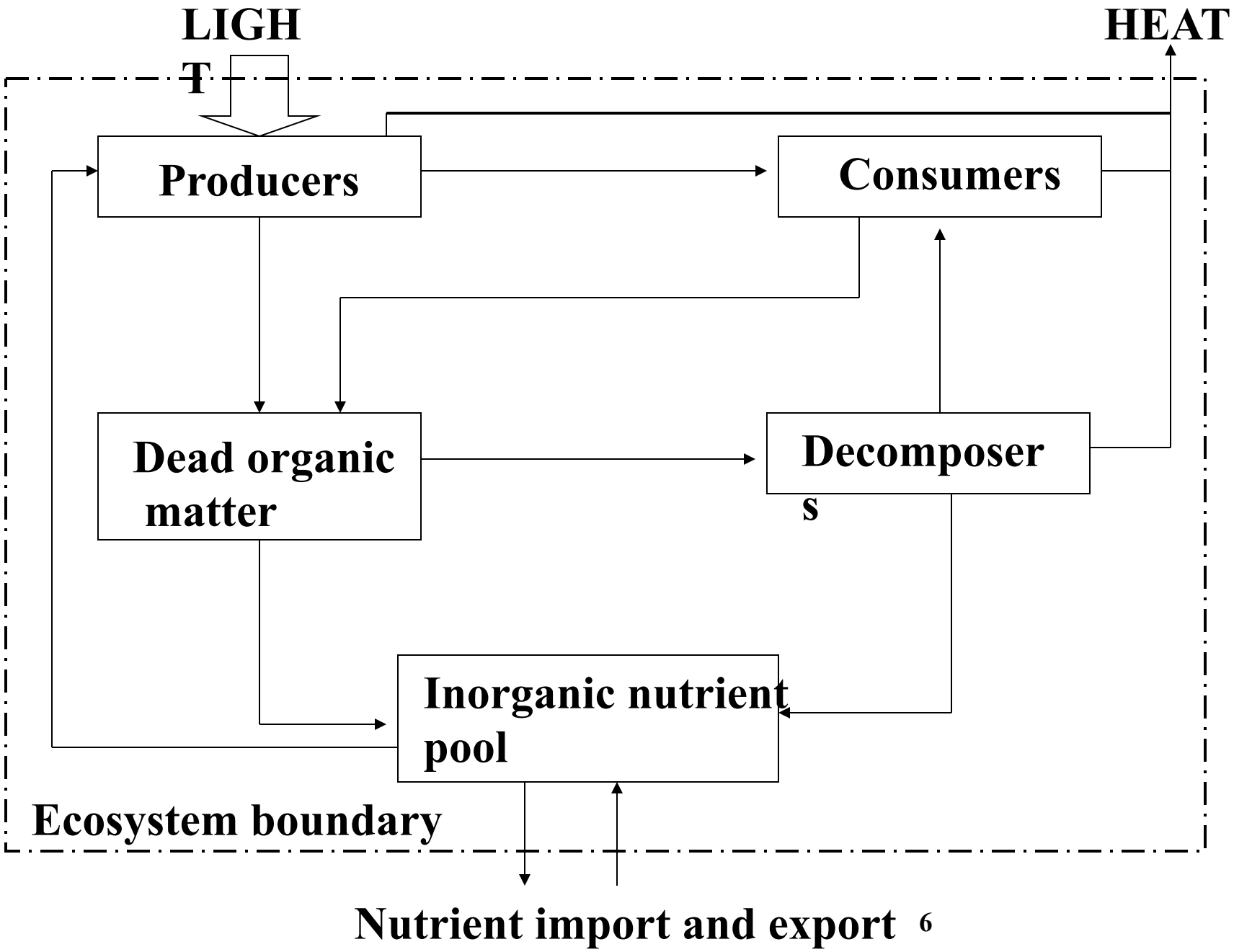
1933 – 2016

An Introduction to Ecology and the Biosphere

- **Ecology**
  - **is the scientific study of the interactions between organisms and the environment**
    - **these interactions determine distribution and abundance**
  - ***oikos* (from Gr.) meaning *household, home or place to live***


Biosphere
Biome
Ecosystem
Community
Population
Individual

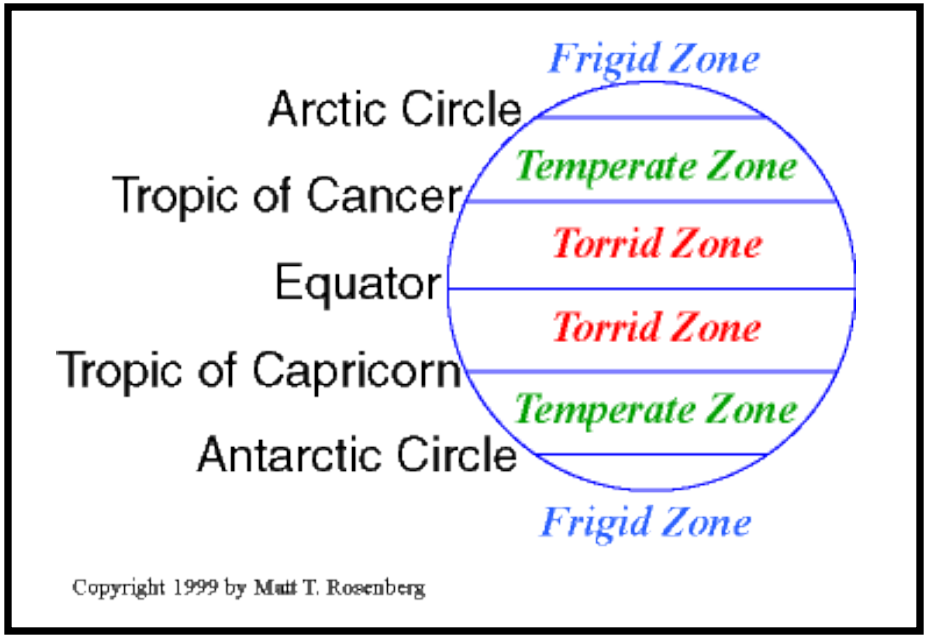

Biosphere approach
Ecosystem approach
Organism approach
Community approach
Population approach

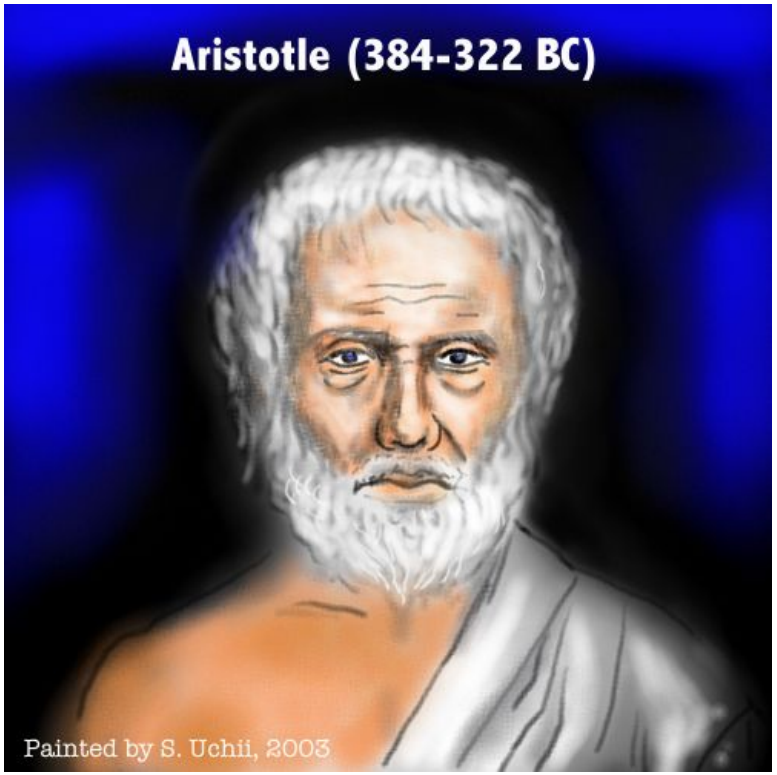

LIGHT
HEAT
Producers
Consumers
Dead organic matter
Decomposers
Inorganic nutrient pool
Ecosystem boundary
Nutrient import and export

Ecology

– has a long history as a descriptive science

Aristotle's climate classification





Ecology

- **today is also a rigorous experimental science**

Predator exclusion cage Sham No cage

Ecology

– **is a highly quantitative science**

Ecology and Evolutionary Biology

- **events that occur in ecological time**
  - **affect life on the scale of evolutionary time**

excerpted from

Begon, M., C.R. Townsend, and J.L. Harper. 2006. Ecology: from individuals to ecosystems. Blackwell Publishing, pp. 577.

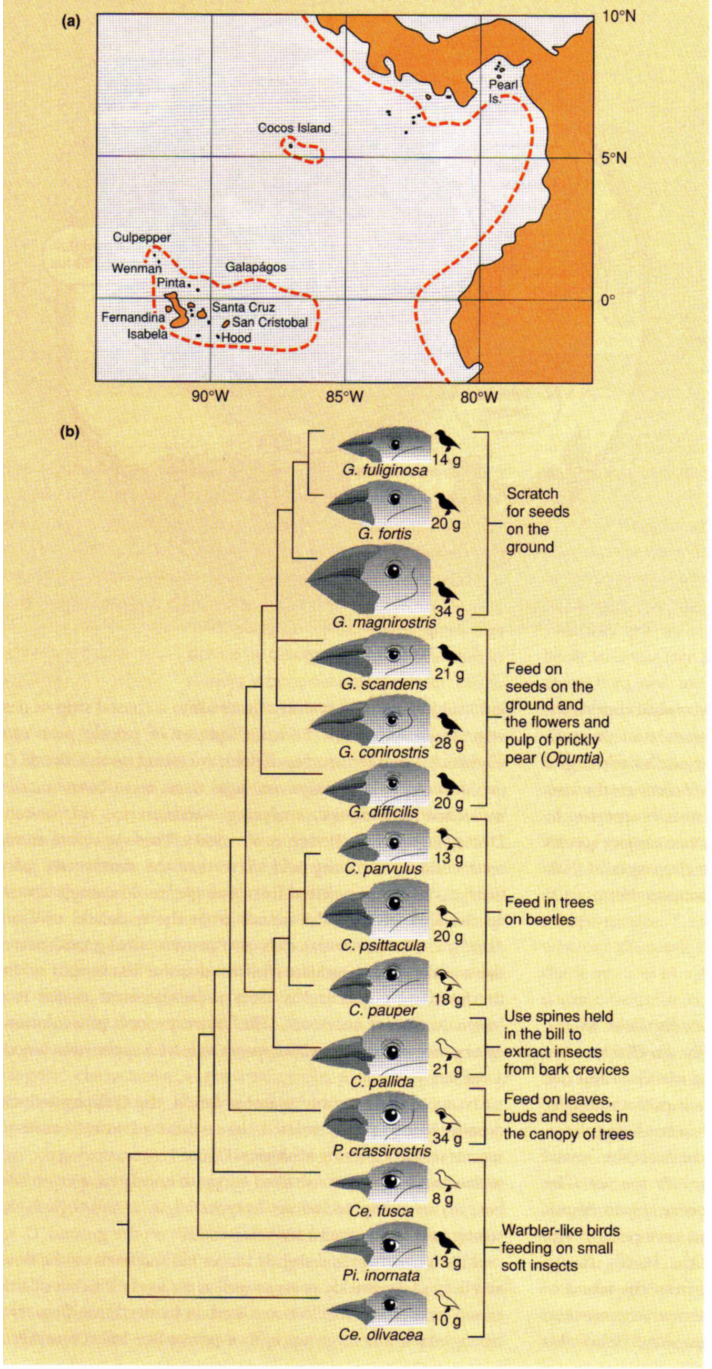
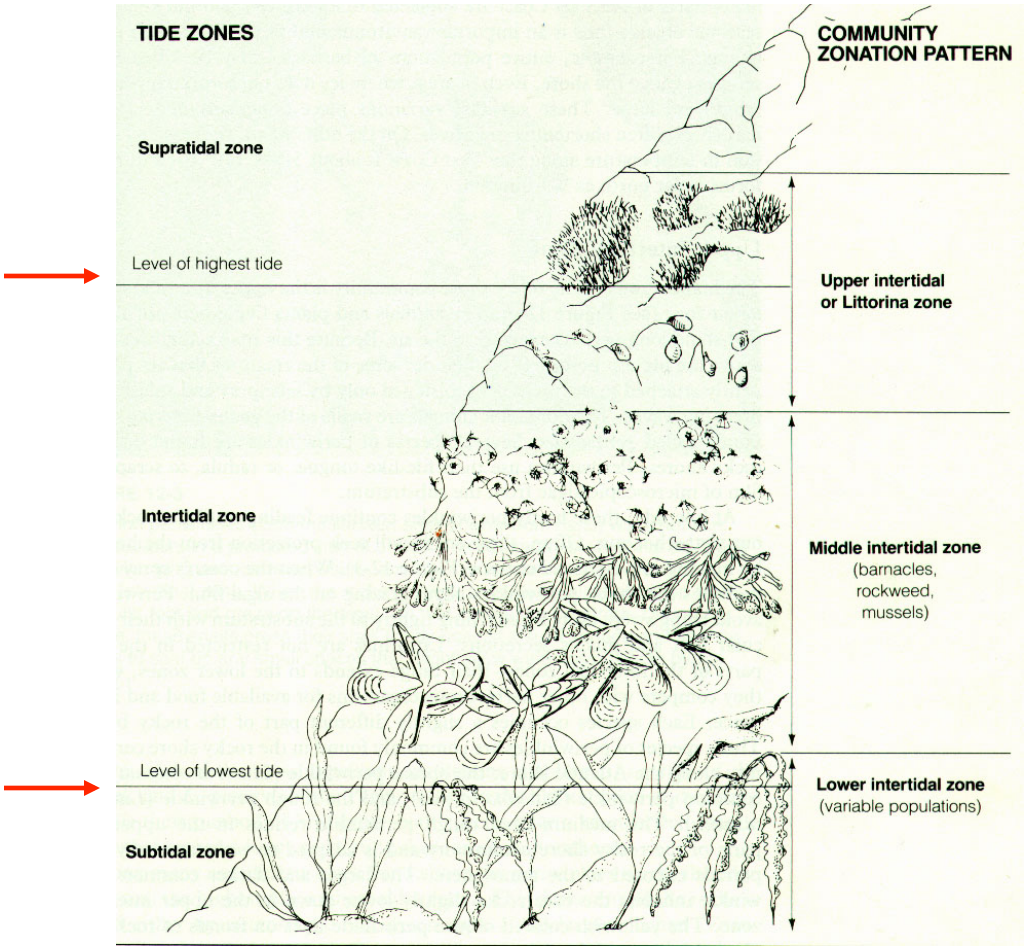


Figure 1.9 (a) Map of the Galápagos Islands showing their position relative to Central America; on the equator 5° equals approximately 560 km. (b) A reconstruction of the evolutionary history of the Galápagos finches based on variation in the length of microsatellite deoxyribonucleic acid (DNA). The feeding habits of the various species are also shown. Drawings of the birds are proportional to actual body size. The maximum amount of black coloring in male plumage and the average body mass are shown for each species. The *genetic distance* (a measure of the genetic difference) between species is shown by the length of the horizontal lines. Notice the great and early separation of the warbler finch (*Certhidea olivacea*) from the others, suggesting that it may closely resemble the founders that colonized the islands. C, *Camarhynchus*; Ce, *Certhidea*; G, *Geospiza*; P, *Platyspiza*; Pi, *Pinaroloxias*. (After Petren *et al.*, 1999.)

Organisms and the Environment

the environment of any organism includes

- **abiotic, or nonliving components**
- **biotic, or living components**



general zonations determined by relative lengths of exposure to the air and to the action of waves

Subfields of Ecology

- **organismal ecology**
  - **how do individuals interact with each other and the physical environment?**

Are Catalina bison suffering from malnutrition?

Population ecology

- **how and why does population size change over time?**

What fraction of potential kelp bass parents successfully reproduce each year?

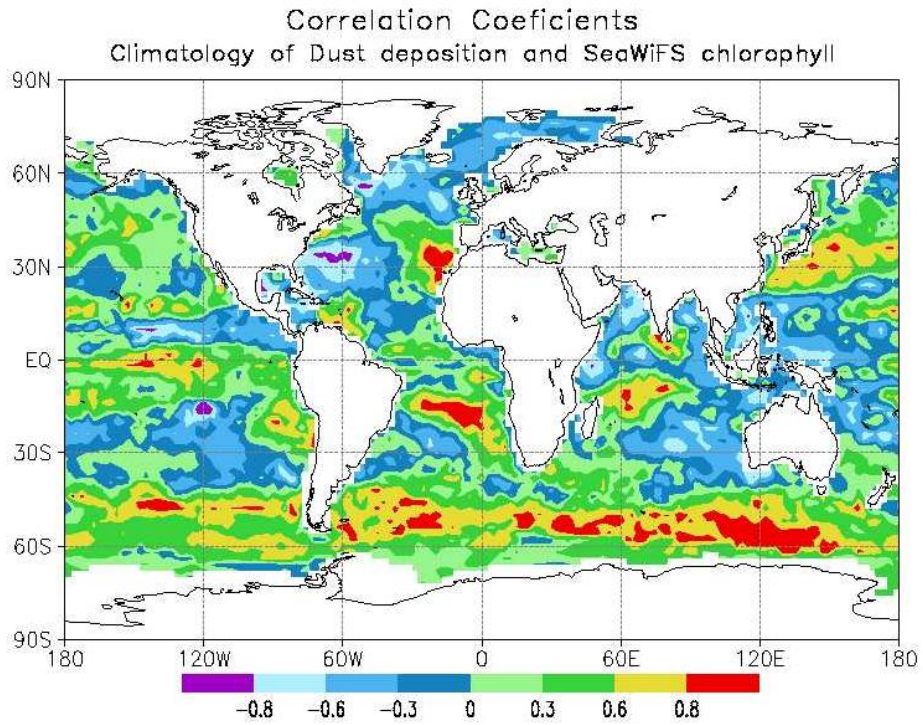
Community ecology

– **how do species interact and with what consequences?**

Will hunting pigs on Santa Cruz I. save the foxes?

Ecosystem ecology

- **emphasizes energy flow and chemical cycling among the various biotic and abiotic components**



Will seeding the ocean with iron increase algal growth, absorb greenhouse gases and cool the planet?

Landscape ecology

- deals with arrays of ecosystems and how they are arranged in a geographic region

To what extent do trees lining drainage channels serve as dispersal corridors?

Ecology ≠ Environmentalism

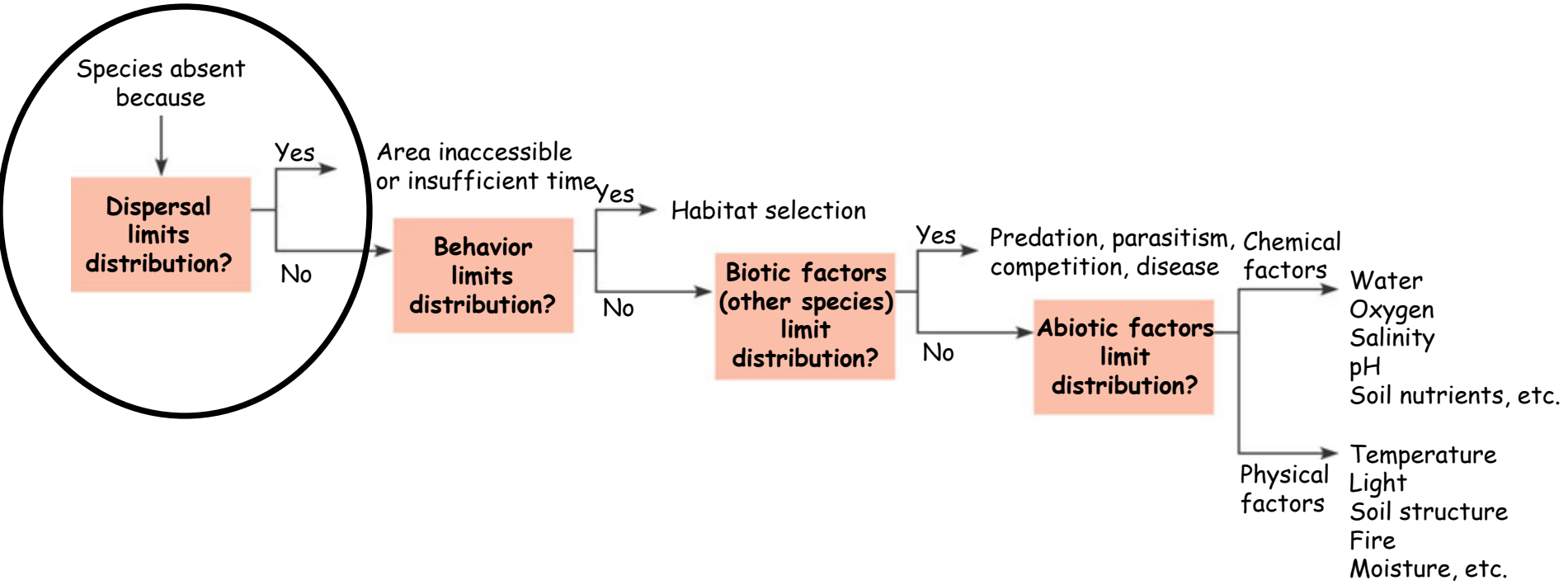
- **Ecologists**
  - **provides the scientific understanding underlying environmental issues**
- **Environmentalists**
  - **advocate for environmental protection**

Rachel Carson

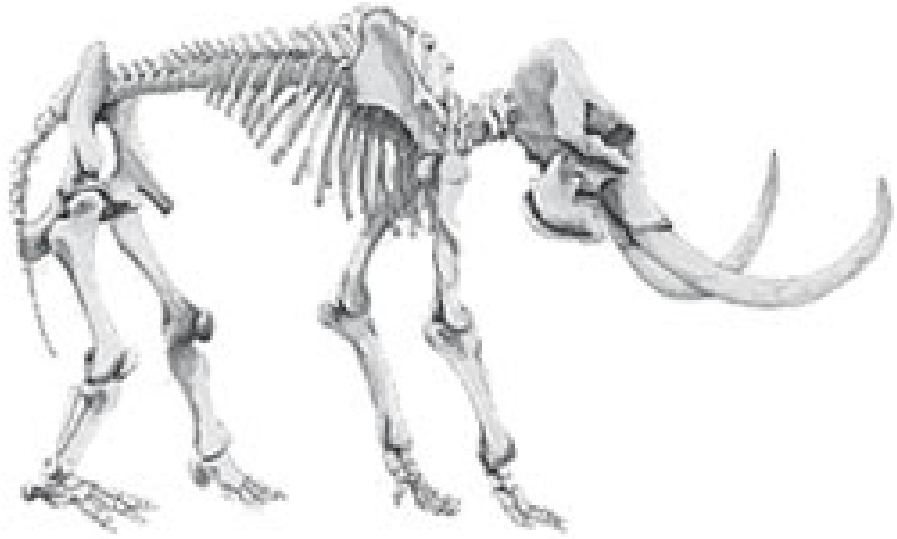
Why do species live where they do?

Biogeography

- provides a good starting point for understanding what limits the geographic distribution of species



Dispersal may explain why pigmy mammoths lived on N. Channel Islands but not S. Channel Islands



Biogeography

- provides a good starting point for understanding what limits the geographic distribution of species

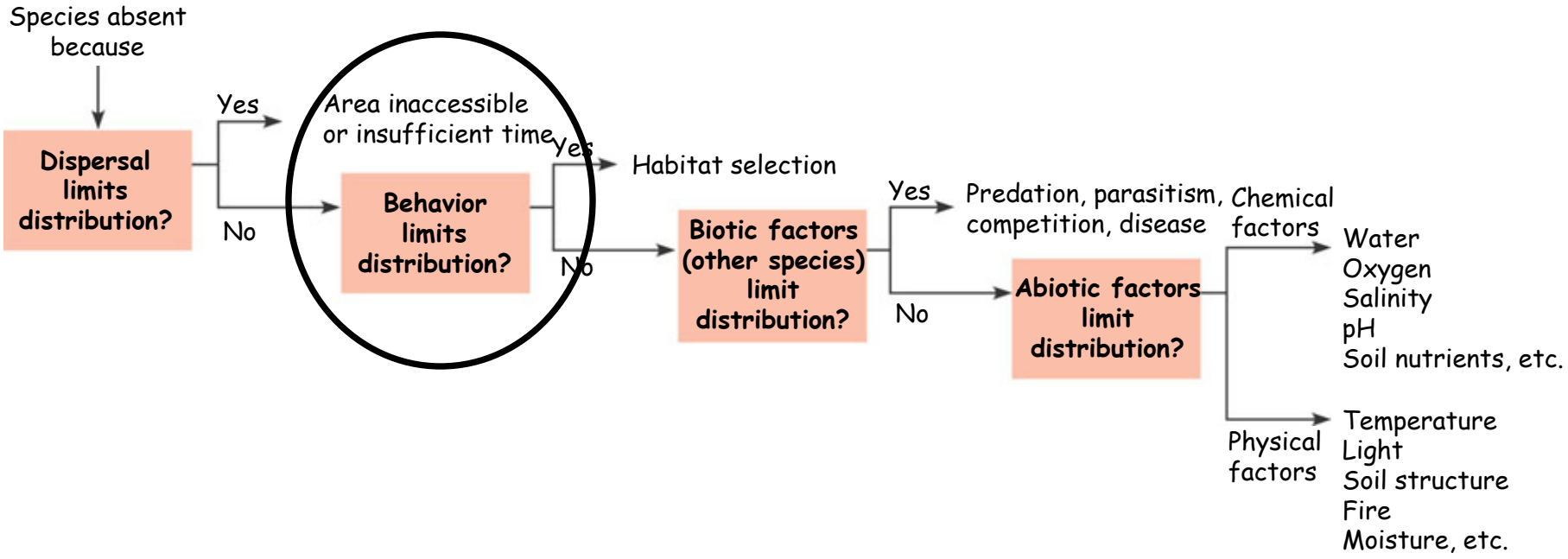
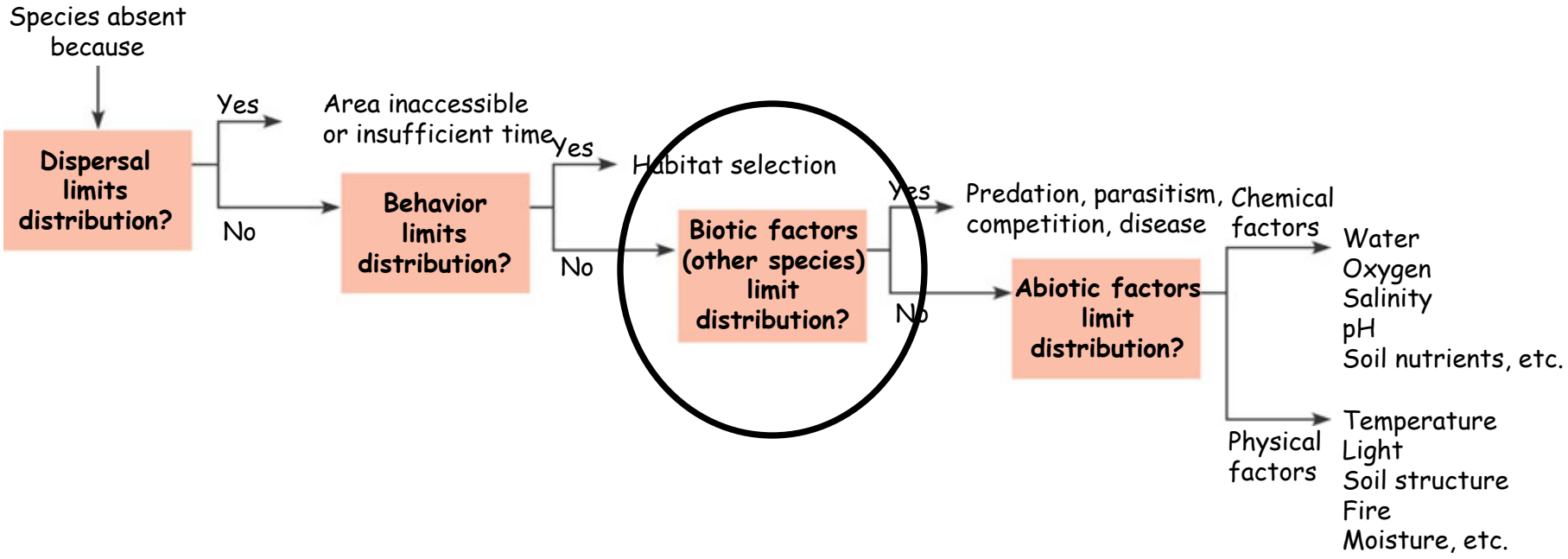


Figure 50.6, 1084

Sea otters could disperse to San Nicolas Is., but they don't want to stay there

Biogeography

- provides a good starting point for understanding what limits the geographic distribution of species



Biotic Factors

- **biotic factors limiting distribution include:**
  - **presence of predators, parasites, competitor(s), disease**
  - **absence of prey, pollinators, symbionts**

A specific case of an herbivore limiting distribution of a food species

EXPERIMENT W. J. Fletcher tested the effects of two algae-eating animals, sea urchins and limpets, on seaweed abundance near Sydney, Australia. In areas adjacent to a control site, either the urchins, the limpets, or both were removed.

RESULTS Fletcher observed a large difference in seaweed growth between areas with and without sea urchins.

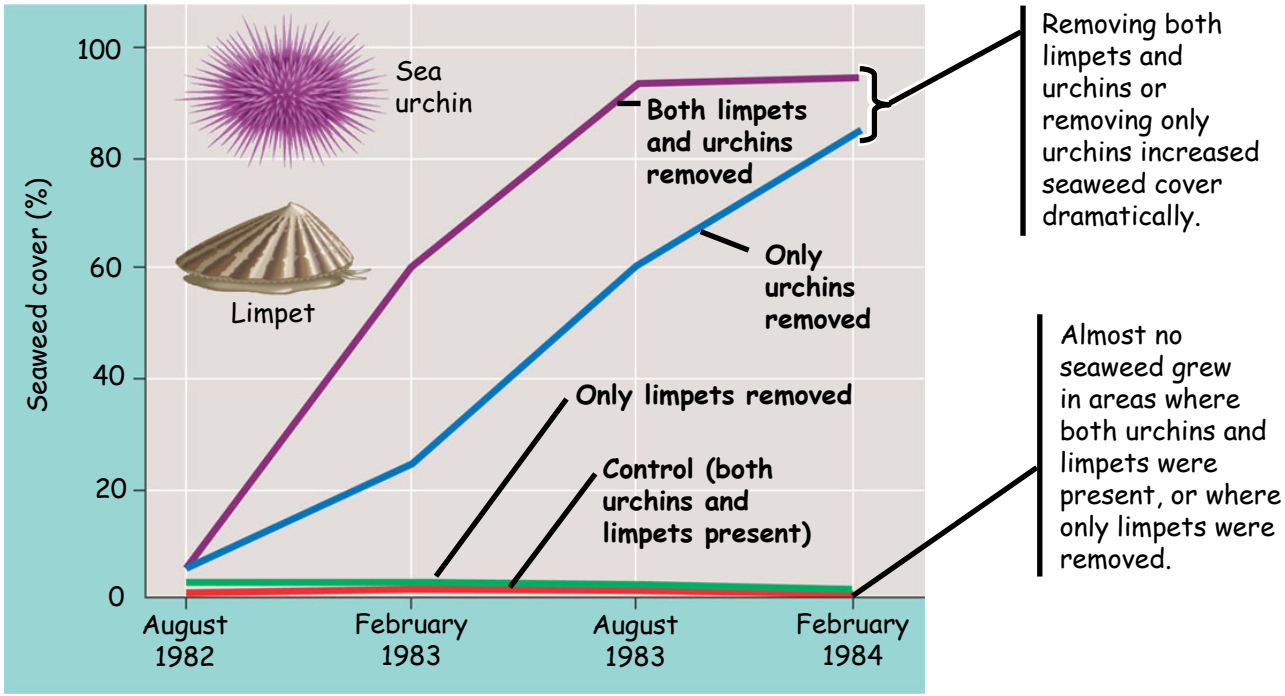
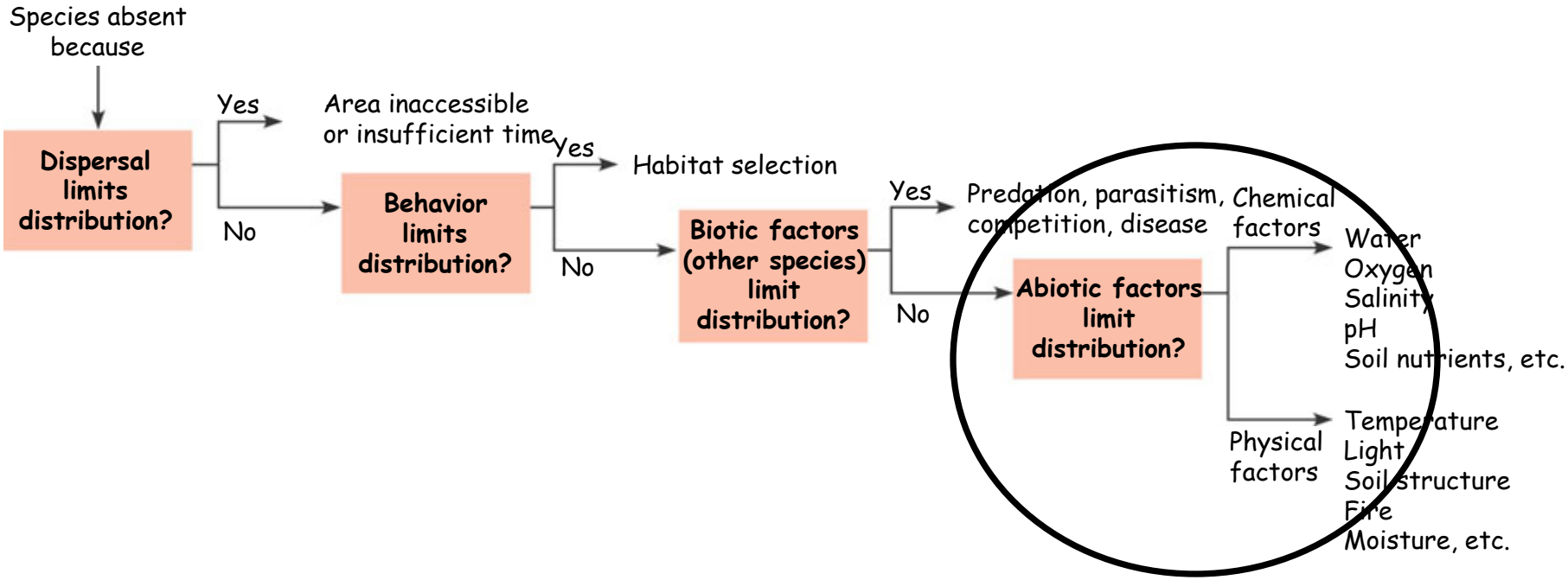


Figure 50.8, 1086

CONCLUSION Removing both limpets and urchins resulted in the greatest increase of seaweed cover, indicating that both species have some influence on seaweed distribution. But since removing only urchins greatly increased seaweed growth while removing only limpets had little effect, Fletcher concluded that sea urchins have a much greater effect than limpets in limiting seaweed distribution.

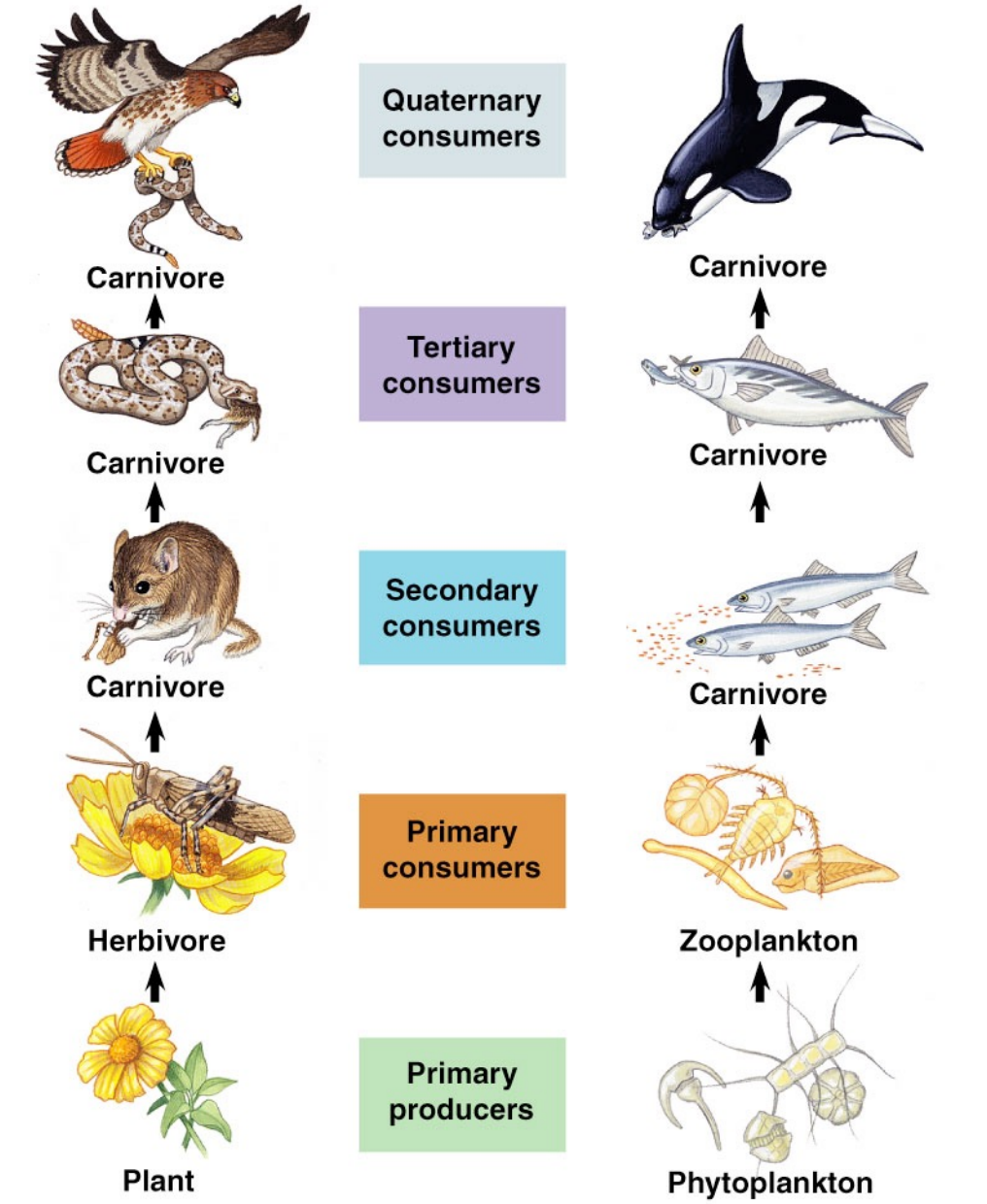
Biogeography

- provides a good starting point for understanding what limits the geographic distribution of species



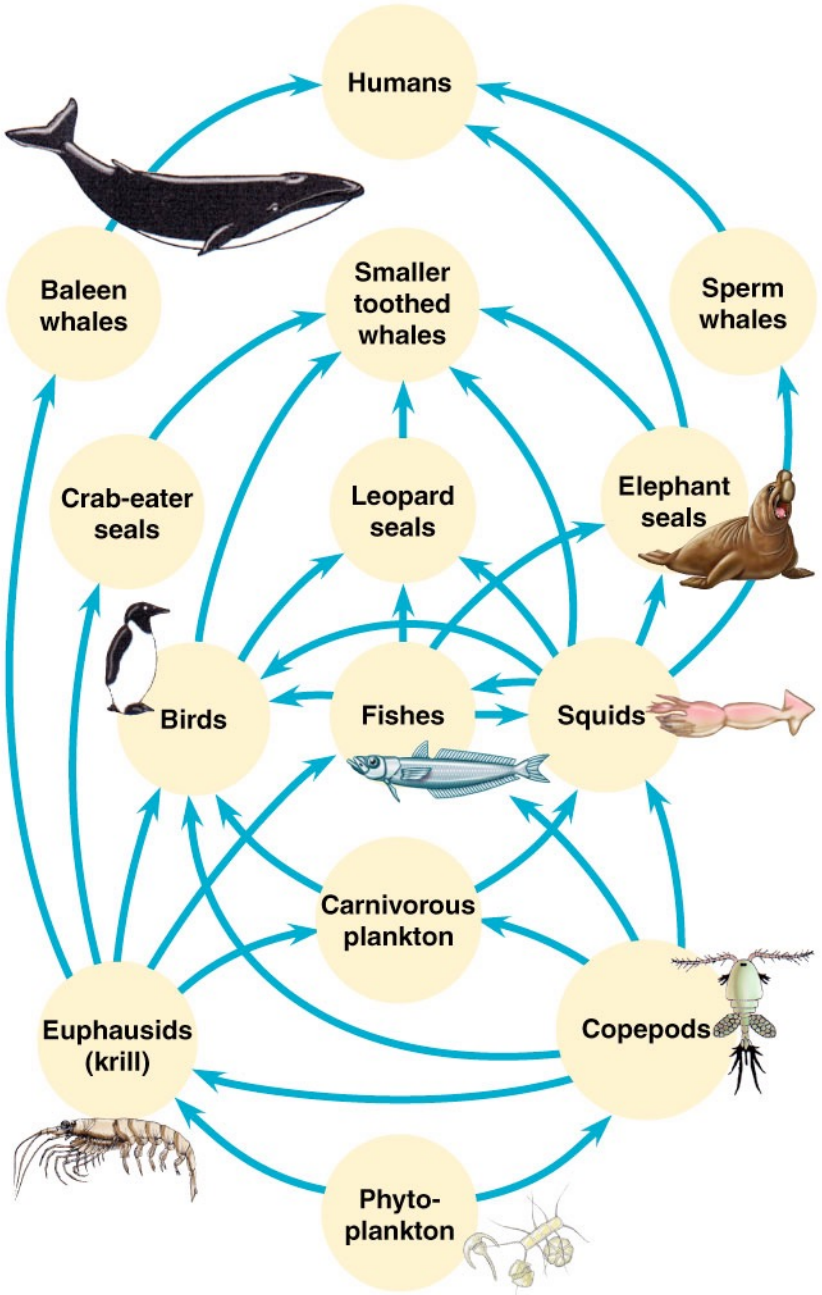
Trophic Structure

terrestrial & marine food chains



Food Webs

Antarctic marine food web



Trophic structure is a key factor in community

- **Detritivores derive their energy from detritus, the dead material produced at all the trophic levels.**
- **Decomposers**
  - **are mainly prokaryotes and fungi and**
  - **secrete enzymes that digest molecules in organic materials and convert them into inorganic forms in the process called decomposition.**

Producers provide the chemical energy and nutrients used by all other members of the food web.

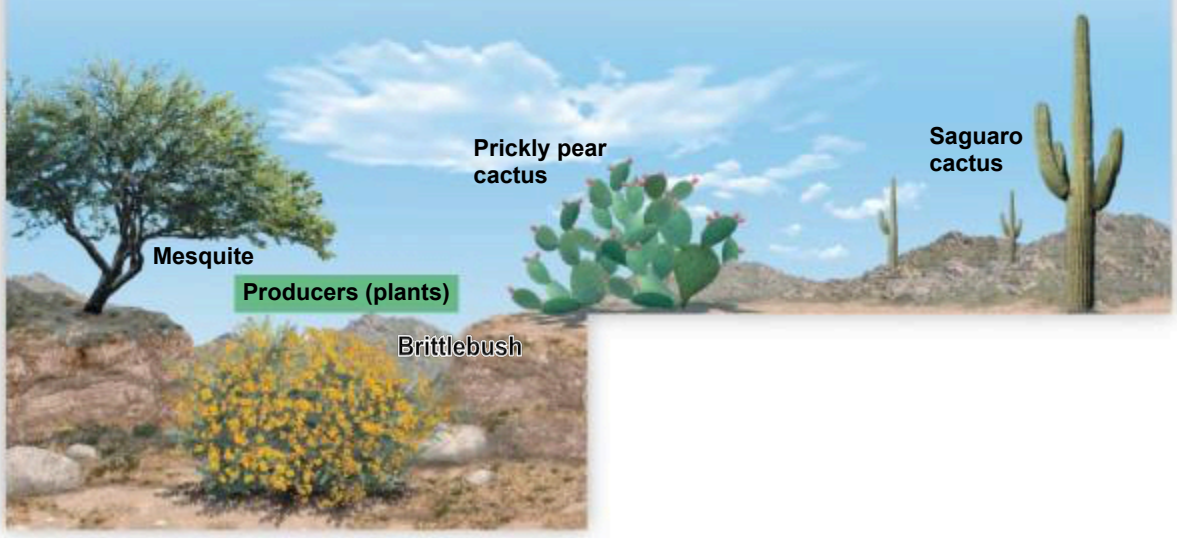


Figure 37.9-2

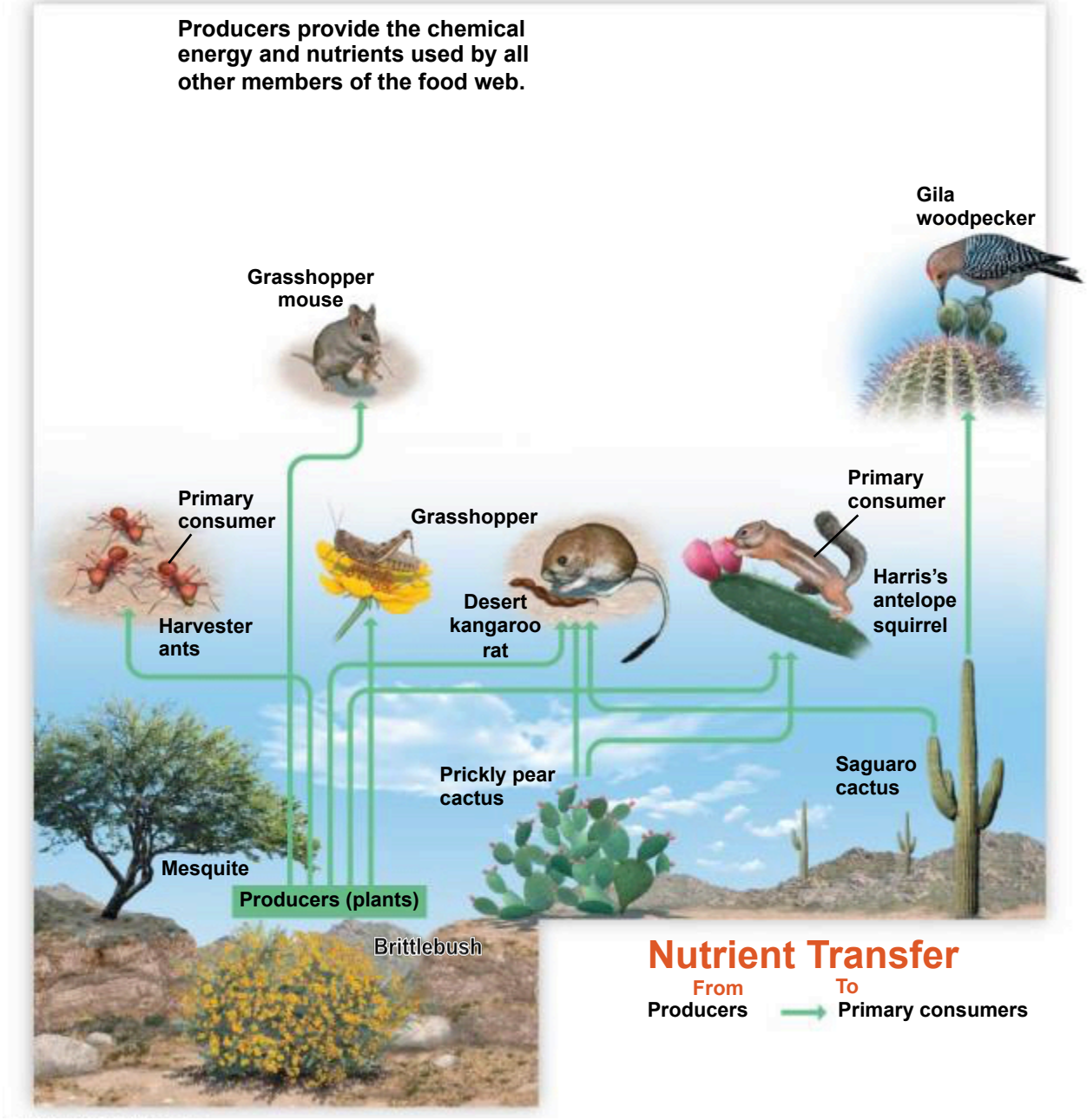

Producers provide the chemical energy and nutrients used by all other members of the food web.
Gila woodpecker
Grasshopper mouse
Primary consumer
Grasshopper
Primary consumer
Harris's antelope squirrel
Desert kangaroo rat
Harvester ants
Prickly pear cactus
Saguaro cactus
Mesquite
Producers (plants)
Brittlebush
Nutrient Transfer
From
Producers
To
Primary consumers

Figure 37.9-3

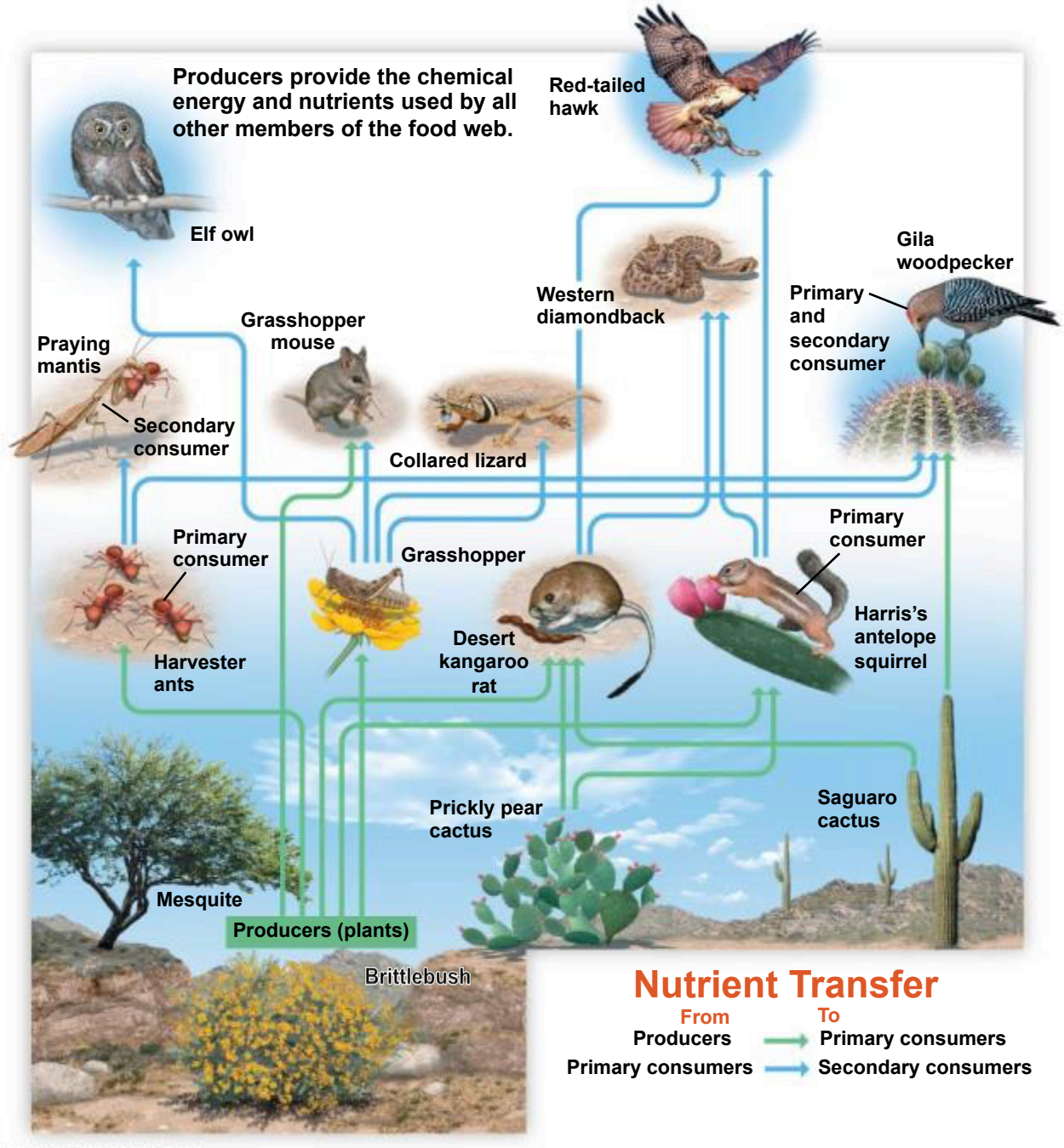
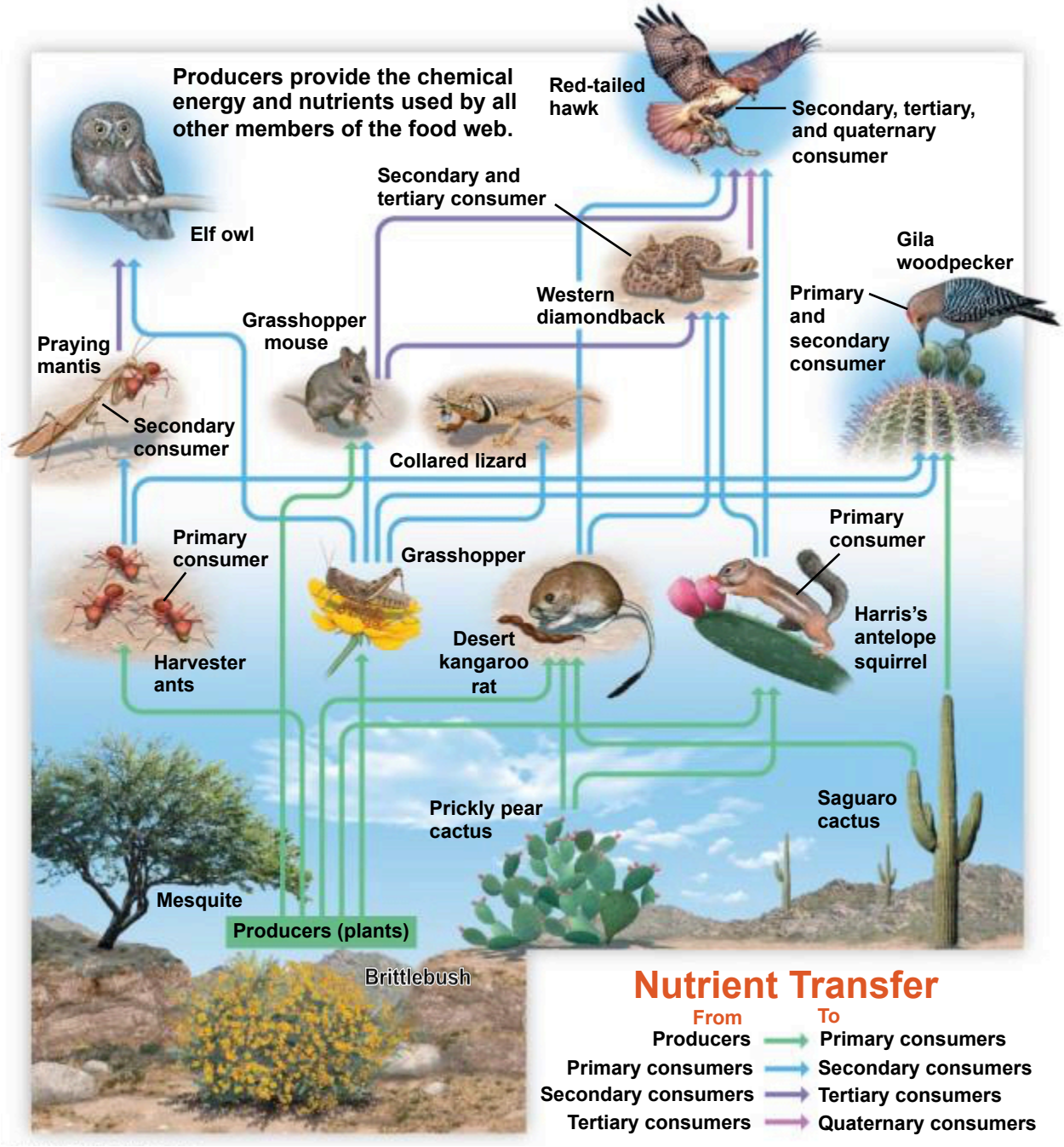

Producers provide the chemical energy and nutrients used by all other members of the food web.
Red-tailed hawk
Elf owl
Western diamondback
Gila woodpecker
Primary and secondary consumer
Grasshopper mouse
Praying mantis
Secondary consumer
Collared lizard
Primary consumer
Grasshopper
Primary consumer
Harris's antelope squirrel
Desert kangaroo rat
Harvester ants
Prickly pear cactus
Saguaro cactus
Mesquite
Producers (plants)
Brittlebush
Nutrient Transfer
From
To
Producers
Primary consumers
Primary consumers
Secondary consumers

Figure 37.9-4


Producers provide the chemical energy and nutrients used by all other members of the food web.
Red-tailed hawk
Secondary, tertiary, and quaternary consumer
Secondary and tertiary consumer
Elf owl
Gila woodpecker
Western diamondback
Primary and secondary consumer
Grasshopper mouse
Praying mantis
Secondary consumer
Collared lizard
Primary consumer
Grasshopper
Primary consumer
Harris's antelope squirrel
Desert kangaroo rat
Harvester ants
Prickly pear cactus
Saguaro cactus
Mesquite
Producers (plants)
Brittlebush
Nutrient Transfer
From
To
Producers
Primary consumers
Primary consumers
Secondary consumers
Secondary consumers
Tertiary consumers
Tertiary consumers
Quaternary consumers

Species with large impact

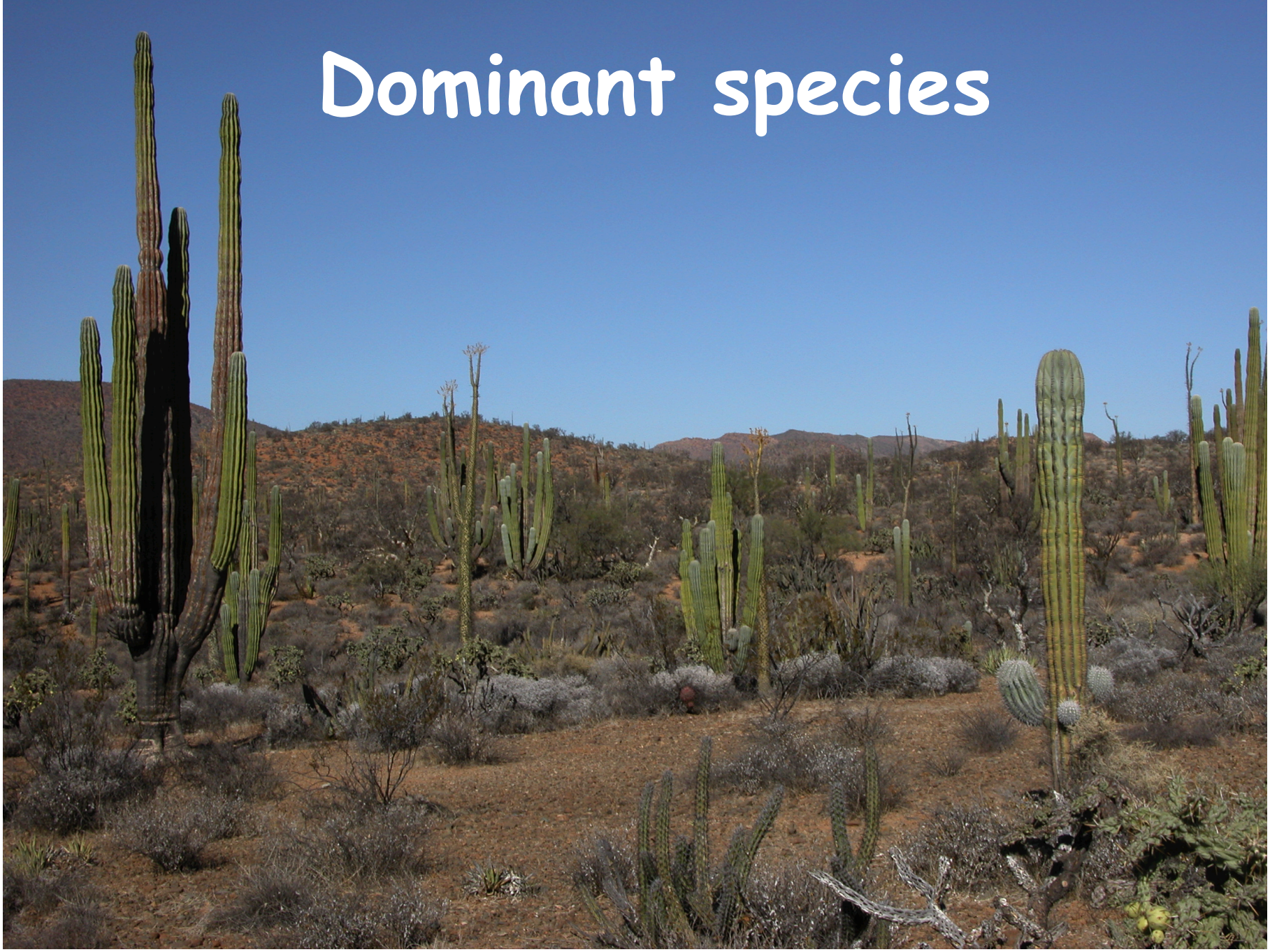
dominant species

- biomass
- invasive species

keystone species - not necessarily abundant

foundation species - or ecosystems engineers

Dominant species



Dominant species

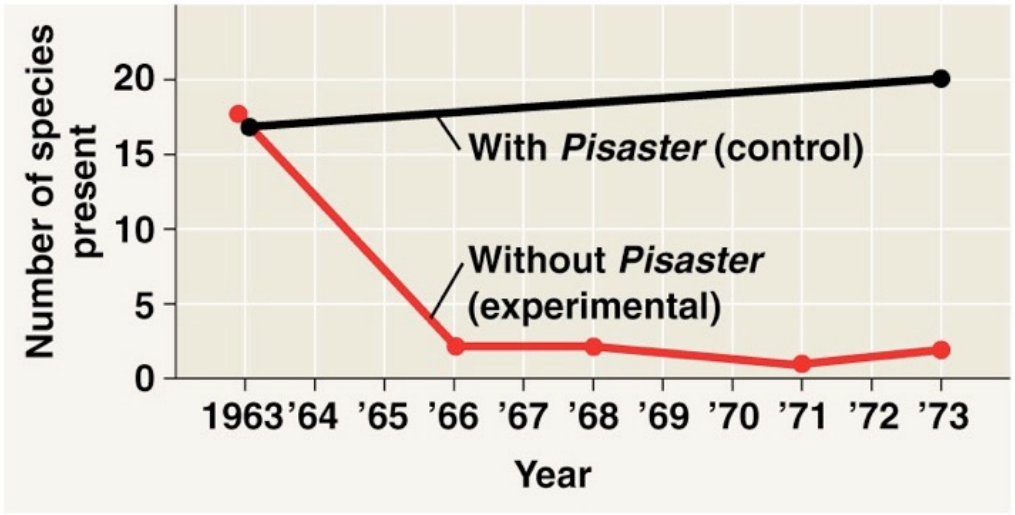
- biomass
- invasive species

Keystone species

<u>keystone species</u> - not necessarily abundant

EXPERIMENT

RESULTS



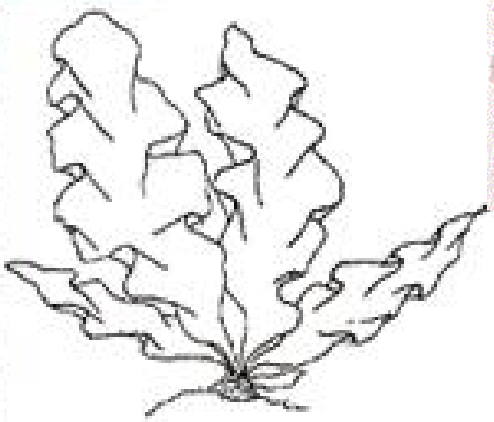
Ecosystem engineers (foundation species)

e.g., beavers

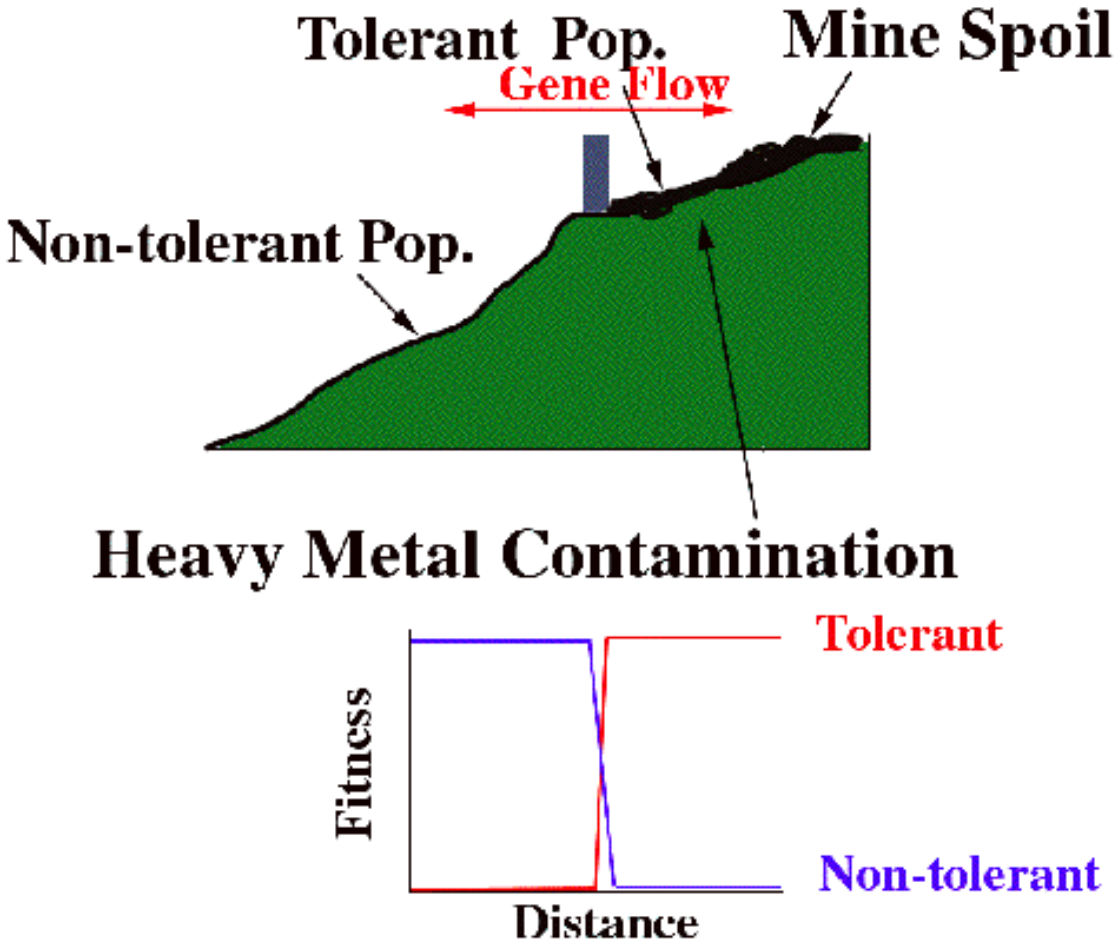
Abiotic Factors

- **temperature**
- **water**
- **sunlight, UV exposure**
- **waves**
- **wind**
- **rocks & soil, pH**

Light penetration affects distribution of algae with different photosynthetic pigments



Soil type can drive parapatric speciation in plants



Abiotic Factors Determine Climate

- **major determinants of climate**
  - **temperature**
  - **water**
  - **sunlight**
  - **wind**
  - **rocks and soil**

- macroclimate: global, regional, local
- microclimate: very fine scale

Global Patterns

Sunlight intensity

- plays a major part in determining the Earth's climate patterns

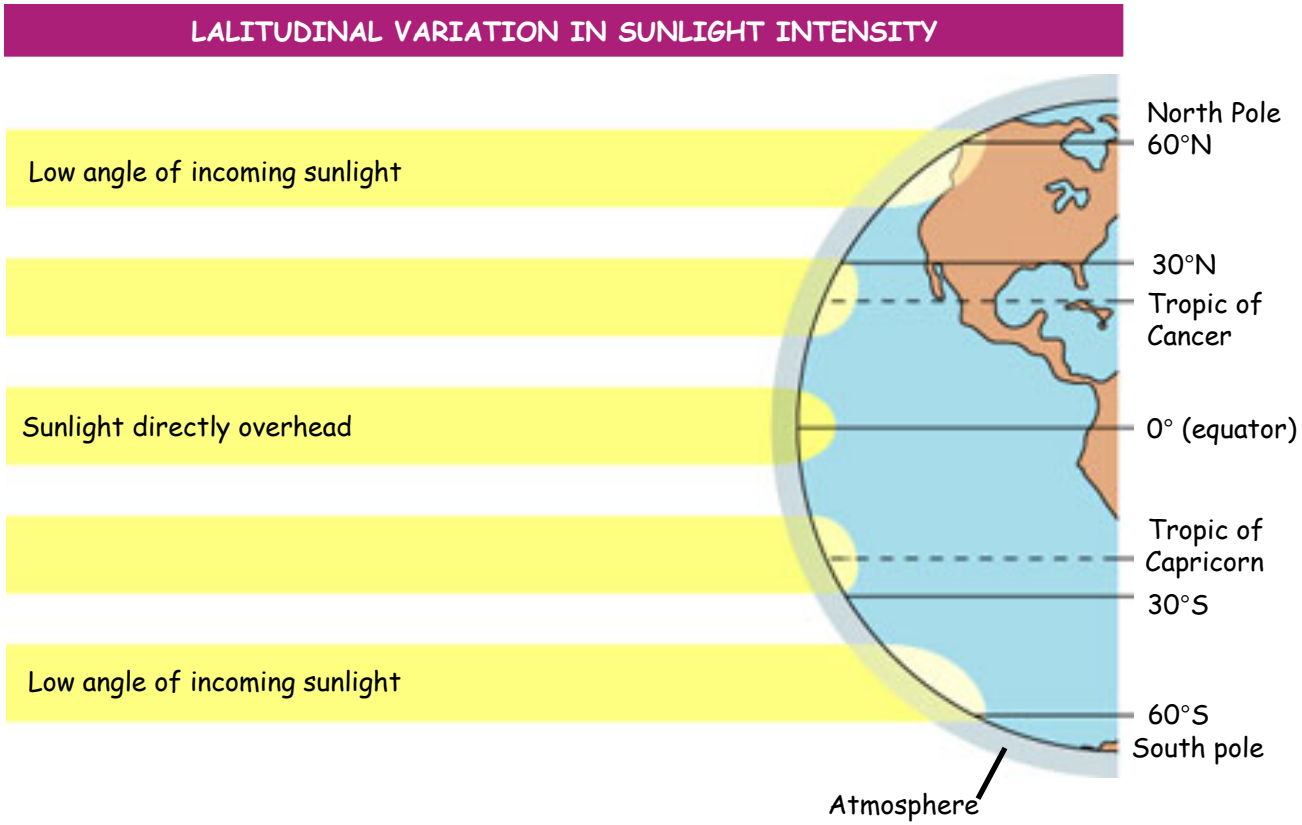
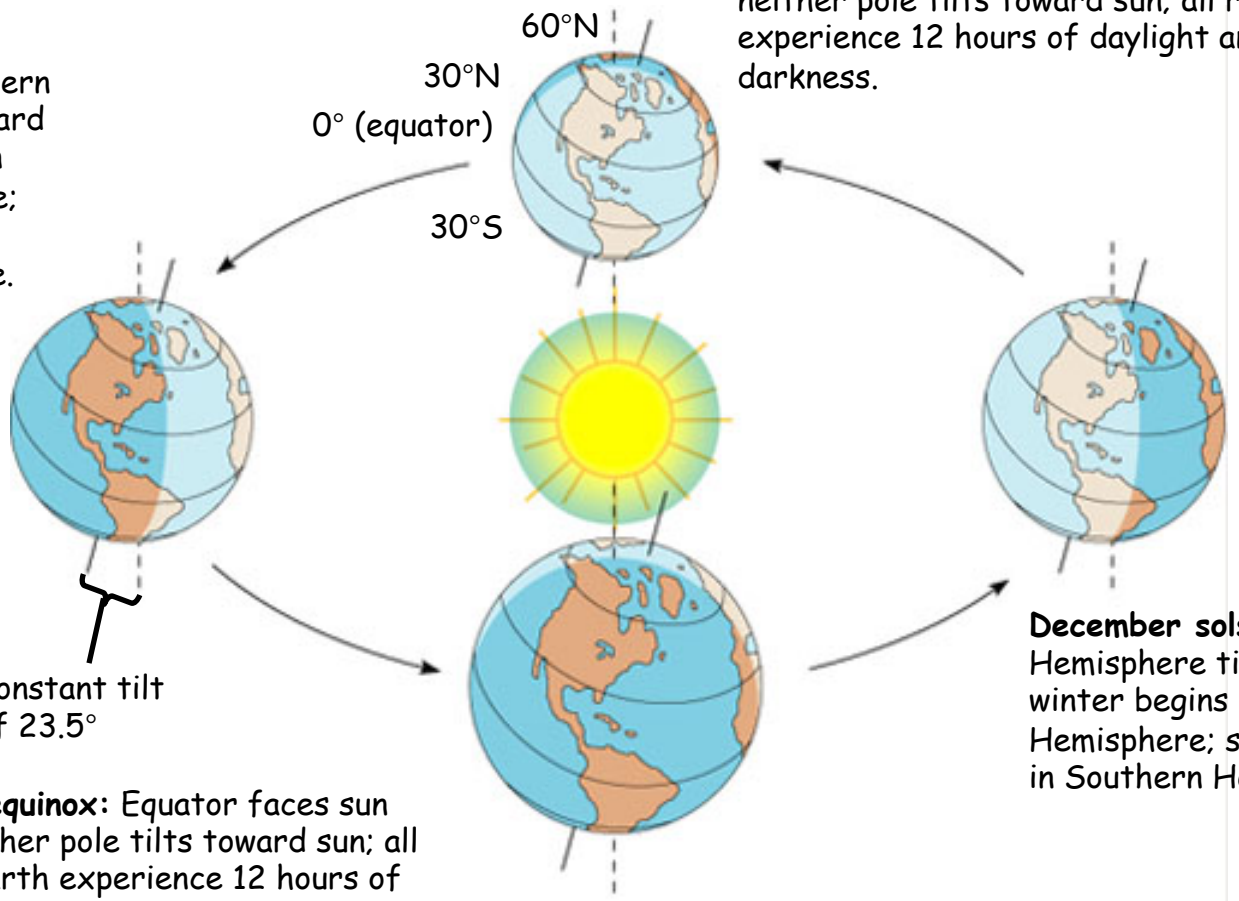


Figure 50.10, pg. 1088

SEASONAL VARIATION IN SUNLIGHT INTENSITY

March equinox: Equator faces sun directly; neither pole tilts toward sun; all regions on Earth experience 12 hours of daylight and 12 hours of darkness.

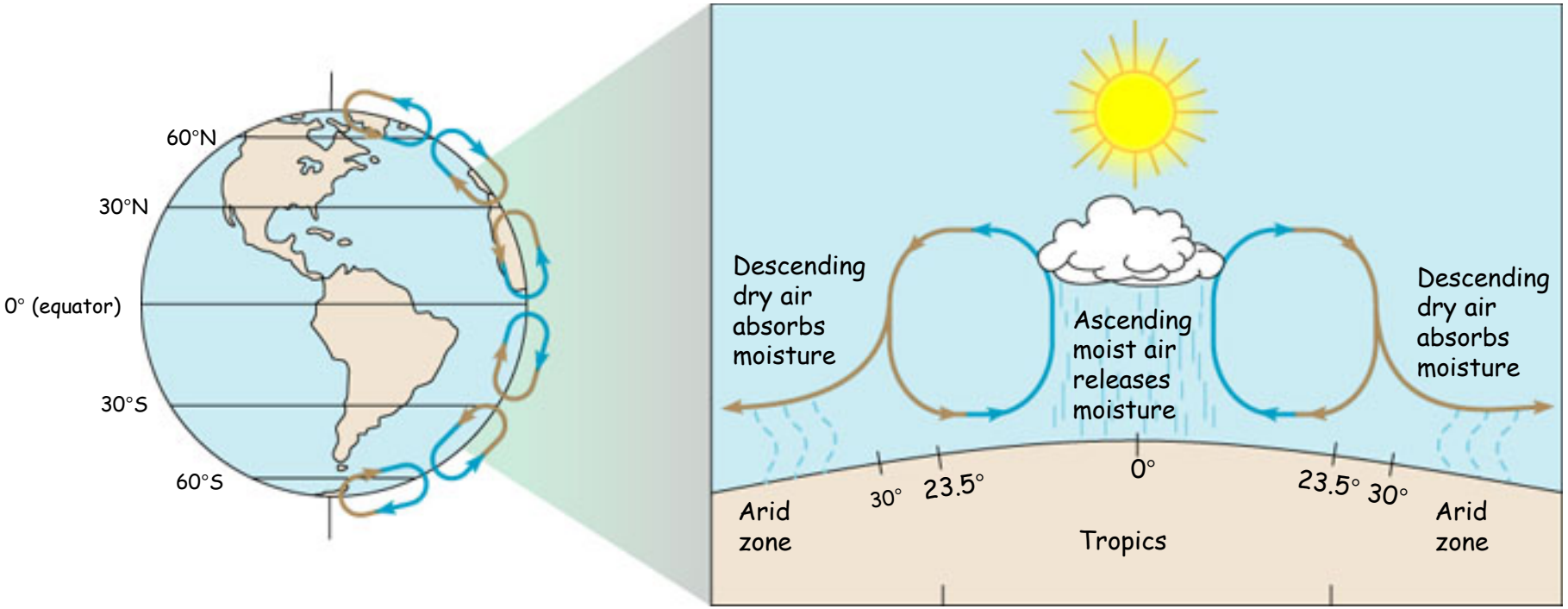
June solstice: Northern Hemisphere tilts toward sun; summer begins in Northern Hemisphere; winter begins in Southern Hemisphere.



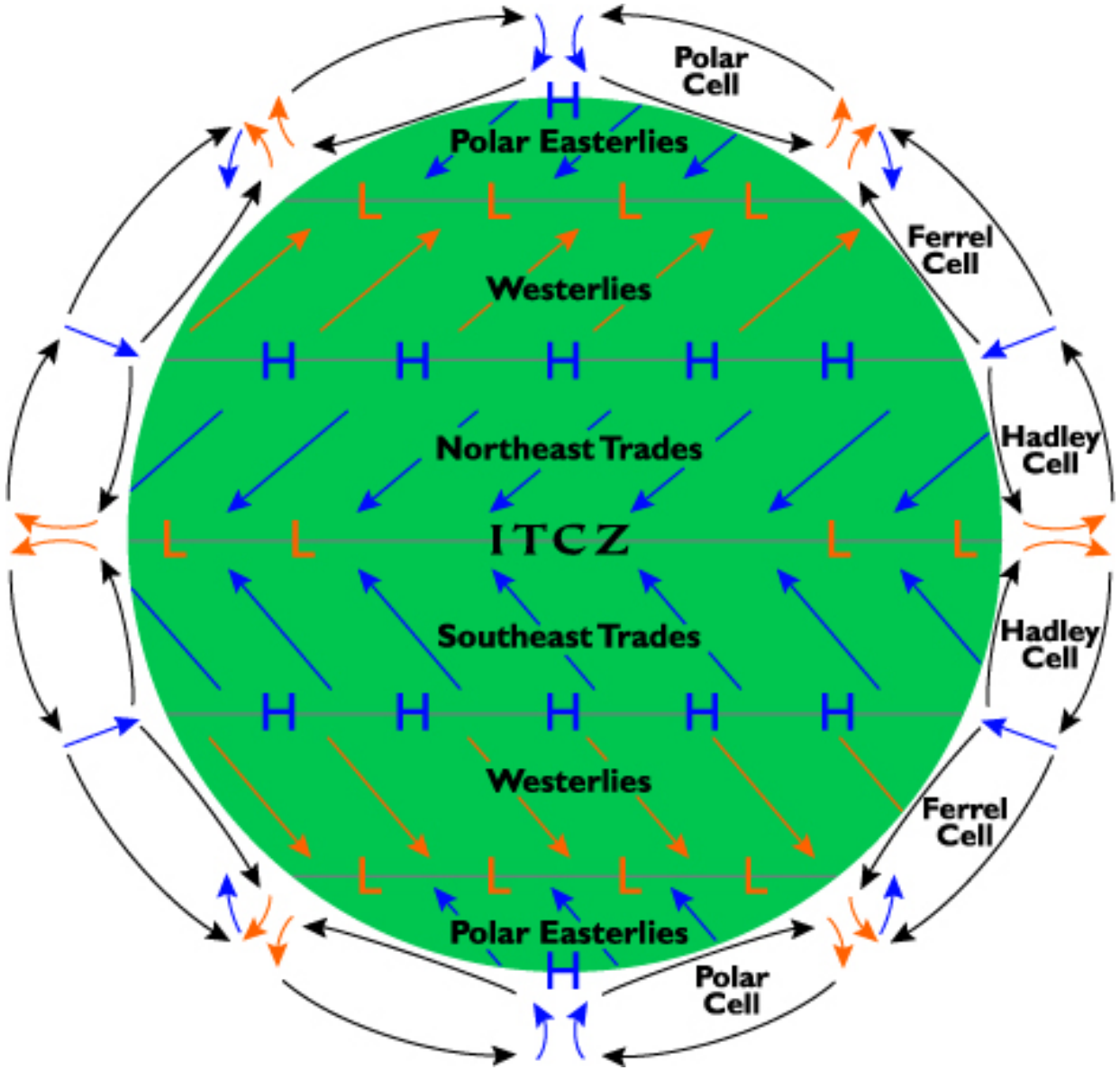
December solstice: Northern Hemisphere tilts away from sun; winter begins in Northern Hemisphere; summer begins in Southern Hemisphere.

September equinox: Equator faces sun directly; neither pole tilts toward sun; all regions on Earth experience 12 hours of daylight and 12 hours of darkness.

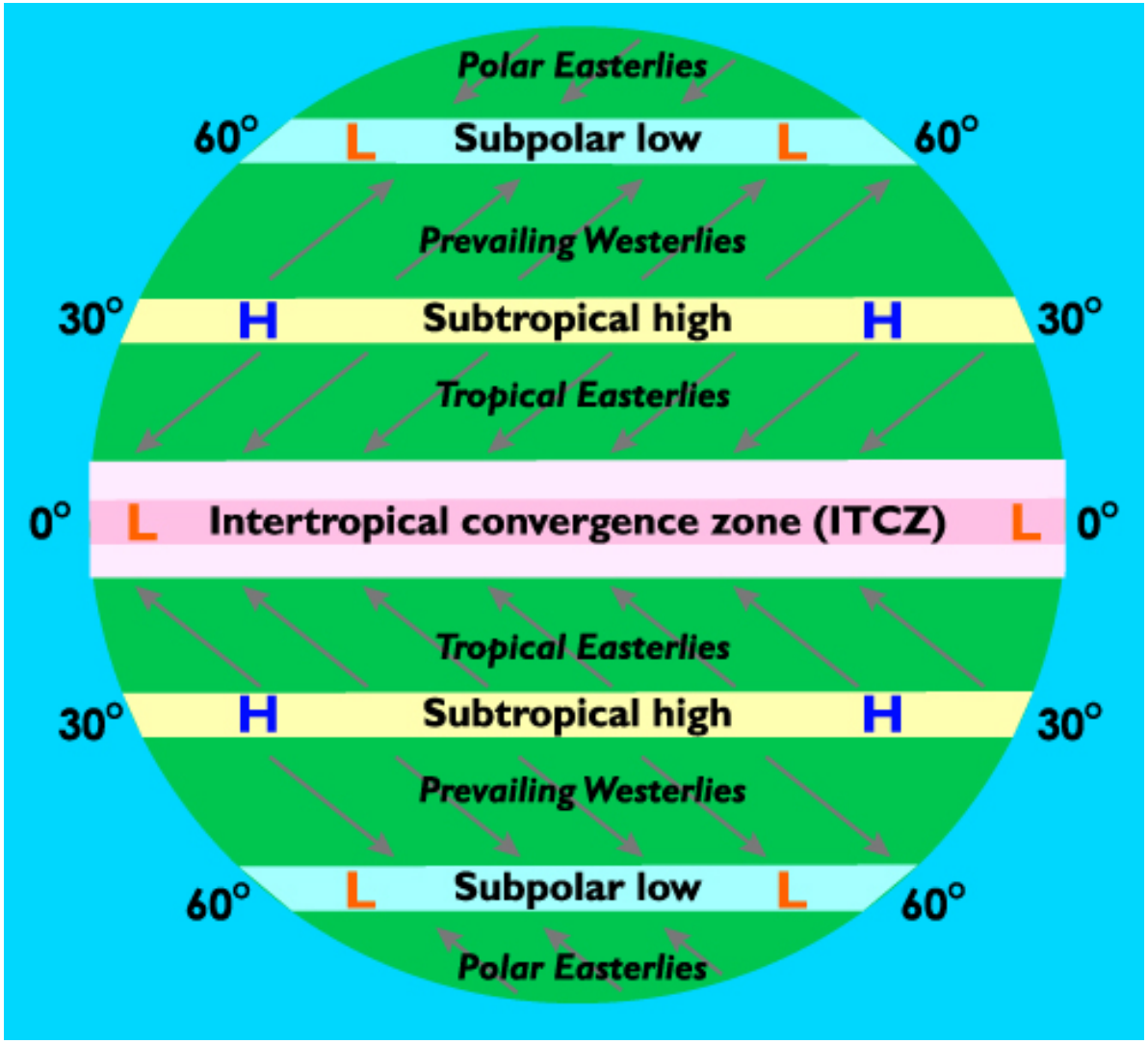
Air circulation cells affect rainfall



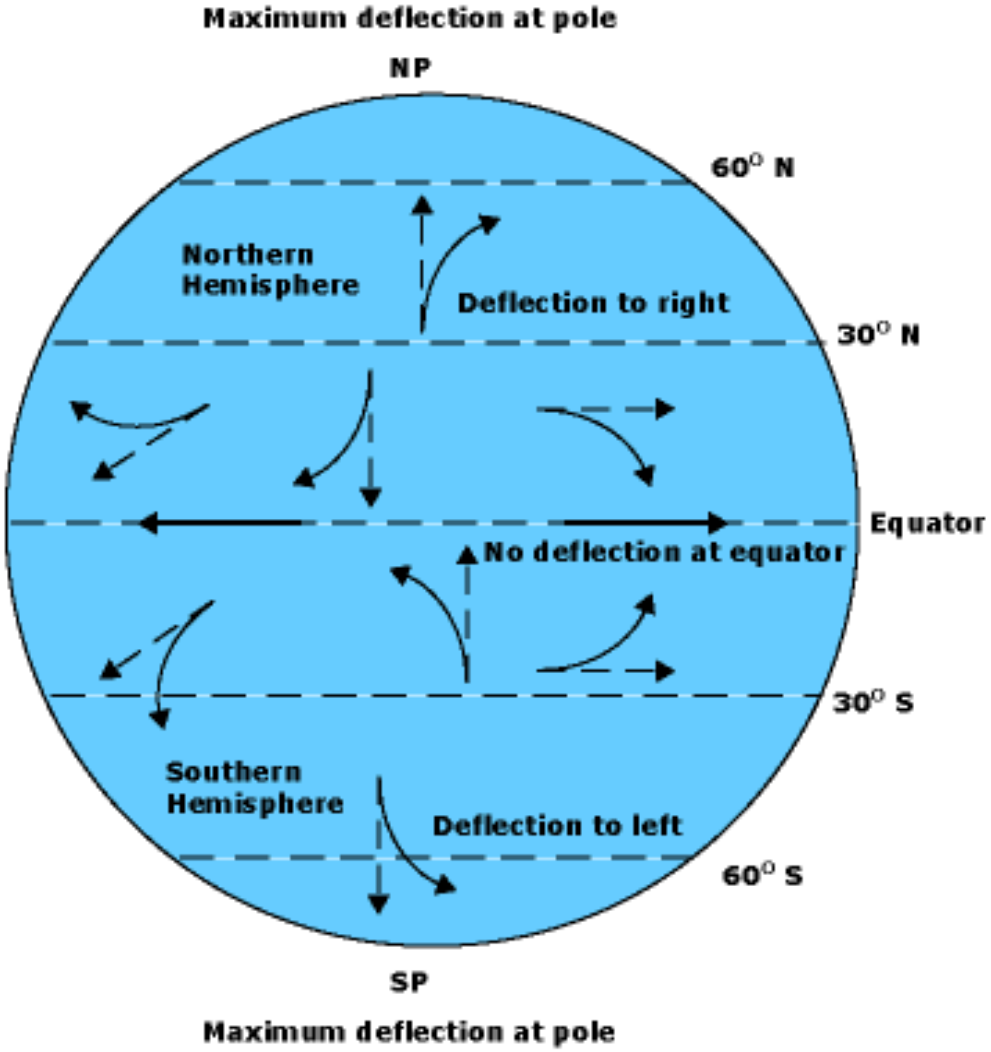
Air circulation cells drive



Global belts of low and high atmospheric pressure

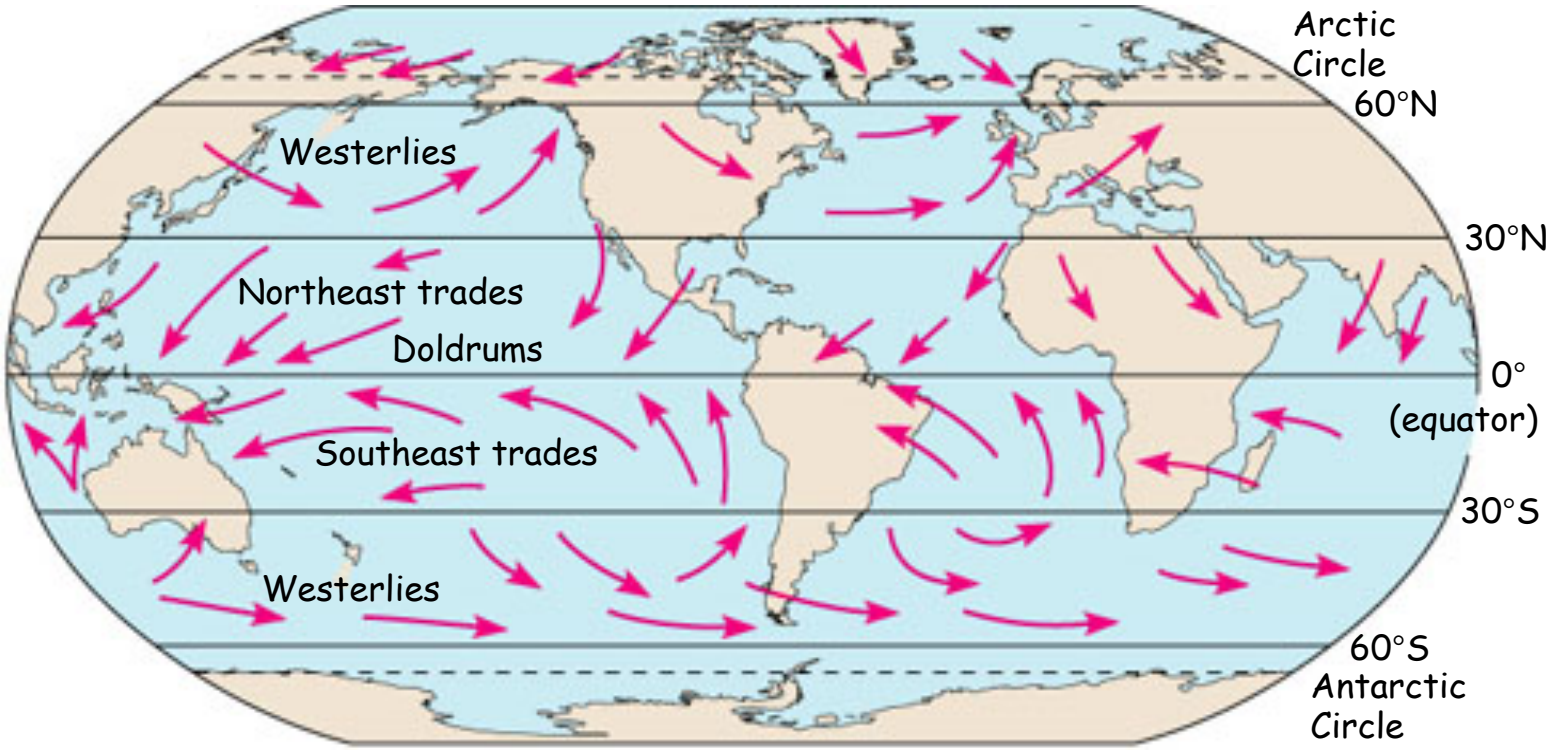


Earth's rotation causes Coriolis



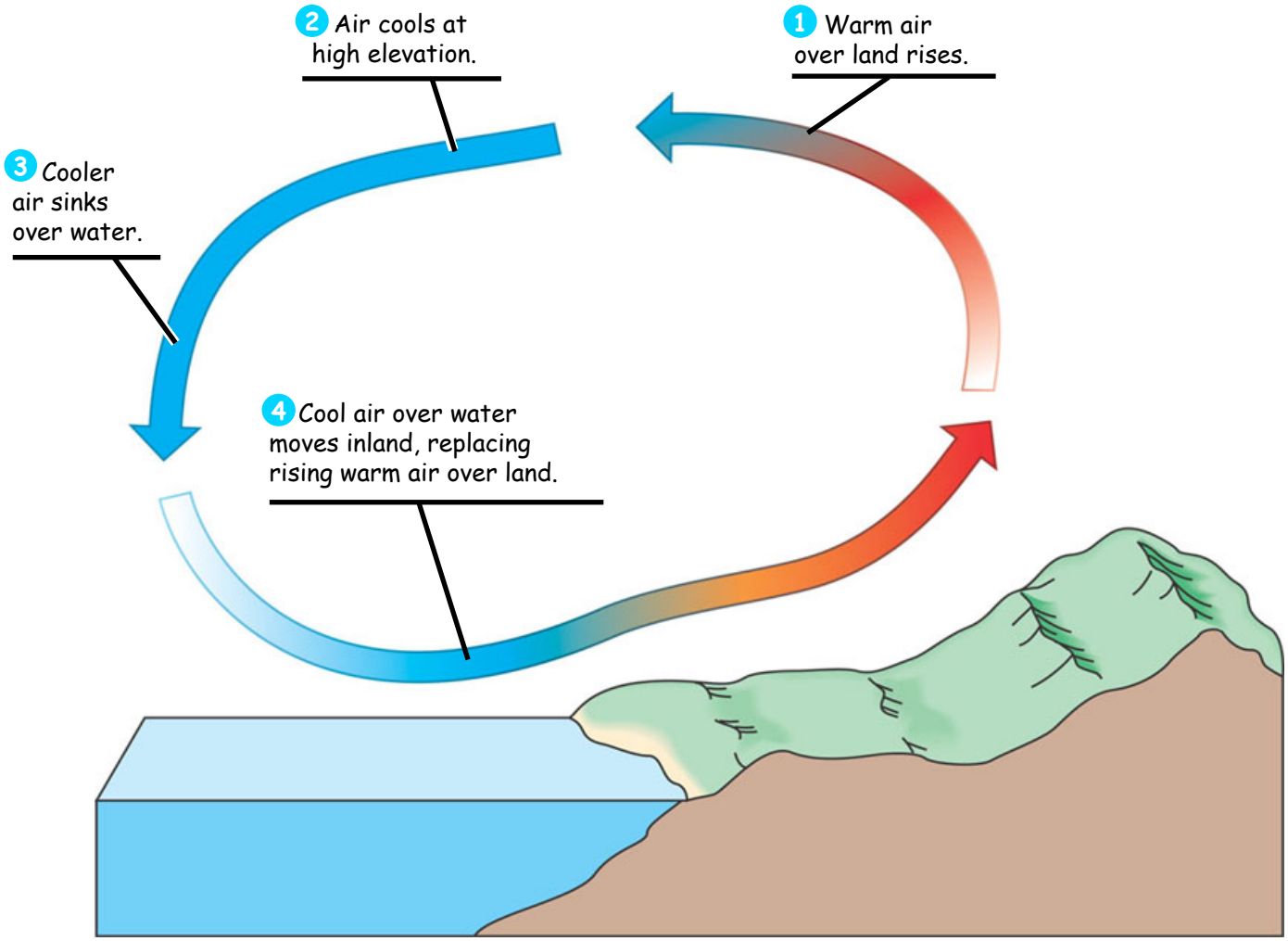
- little deflection at equator
- deflected right in northern hemisphere
- deflected left in southern hemisphere

GLOBAL WIND PATTERNS

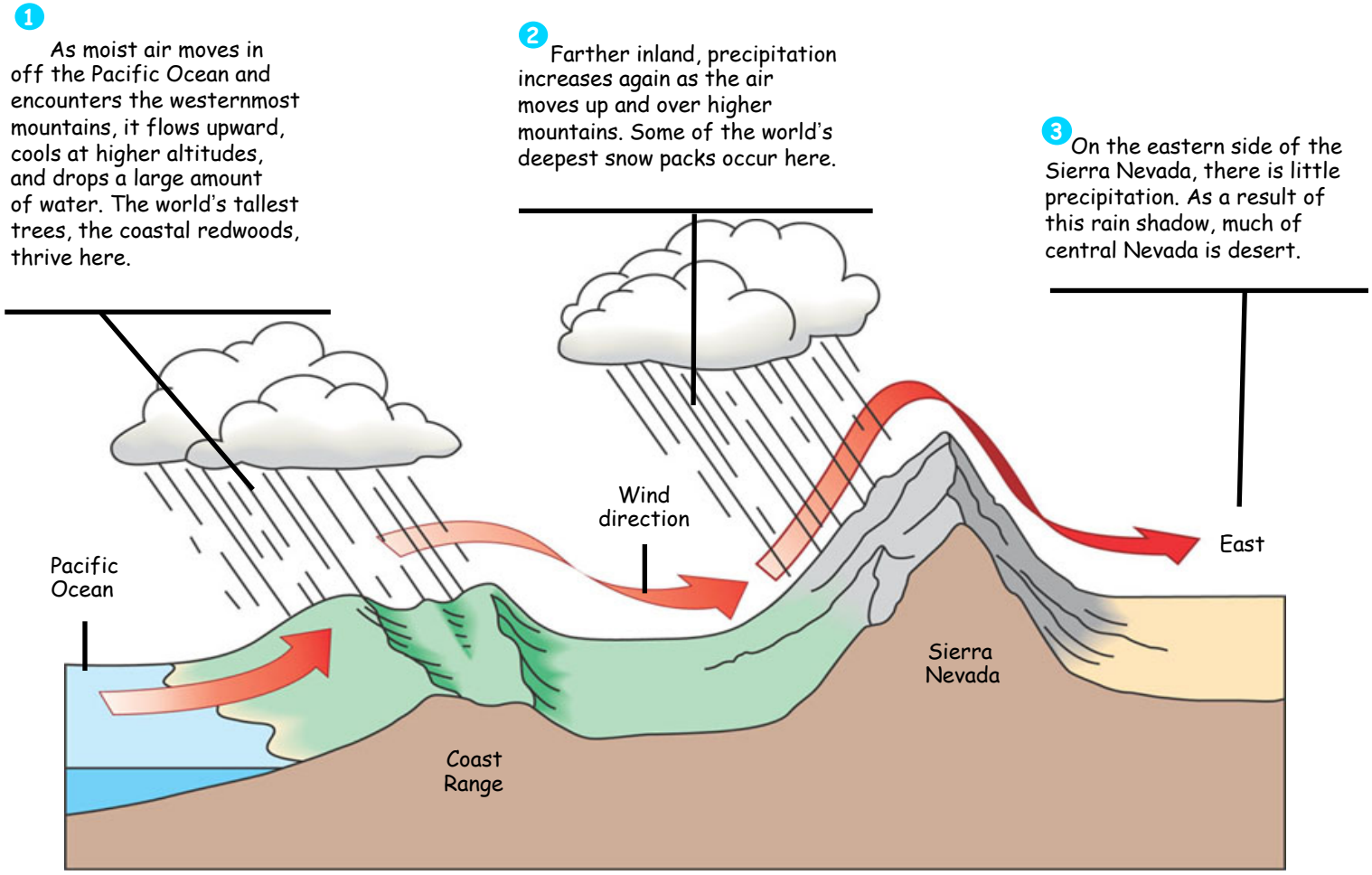


Regional Patterns

Oceans and large lakes moderate climate

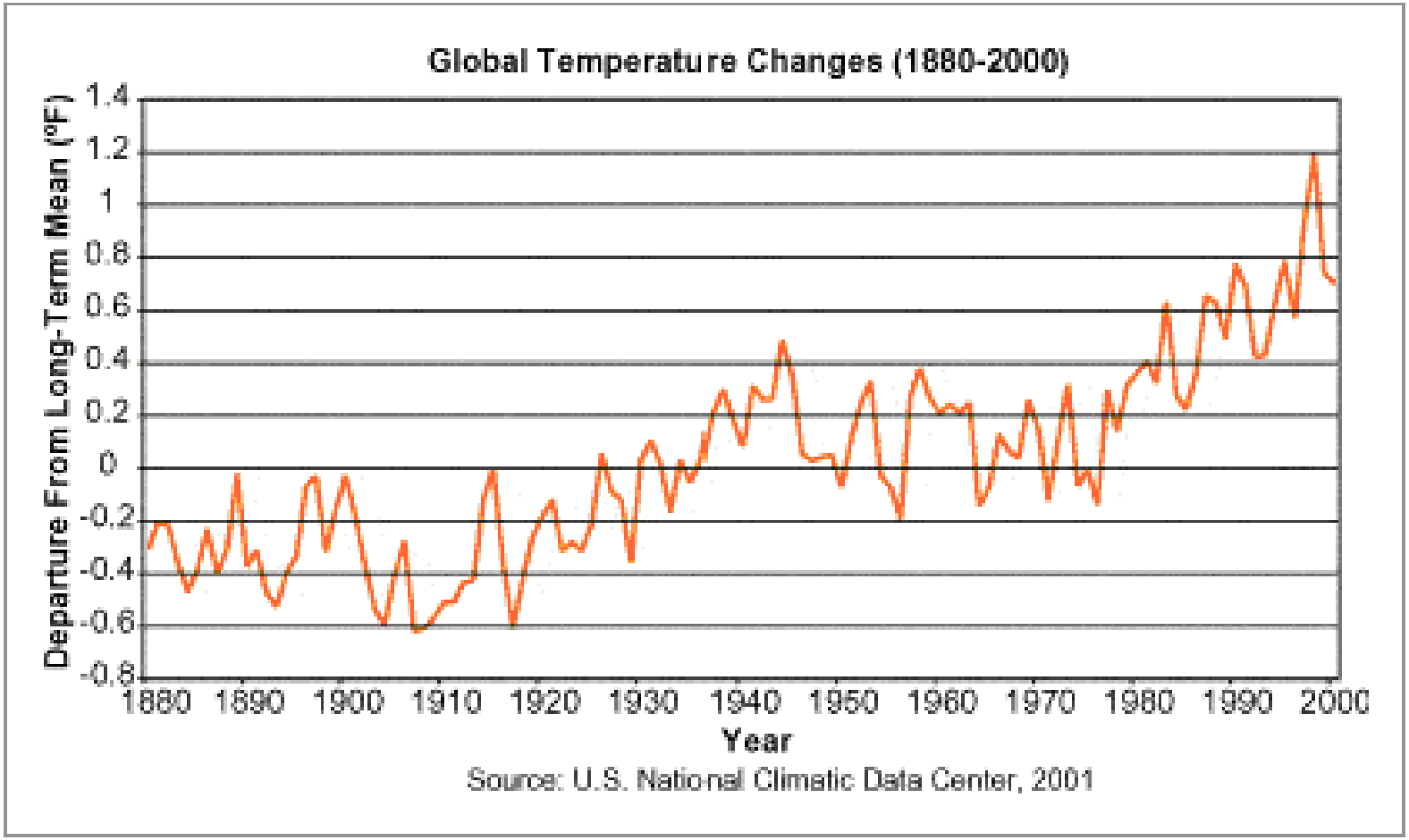


Mountains produce "rain shadow"



Long Term Climate Change

Temperature has risen ~1 C over past century



Can organisms adapt to changing conditions?

- coral bleaching attributed to thermal stress
- major diebacks already attributed to global warming
- must move, adapt or go extinct