Biodiversity and **E**cology

EAWAG

Eine Forschungsanstalt des ETH-Bereichs

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Course contents and goals

- Lecture I **Ecology-Distribution**
- Lecture II **Subfields of Ecology: Organismal-Ecosystem**
- Lecture III **Population Ecology I**
- Lecture IV **Population Ecology II**
- Lecture V **Community Ecology I**
- Lecture VI **Community Ecology II**
- Lecture VII **Biodiversity**
- Lecture VIII **Conservation biology and Restoration**

Goals for today

1. **Introduce ecology**

2. **Make you like it**

3. **Make you think like an ecologist**

4. **Get one person to become an ecologist**

5. **Finish lecture**

What is Ecology?

The study of the natural environment and of the relations of organisms to one another and to their surroundings

Ricklefs & Miller

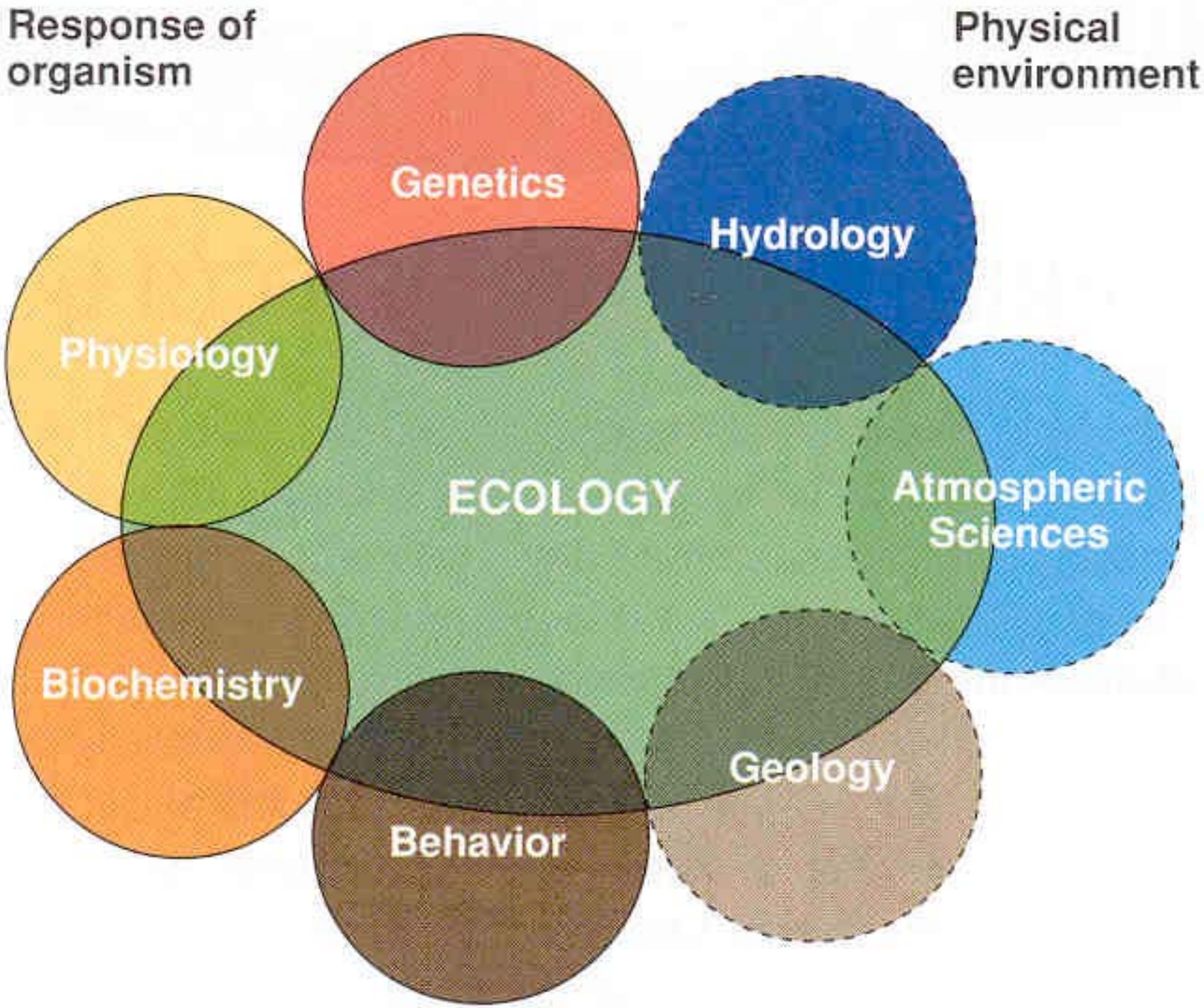


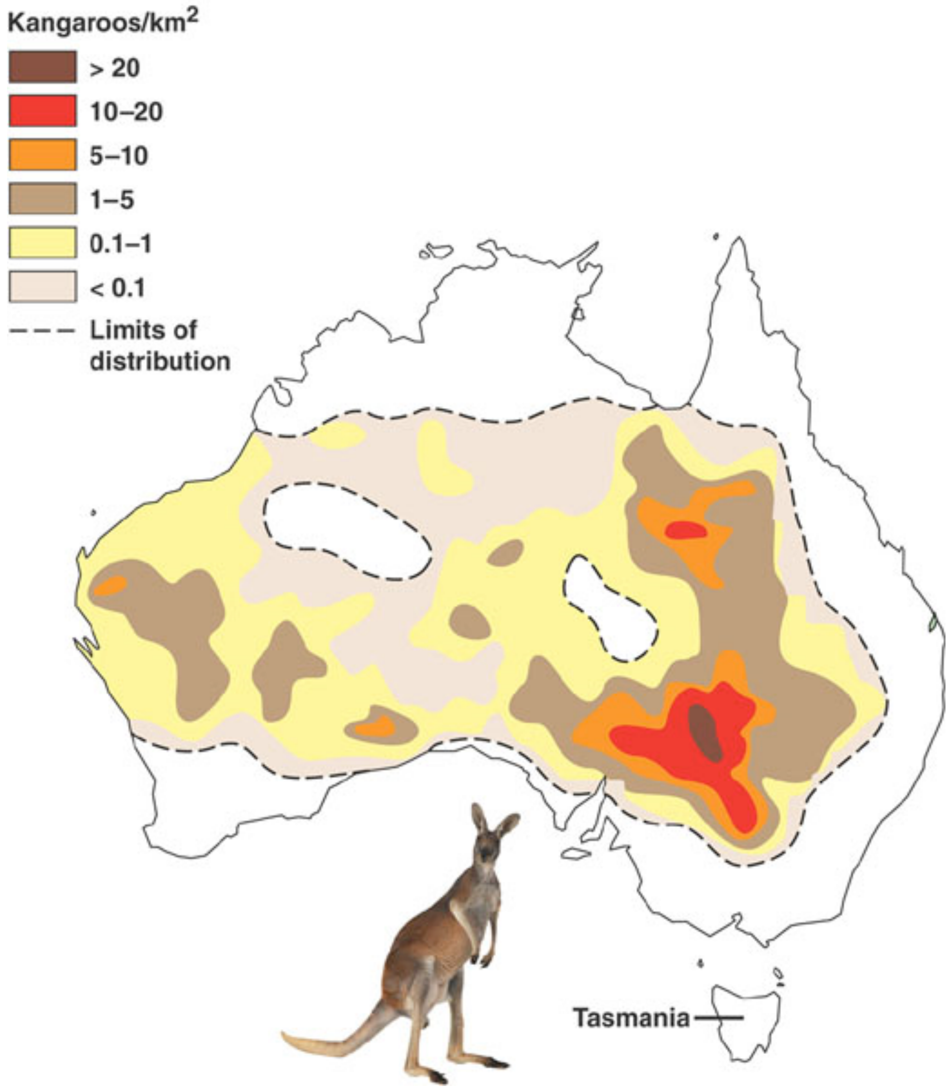
FIGURE 1.2 Ecology is an interdisciplinary science. It overlaps with many elements of physical and biological sciences.

Macroecology

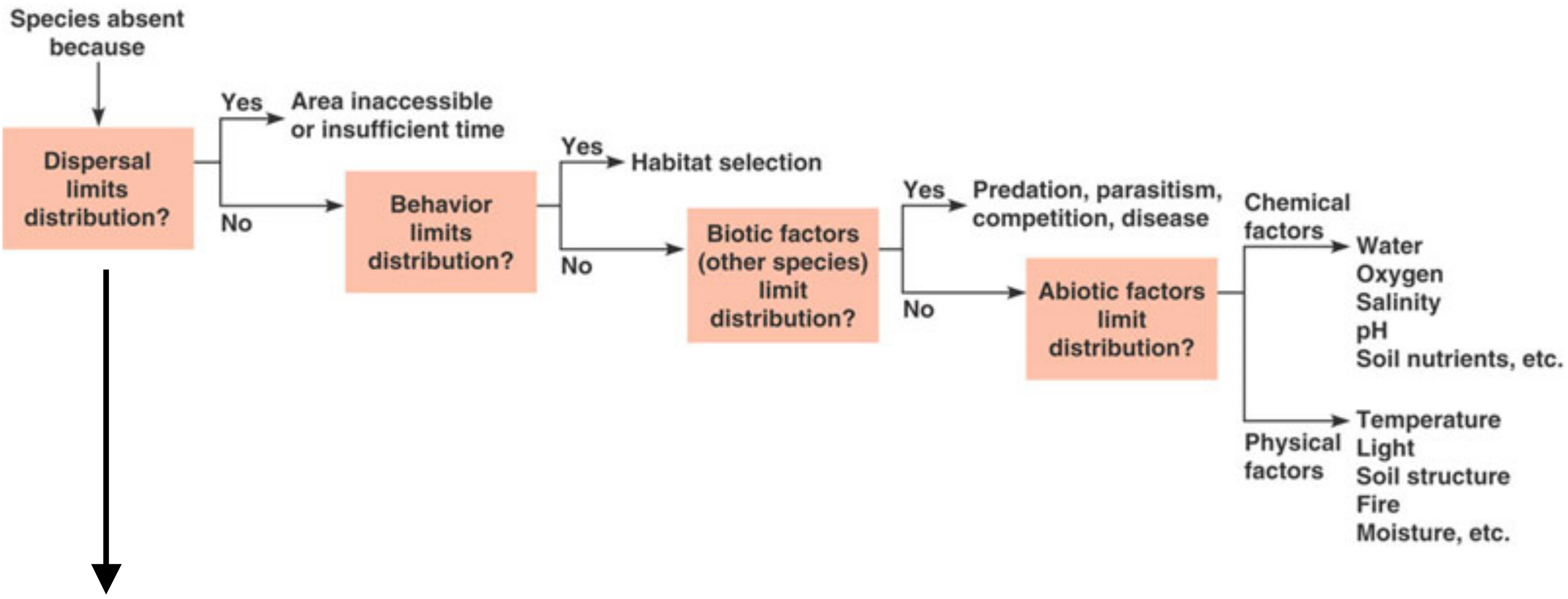
Study of the relationships between organisms and their environment that involves characterizing and explaining patterns of abundance, **distribution**, and diversity

James Brown, on the 1

Why do kangaroos not occur everywhere in Australia?



what limits the geographical distribution of any species?

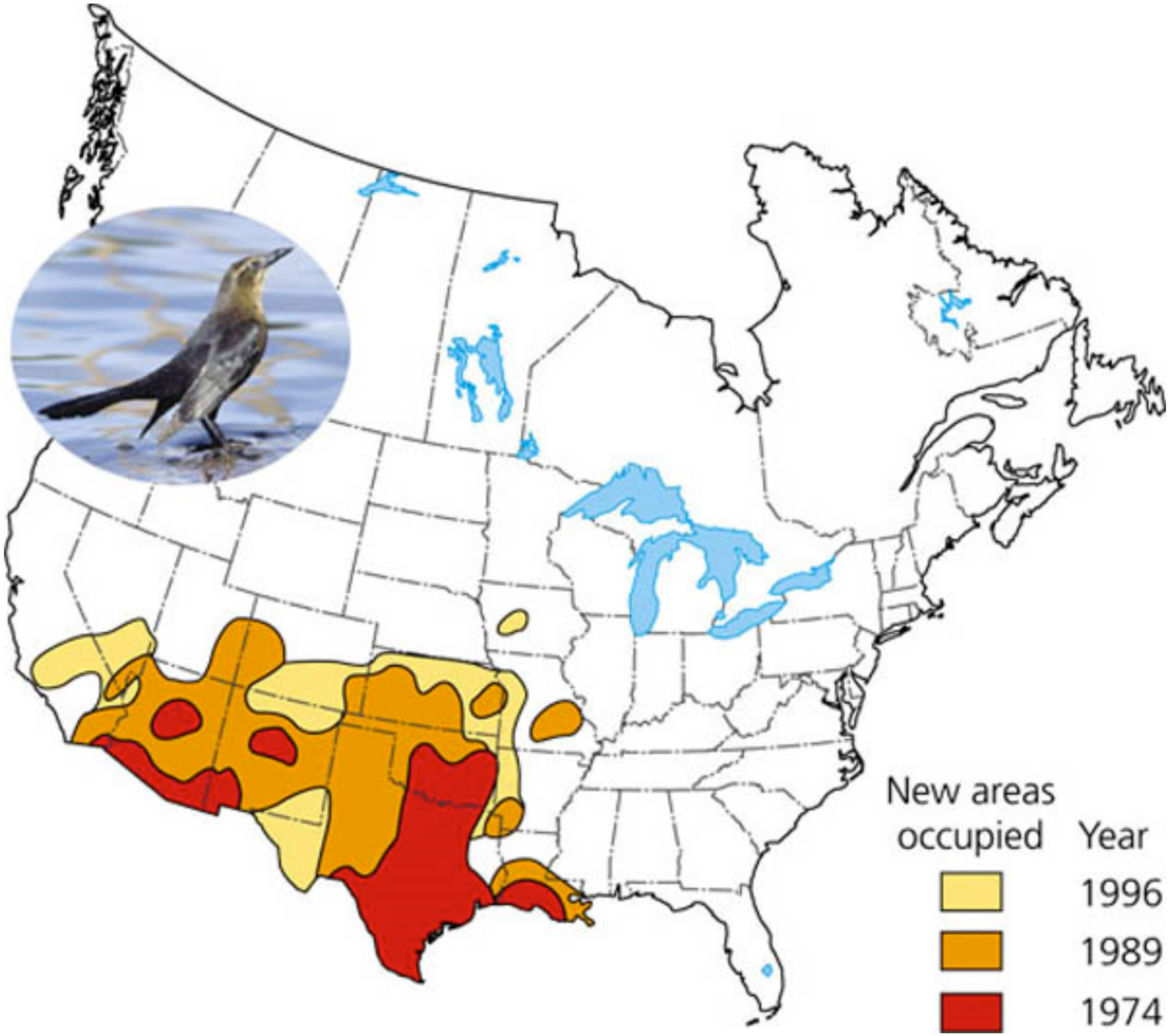


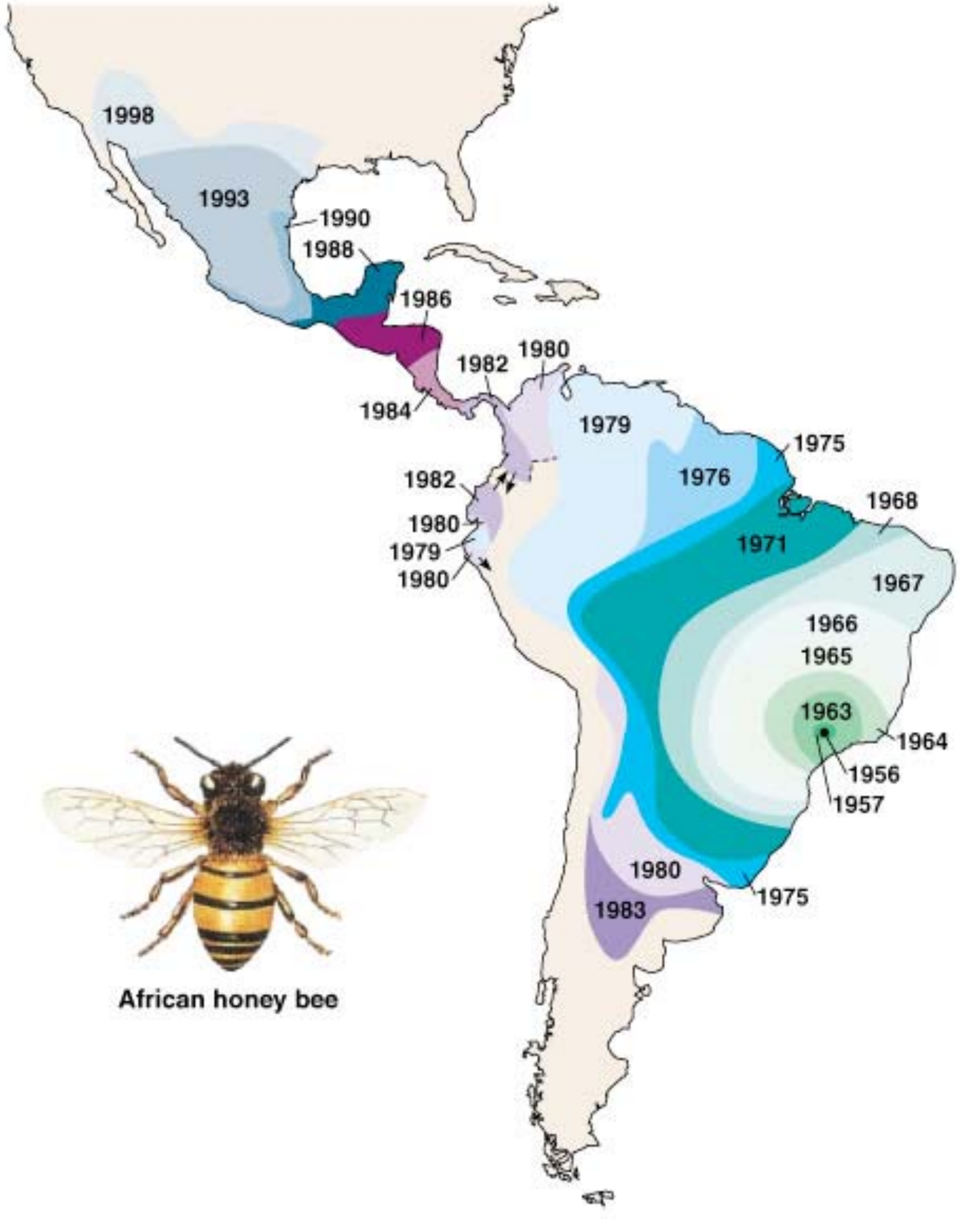
Dispersal: The movement of individuals away from centers of high population density or from their area of origin

How do we know if **dispersal** limits distribution?

INTRODUCED SPECIES

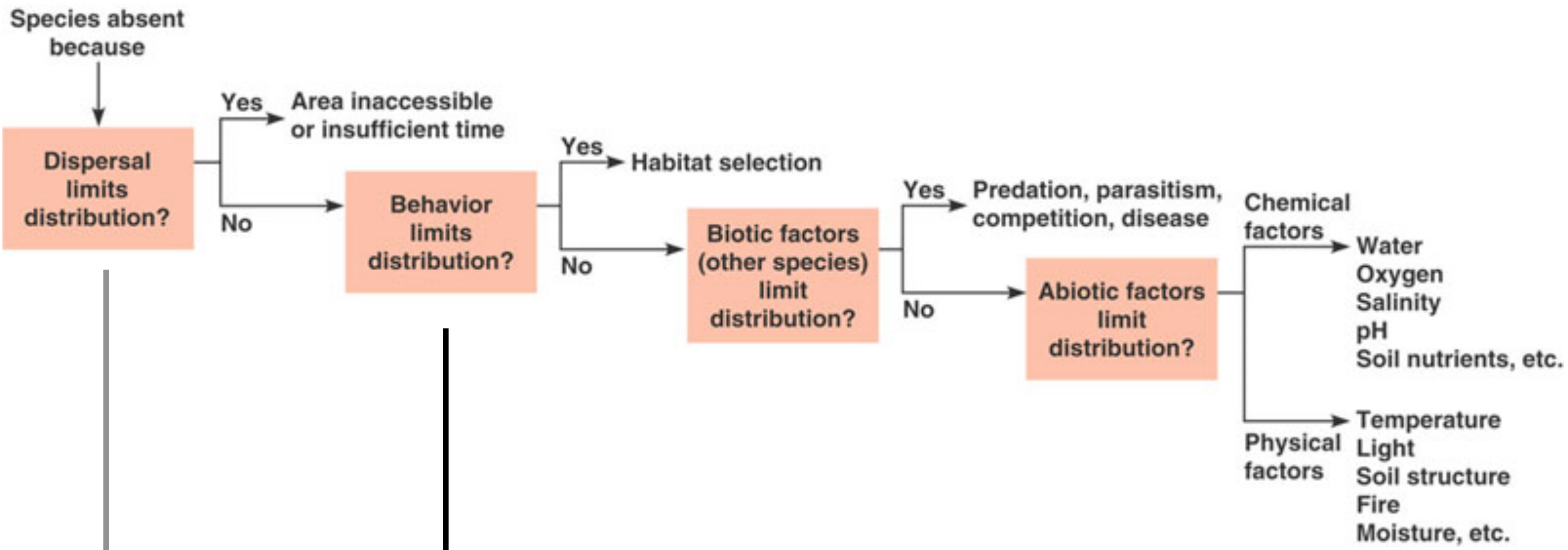
the great–tailed grackle





African honey bee

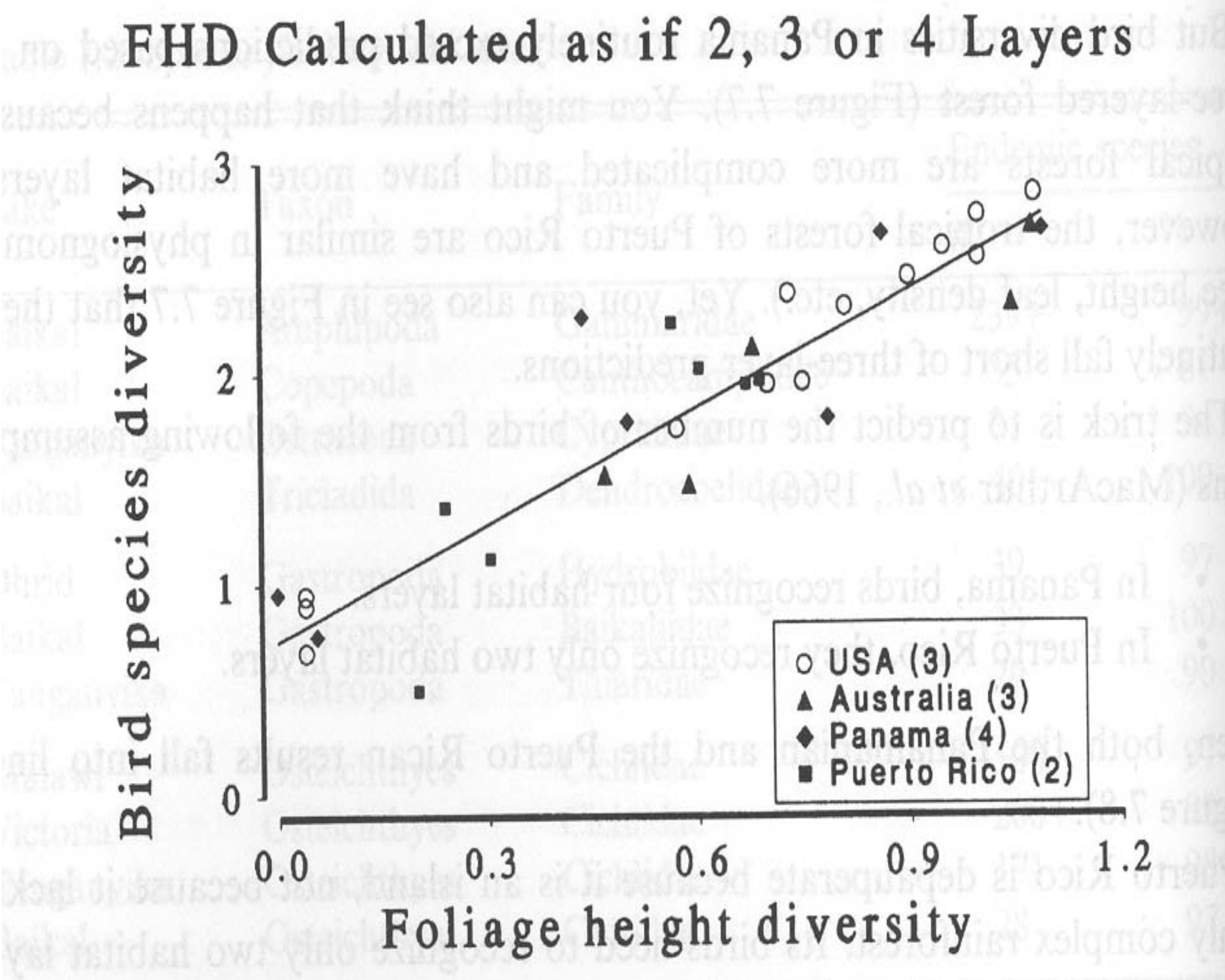
what limits the geographical distribution of any species?



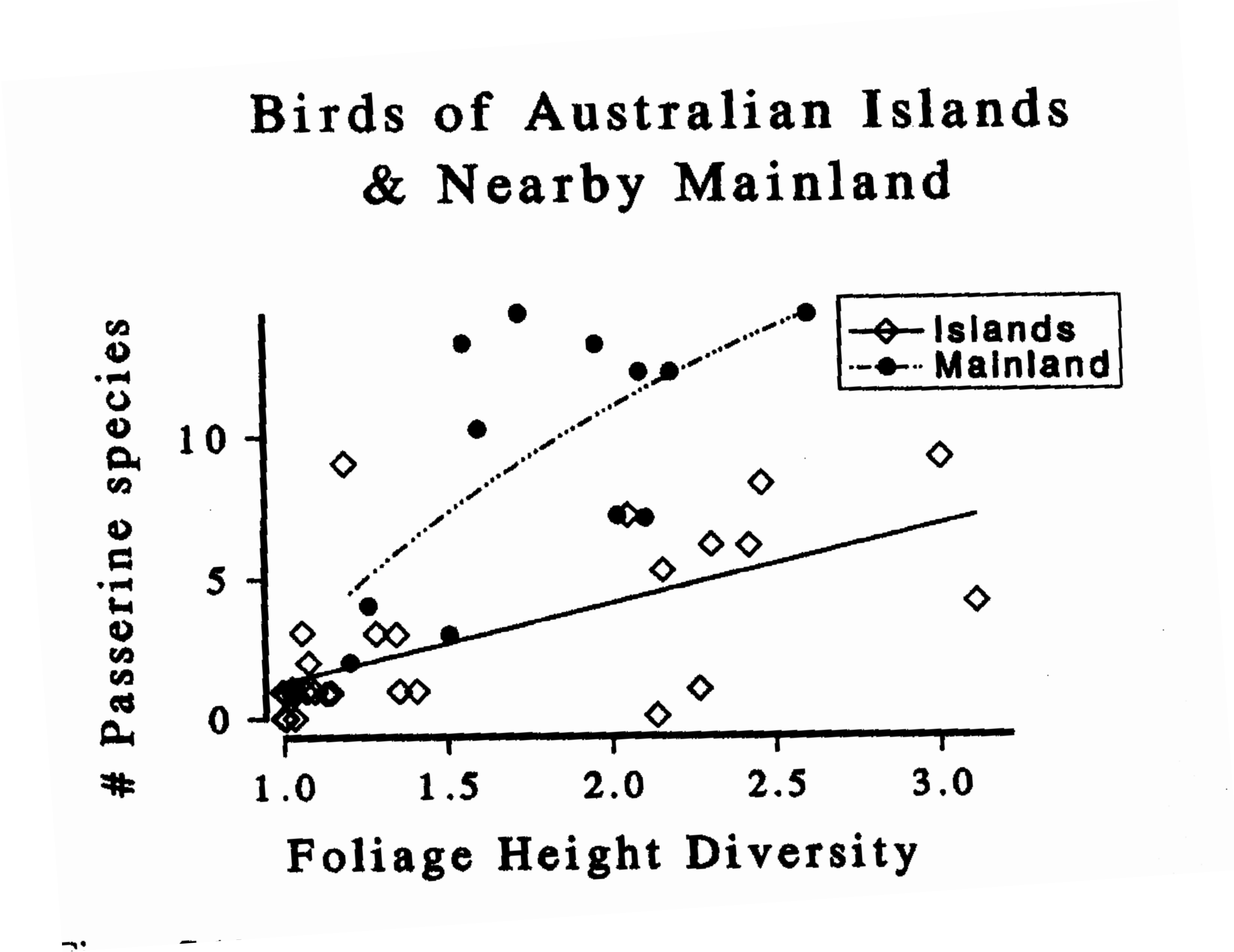
Distribution

Behaviour
Habitat selection

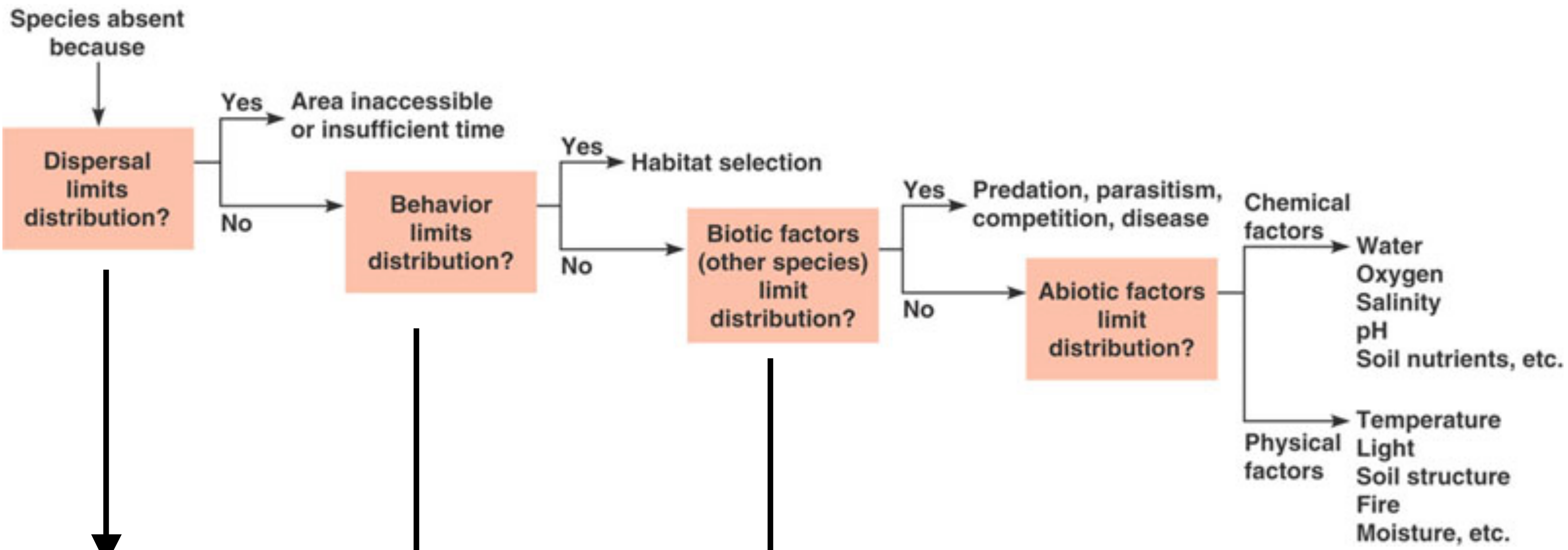
bird species diversity increases with habitat diversity



but the pattern is different for islands and mainland??..........



what limits the geographical distribution of any species?



Distribution

Behaviour
Habitat selection

Interspecific Interactions

Competition: In Peruvian mountains congeneric bird ranges do not overlap, and range size increases with elevation

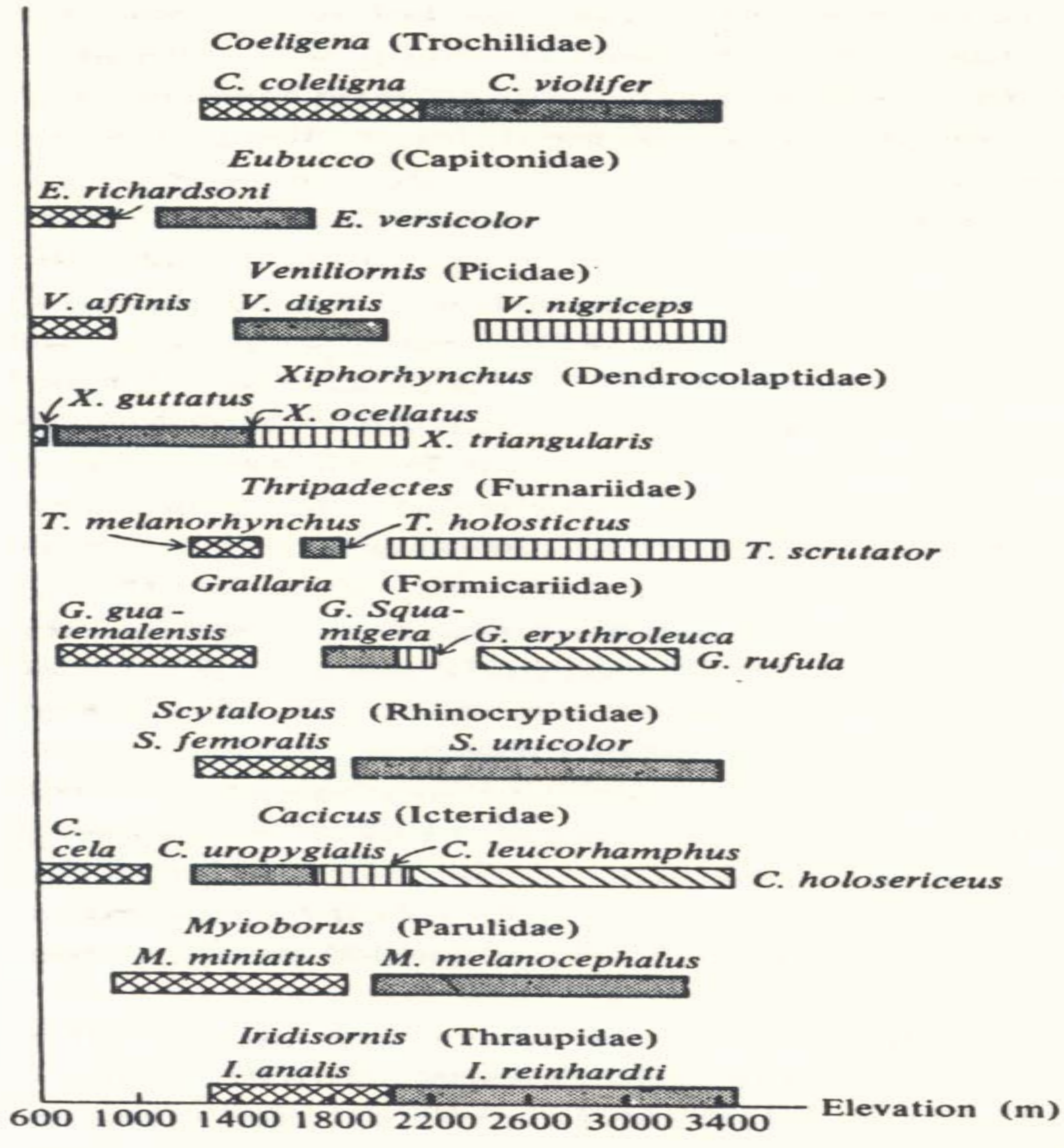


Fig. 6-3

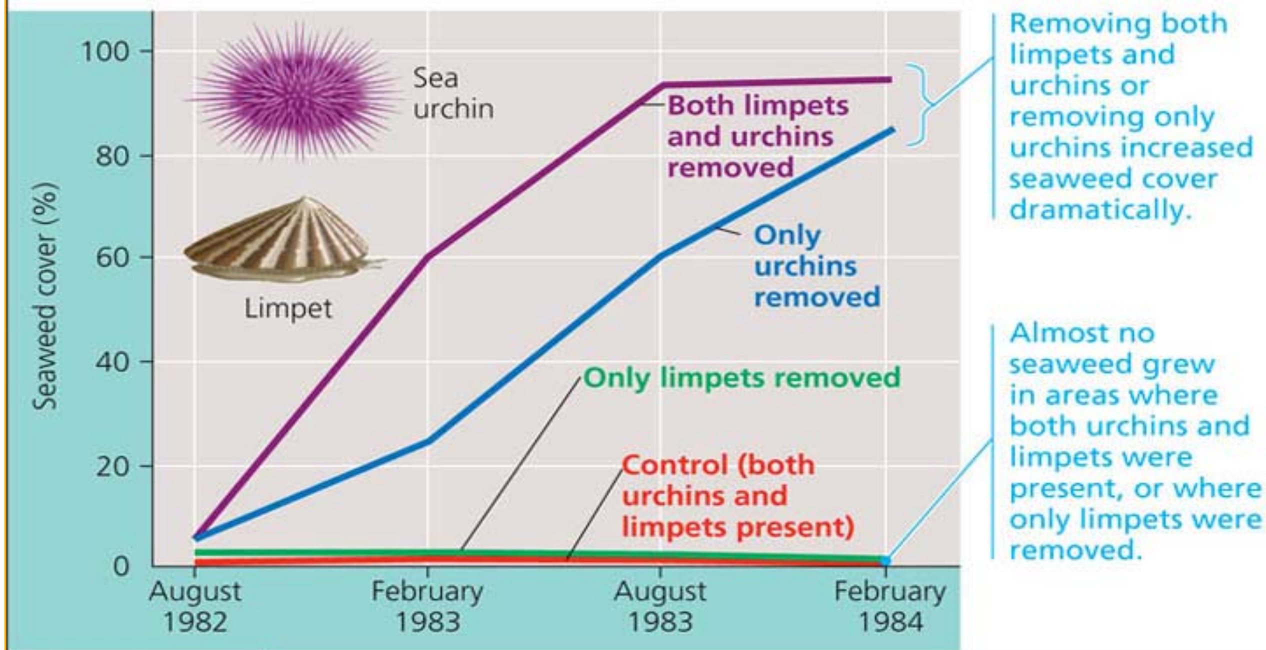
Predation: urchins and limpets limit the range of seaweed

Figure 50.8

Inquiry **Does feeding by sea urchins and limpets affect seaweed distribution?**

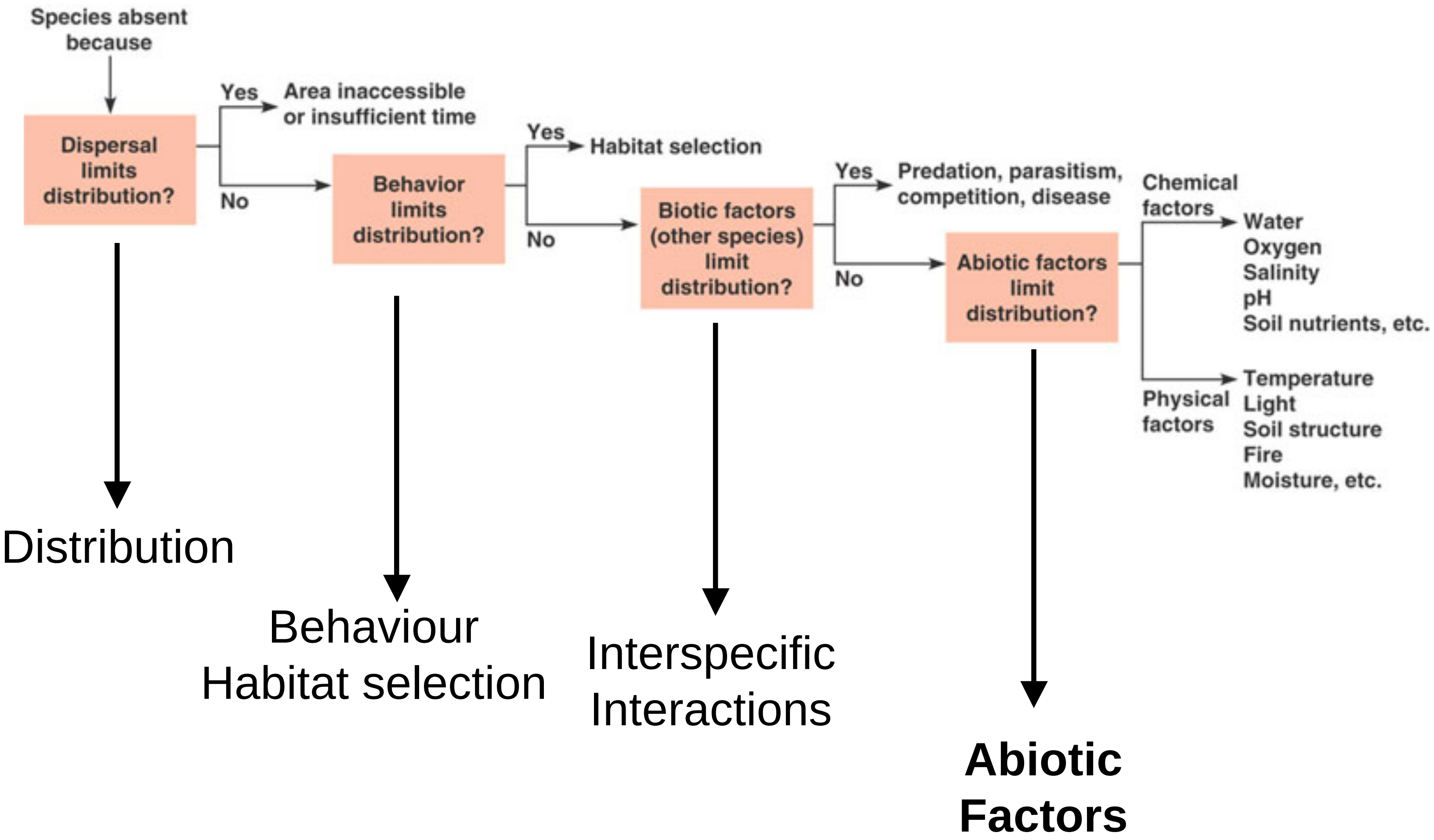
EXPERIMENT W. J. Fletcher tested the effects of two algae-eating animals, sea urchins and limpets, on seaweed abundance near Sydney, Australia. In areas adjacent to a control site, either the urchins, the limpets, or both were removed.

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



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.

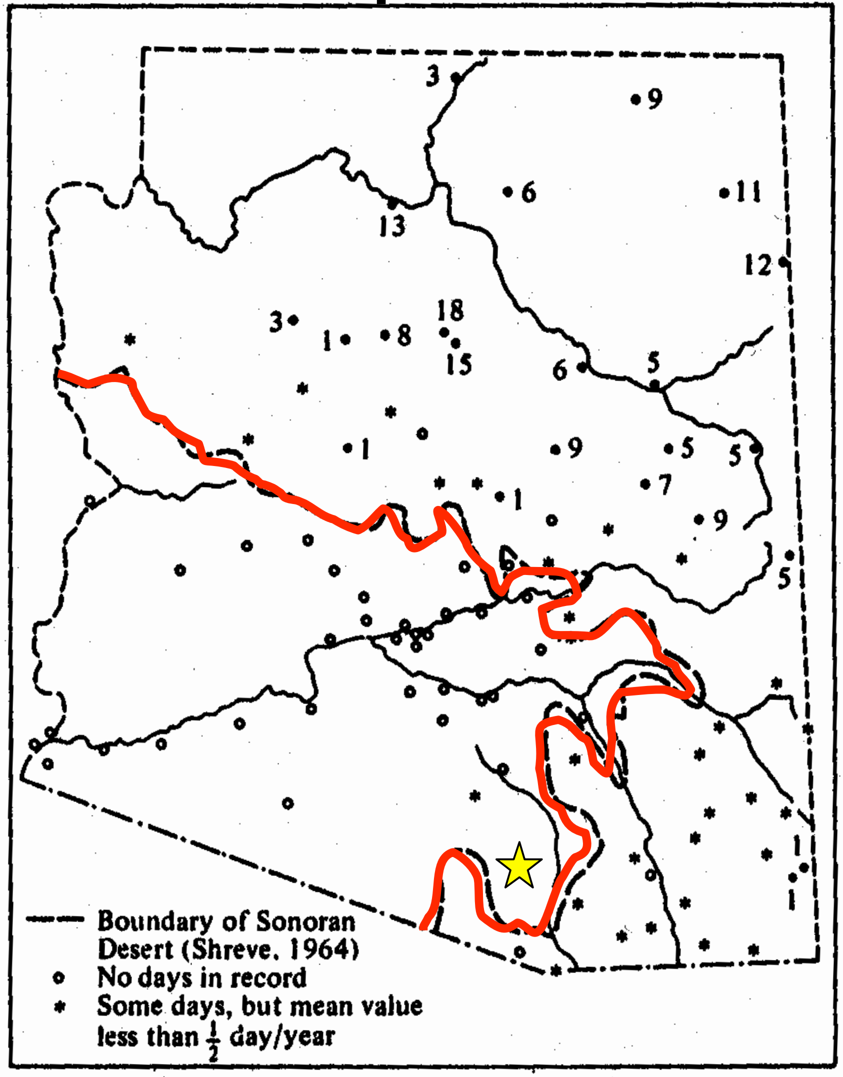
what limits the geographical distribution of any species?



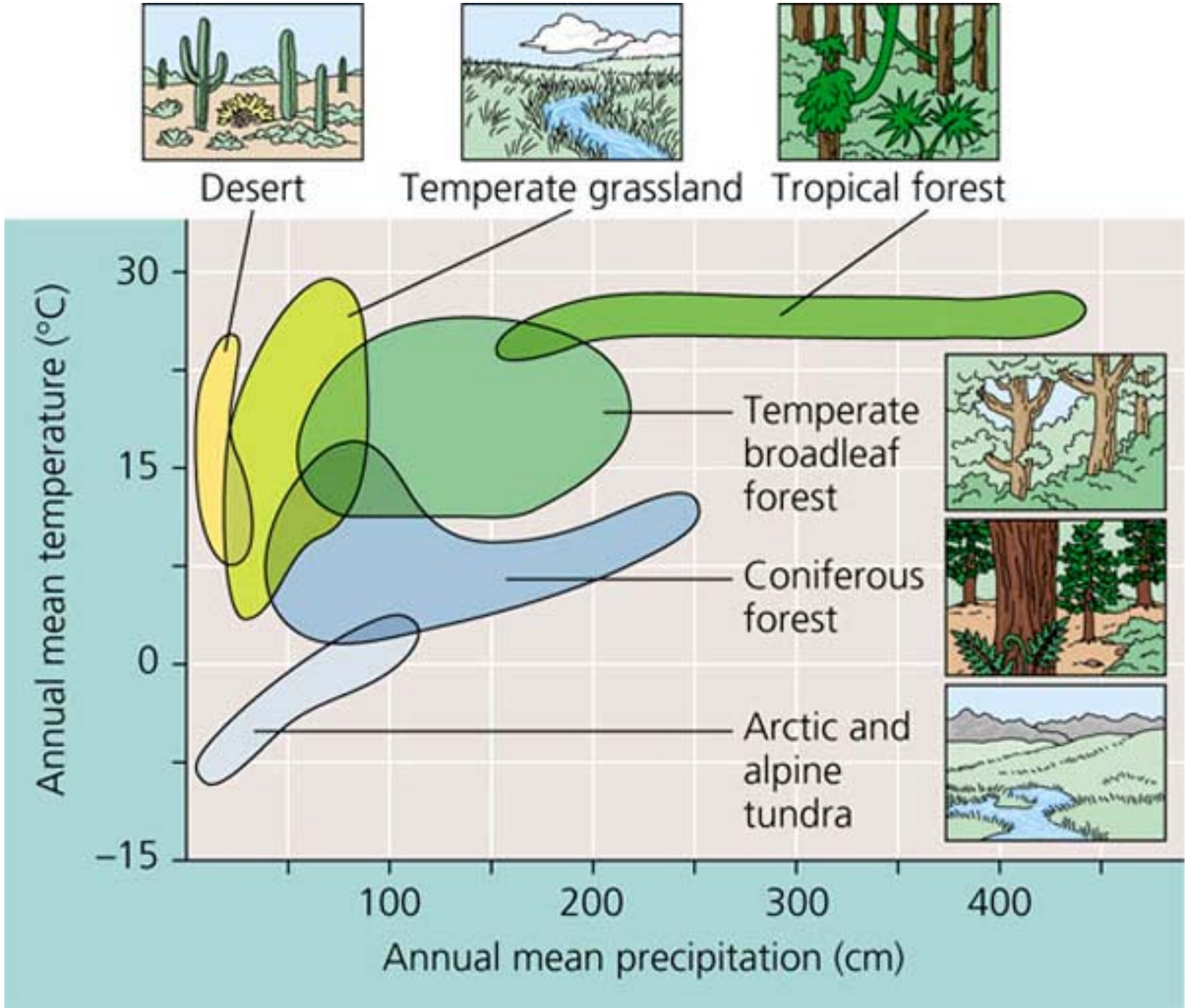
WIND

Sonoran Desert

temperature

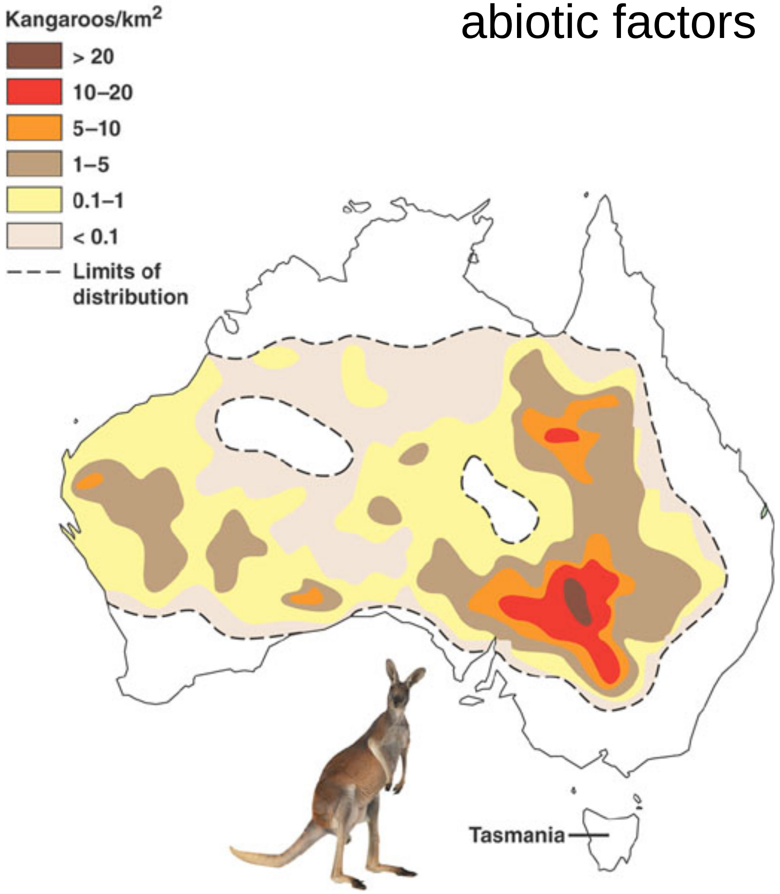


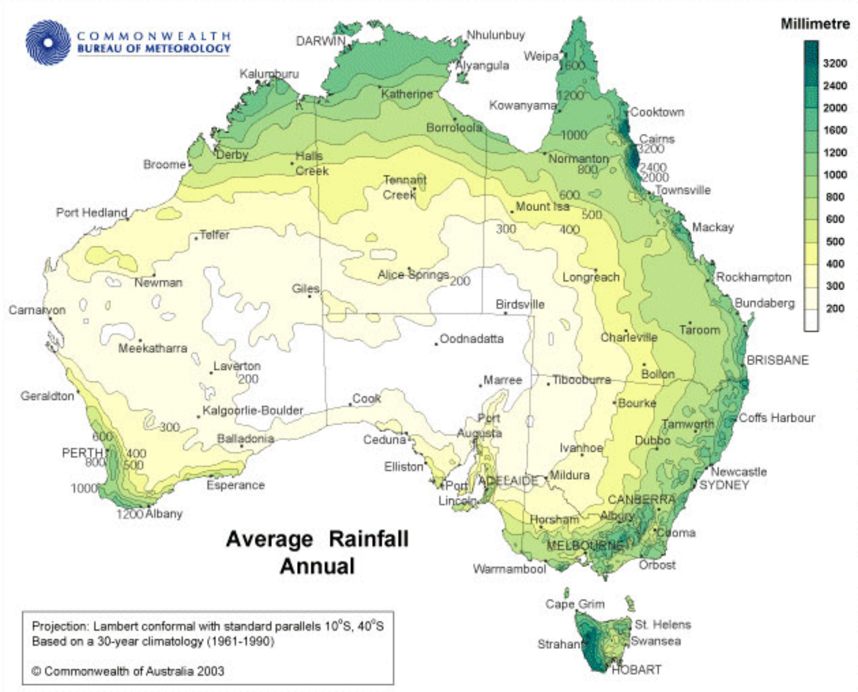
Temperature & water



So why aren't kangaroos everywhere?

migration limitation
habitat selection
interspecific interactions
abiotic factors





If climate is so important in determining ranges

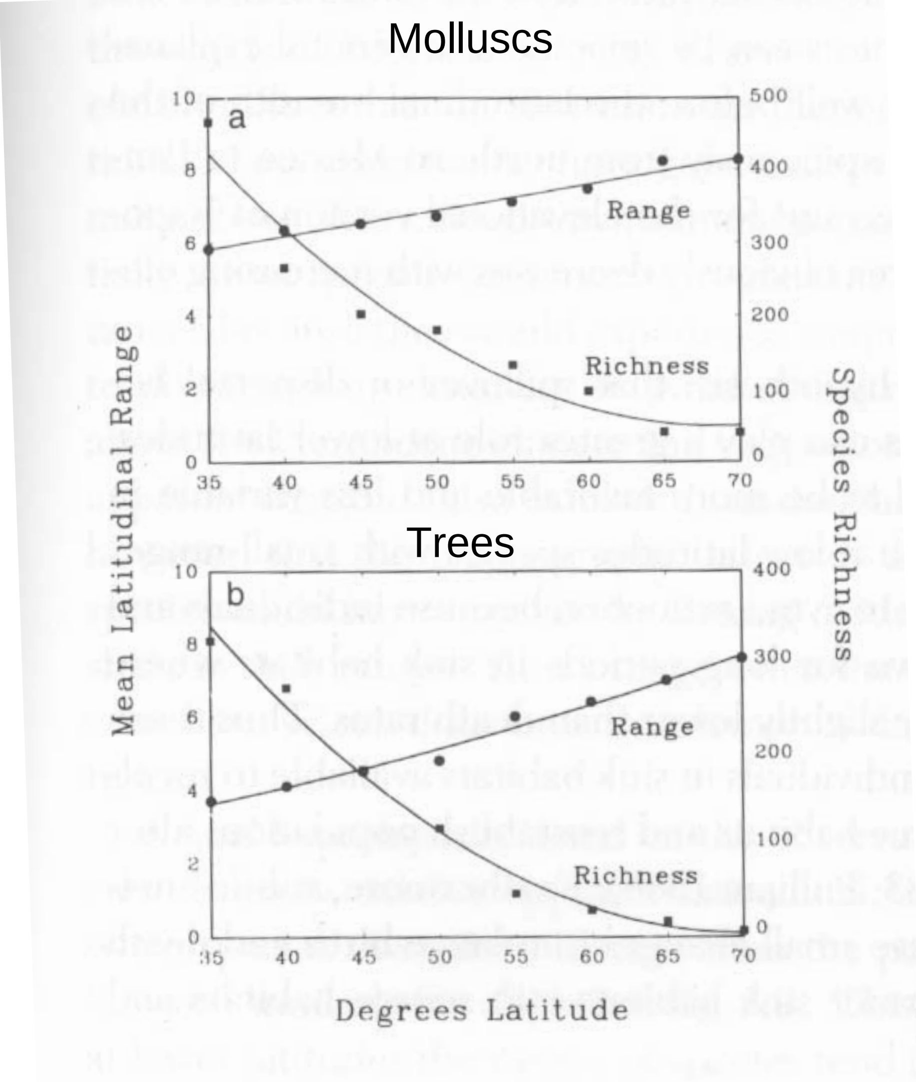
is there a general, global pattern in range size?

Yes! “Rapoport’s Rule”

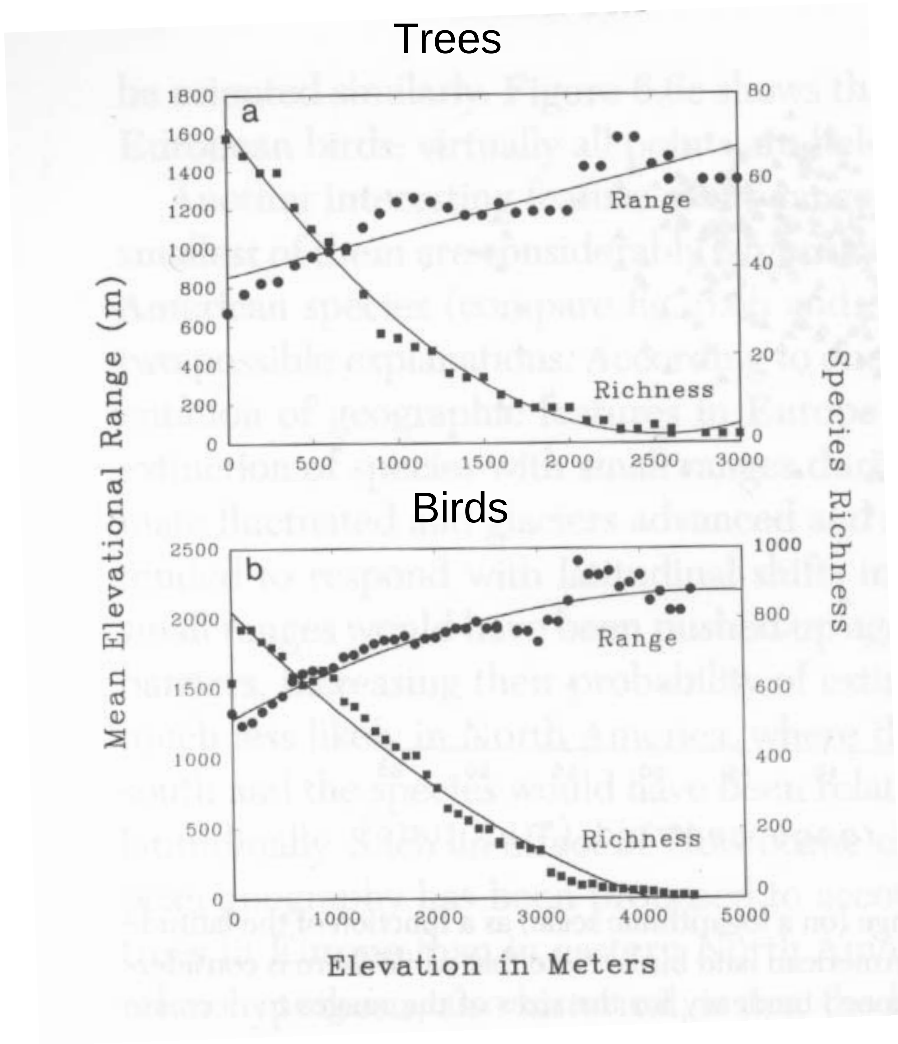
Range size increases with latitude and altitude

(species richness shows the opposite trend)

North American



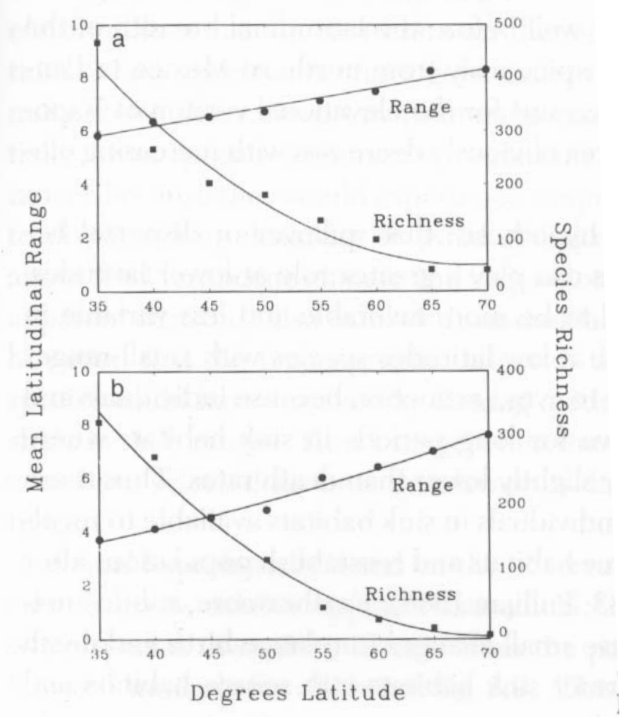
Latin American



North American

Molluscs

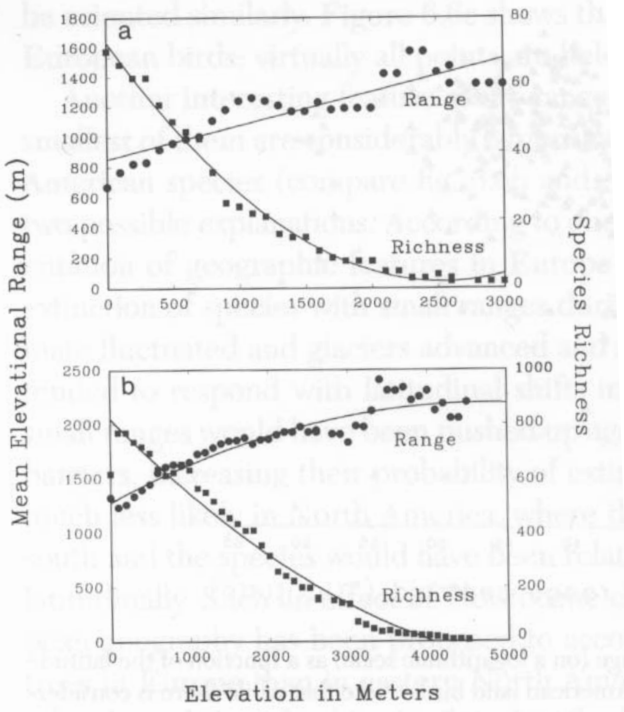
Trees



Latin American

Trees

Birds

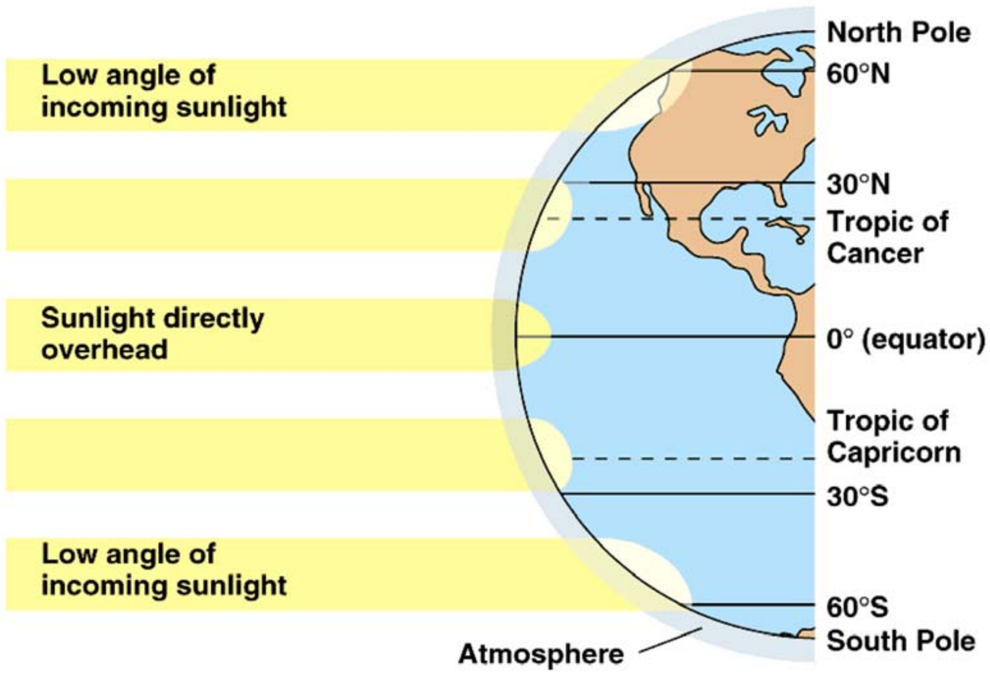


WHY?

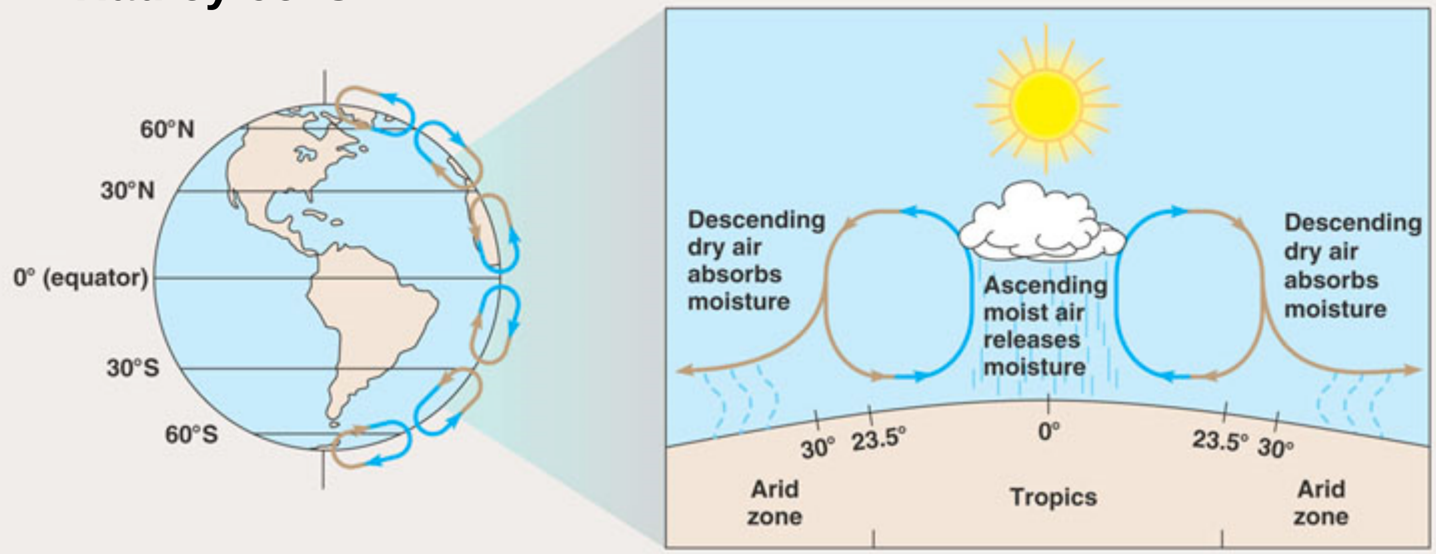
Because climate is less variable at low latitudes.....
- small populations can survive longer in the tropics leading to small ranges
- mountains constrain migration more at low latitudes thus reducing ranges

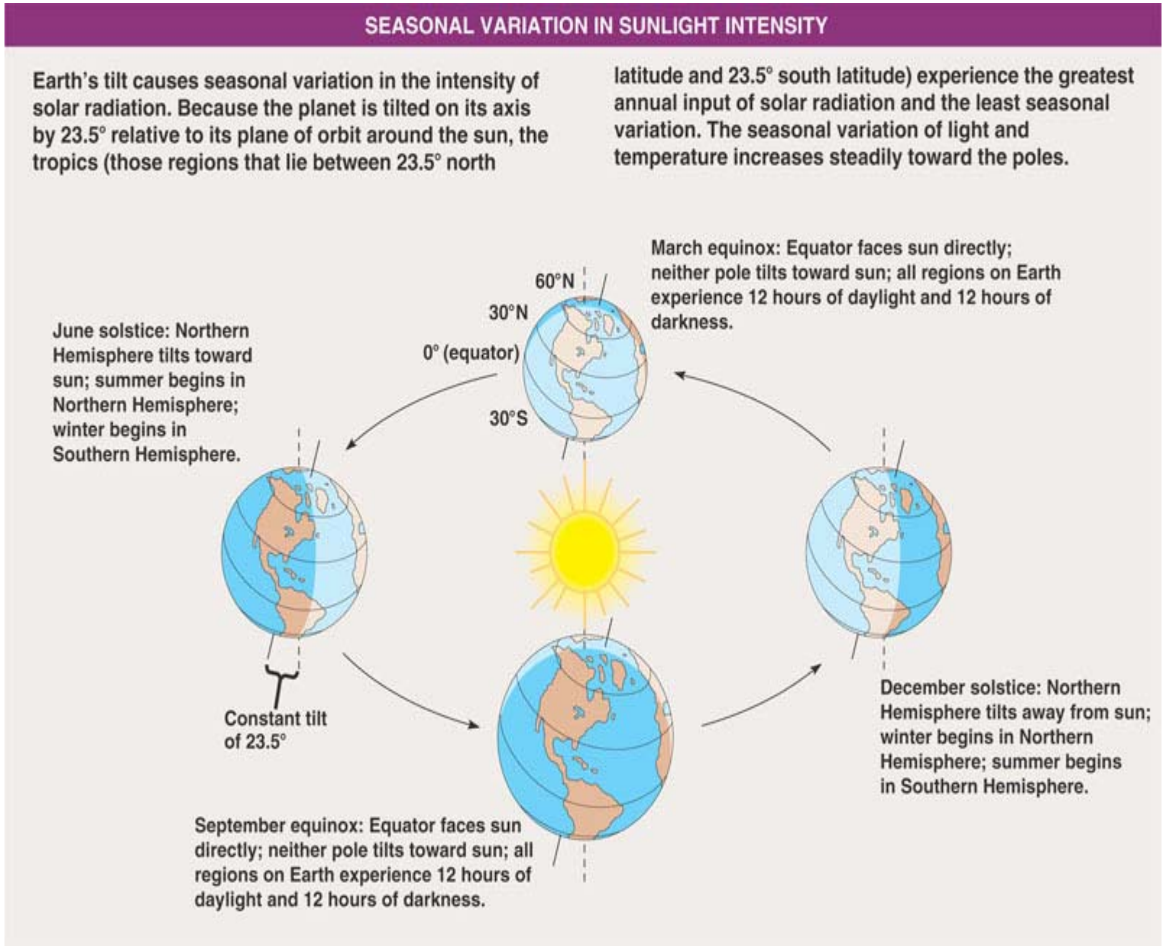
- glaciations drive species unable to migrate to extinction, selects for large ranges
- at low latitudes more intense species interactions (competition) reduce range size

Global climate

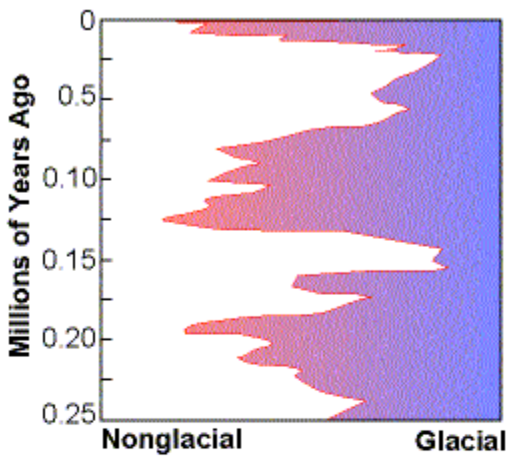


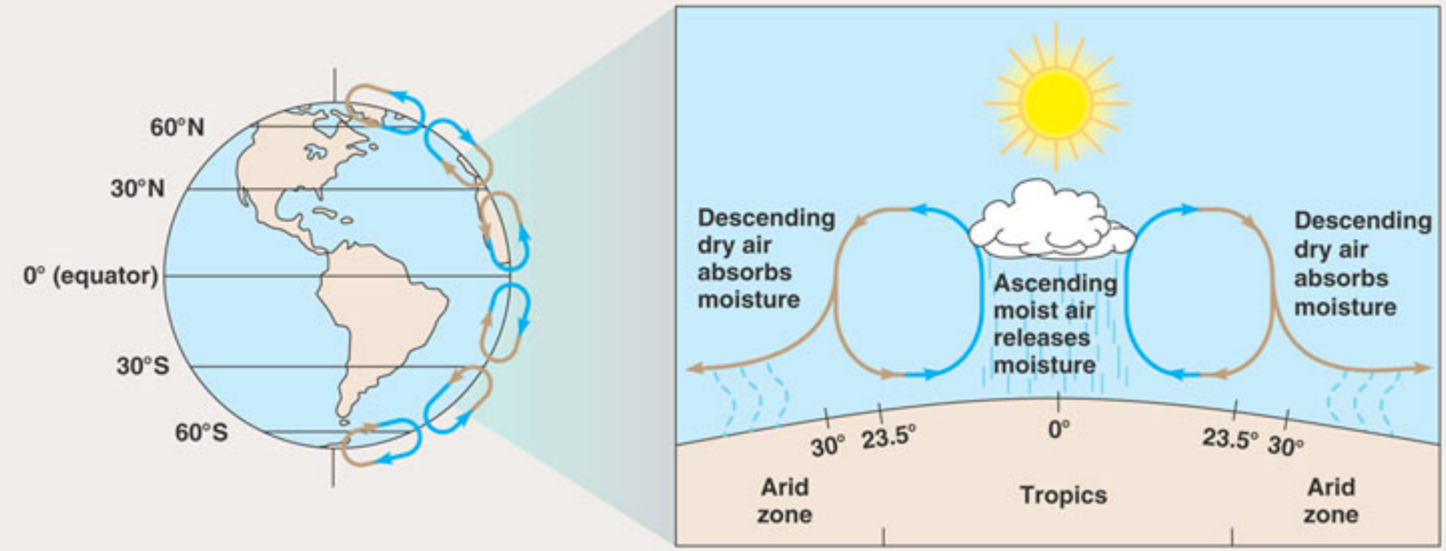
Hadley cells



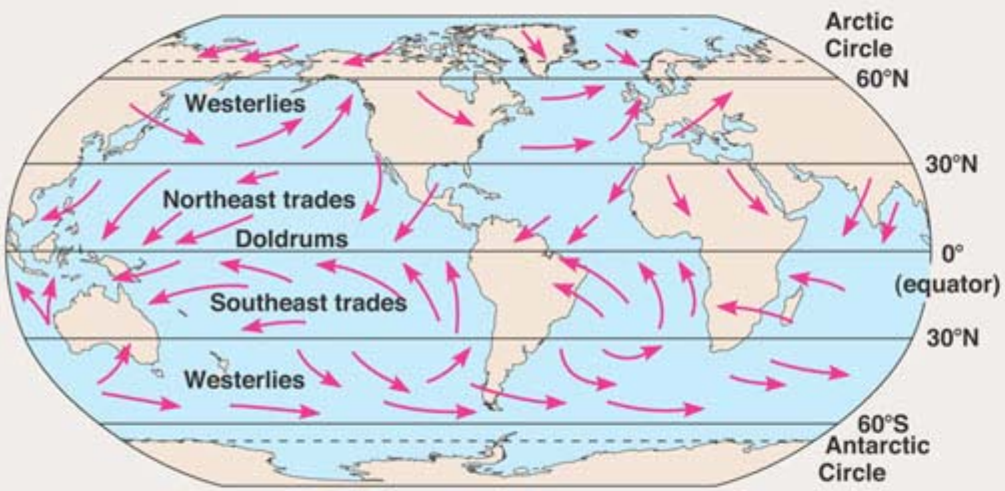


eccentricity
(100,000 yrs)
+
tilt
(41,000 yrs)
+
wobble
(23,000 yrs)
=
ice ages





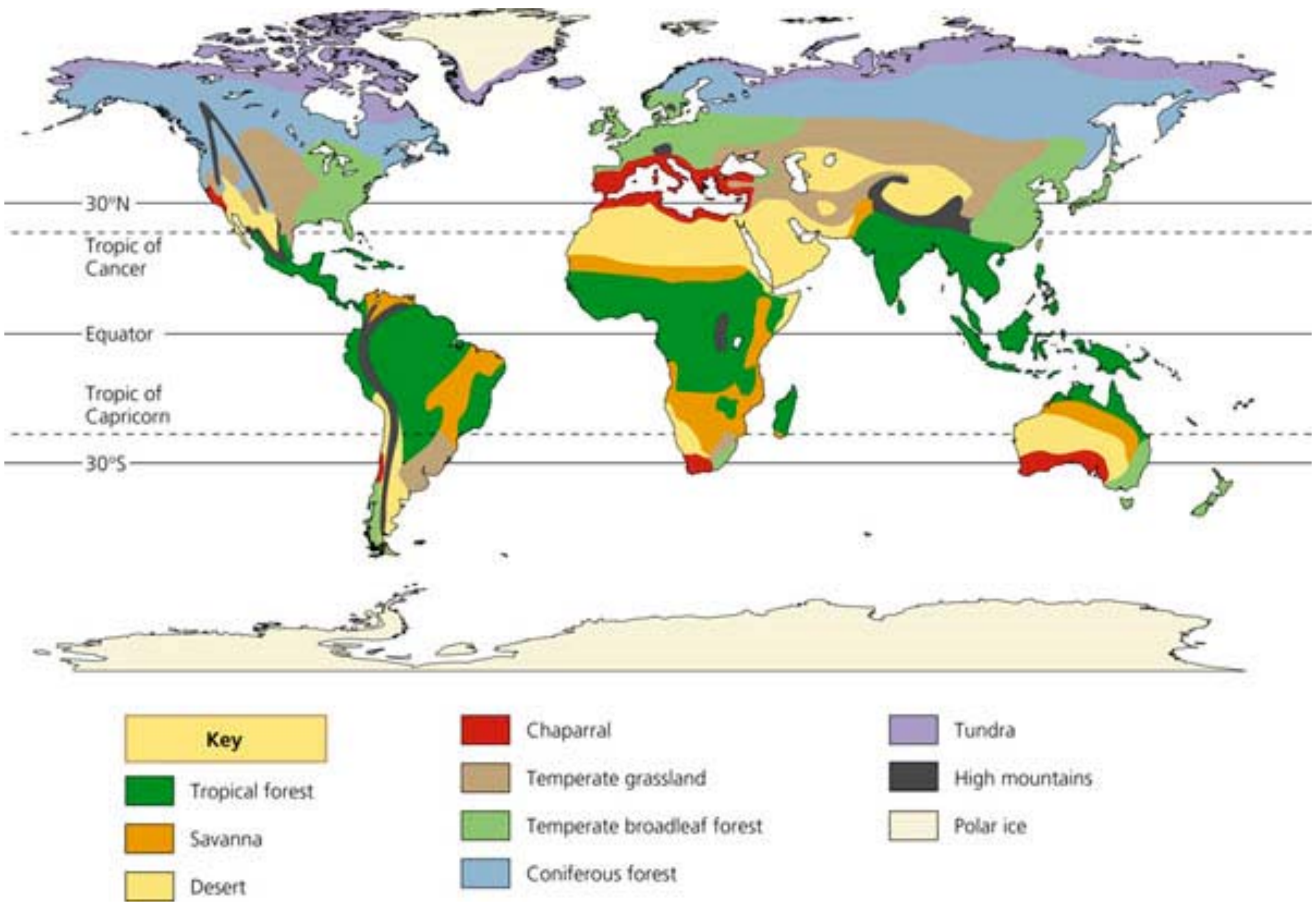
GLOBAL WIND PATTERNS

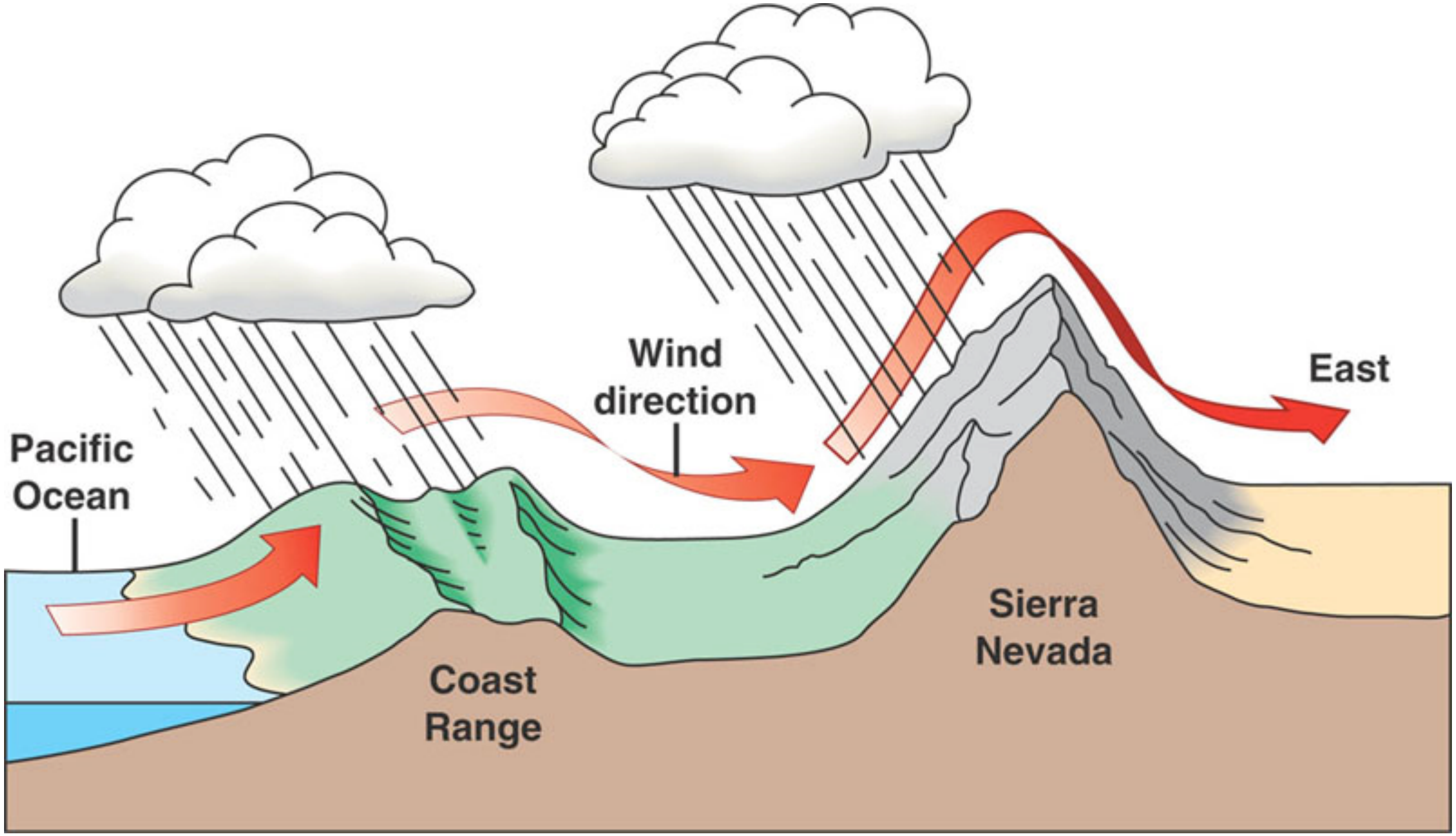


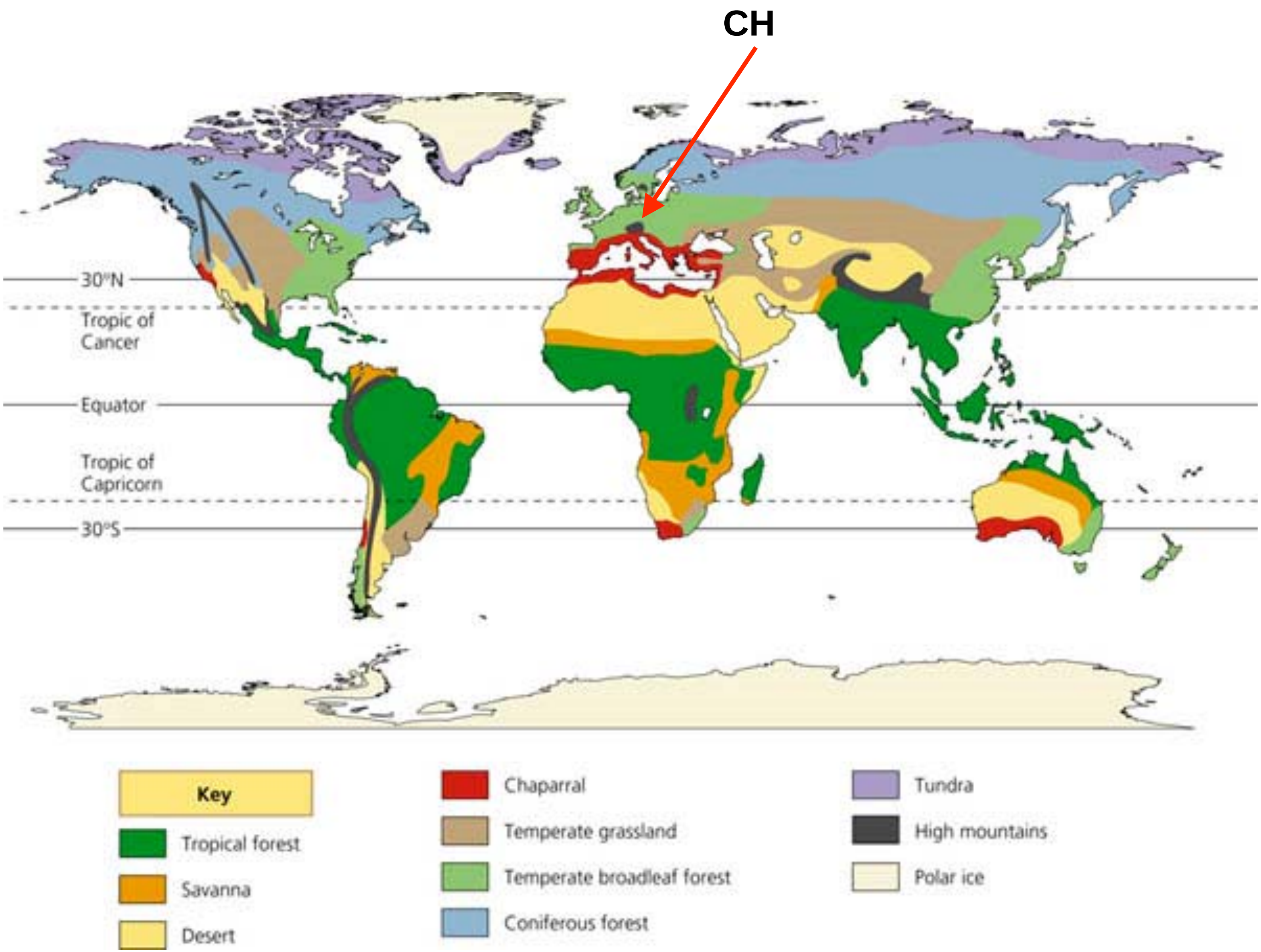
Air flowing close to Earth's surface creates predictable global wind patterns. As Earth rotates on its axis, land near the equator moves faster than that at the poles, deflecting the winds from the vertical paths shown above and creating more easterly and westerly flows. Cooling trade winds blow from east to west in the tropics; prevailing westerlies blow from west to east in the temperate zones, the regions between the tropics and the Arctic Circle or the Antarctic Circle.

Climate (temperature, water, light, wind, seasonality)

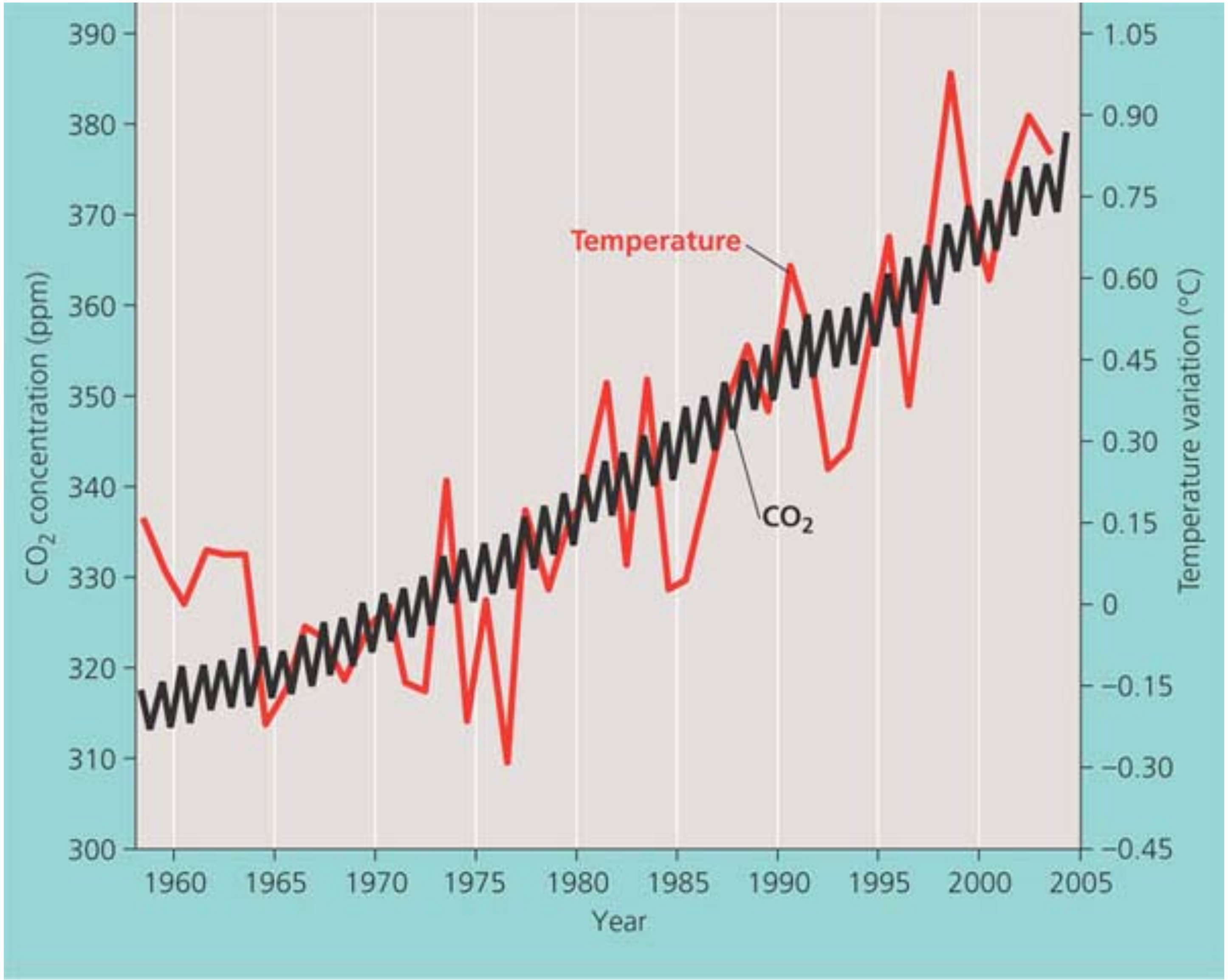
determines the makeup of **biomes**, the major types of ecosystems.



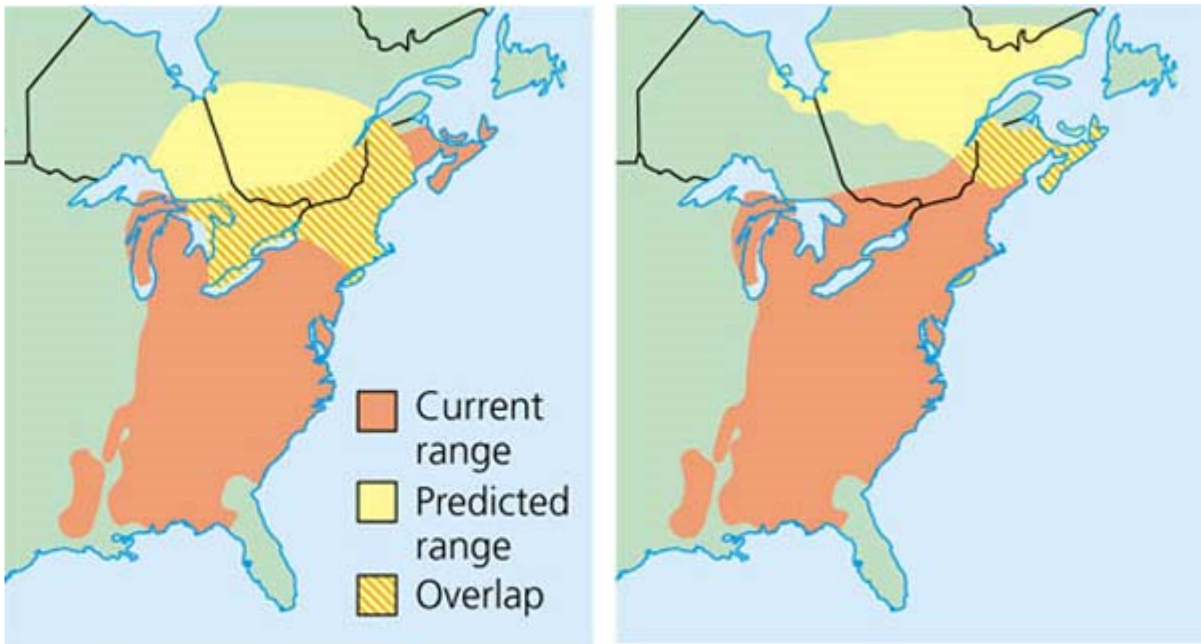

Wind
direction
East
Pacific
Ocean
Coast
Range
Sierra
Nevada


CH
30°N
Tropic of Cancer
Equator
Tropic of Capricorn
30°S
Key
Tropical forest
Savanna
Desert
Chaparral
Temperate grassland
Temperate broadleaf forest
Coniferous forest
Tundra
High mountains
Polar ice

The increase in atmospheric carbon dioxide at Mauna Loa, Hawaii, and average global temperatures over land from 1958 to 2004.



Range change in some unknown species !#@$!@#$



(a) 4.5°C warming over next century

(b) 6.5°C warming over next century

smoke break

Subfields of Ecology

Organismal ecology

Population ecology

Community ecology

Ecosystem ecology

Landscape ecology deals with the array of ecosystems and their arrangement in a geographic region. A landscape or seascape consists of several different ecosystems linked by exchanges of energy, materials, and organisms.

(a) Organismal ecology. How do humpback whales select their calving areas?

(b) Population ecology. What enviromental factors affect the reproductive rate of deer mice?

(c) Community ecology. What factors influence the diversity of species that make up a particular forest?

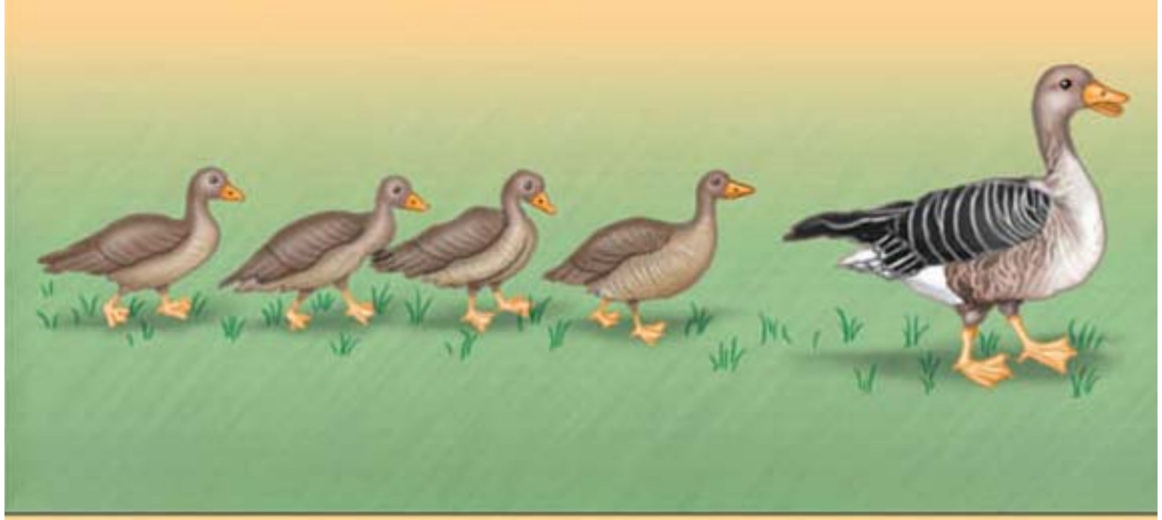
(e) Landscape ecology. To what extent do the trees lining the drainage channels in this landscape serve as corridors of dispersal for forest animals?

(d) Ecosystem ecology. What factors control photosynthetic productivity in a temperate grassland ecosystem?

Organismal ecology is concerned with the behavioral, physiological, and morphological ways individuals interact with the environment.

observations of animal behavior by studying how such behavior is controlled and how it develops, evolves, and contributes to survival and reproductive success.

BEHAVIOR: Young geese follow and imprint on their mother.



PROXIMATE CAUSE: During an early, critical developmental stage, the young geese observe their mother moving away from them and calling.

ULTIMATE CAUSE: On average, geese that follow and imprint on their mother receive more care and learn necessary skills, and thus have a greater chance of surviving than those that do not follow their mother.

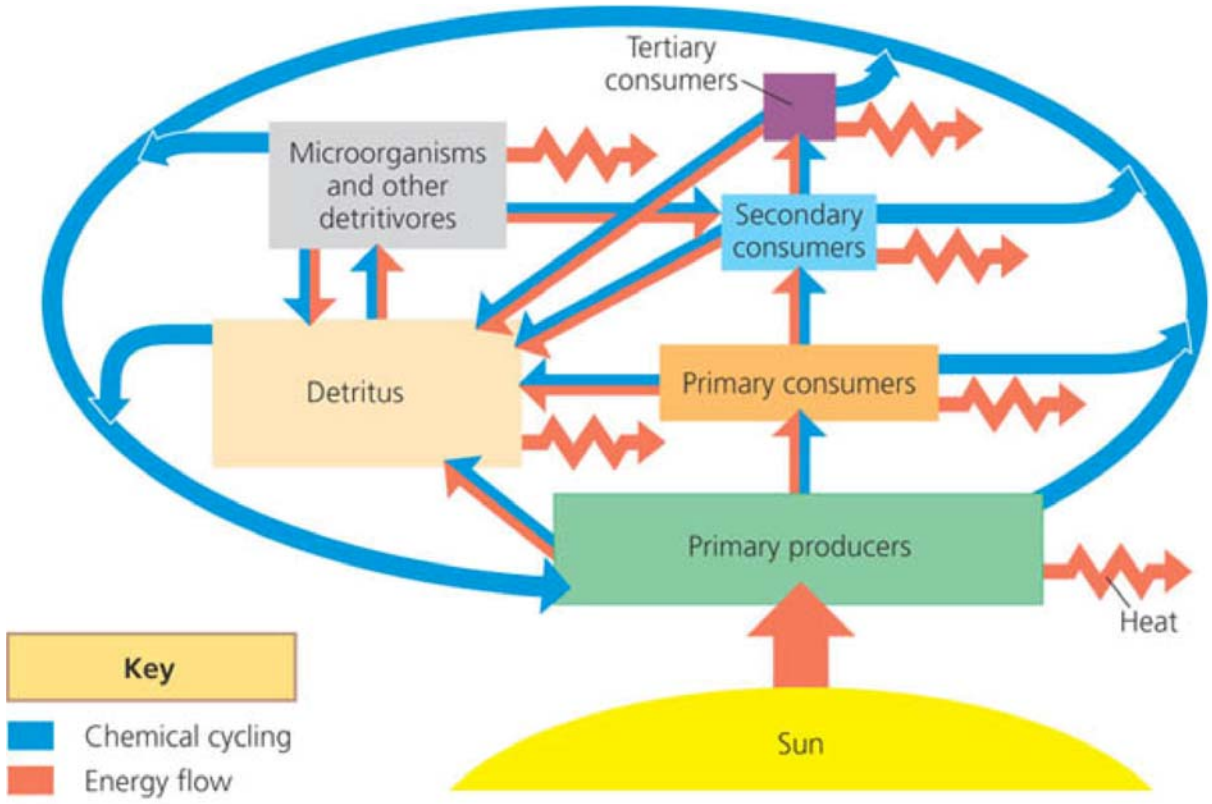
environmental stimuli, if any, that trigger a behavior, as well as the genetic, physiological, and anatomical mechanisms underlying a

the evolutionary significance of a behavioral act.

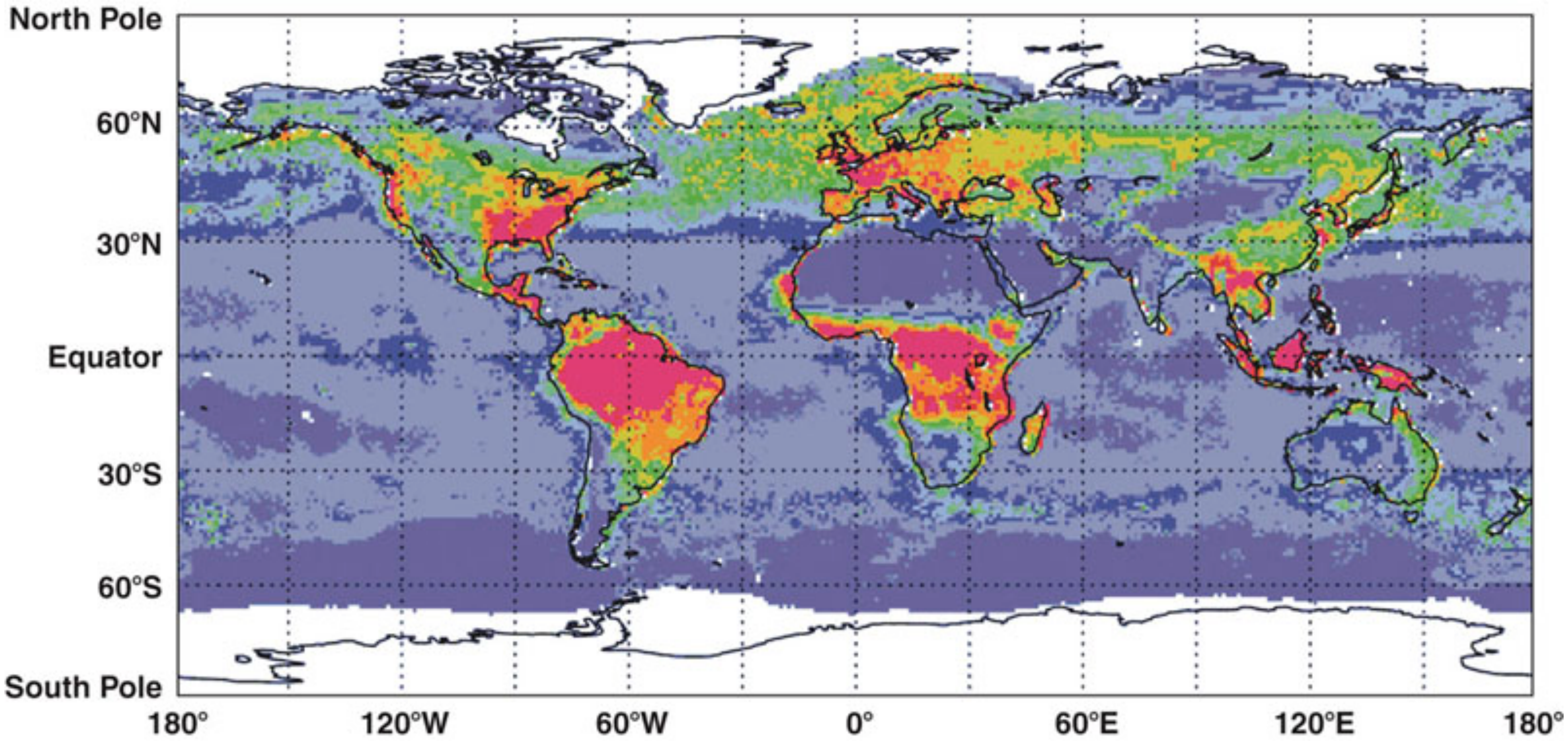
Ecosystem ecology examines the energy flow and cycling of chemicals among the various abiotic and biotic components.

an **ecosystem** consists of all the organisms living in a community as well as all the abiotic factors with which they interact.

energy flow in an ecosystem is HOT



Physical and chemical factors limit primary production in ecosystems



Gross and Net Primary Production

Total primary production in an ecosystem = **gross primary production** (GPP)—the amount of light energy that is converted to chemical energy by photosynthesis per unit time.

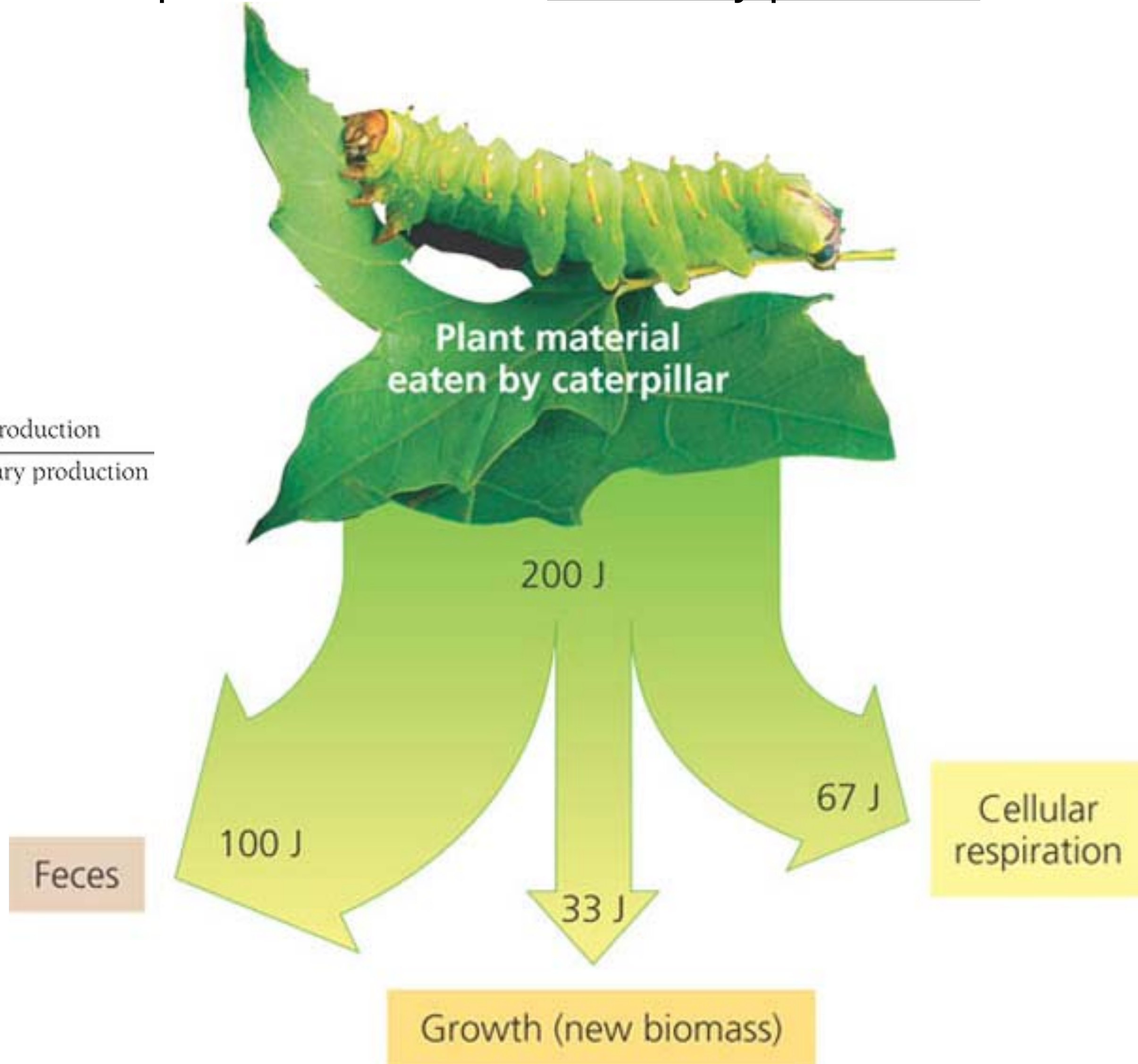
Net primary production (NPP) is equal to gross primary production minus the energy used by the primary producers for respiration (R):

Detritivores, or decomposers, are consumers that get their energy from detritus, which is nonliving organic material, such as the remains of dead organisms, feces, fallen leaves, and wood.

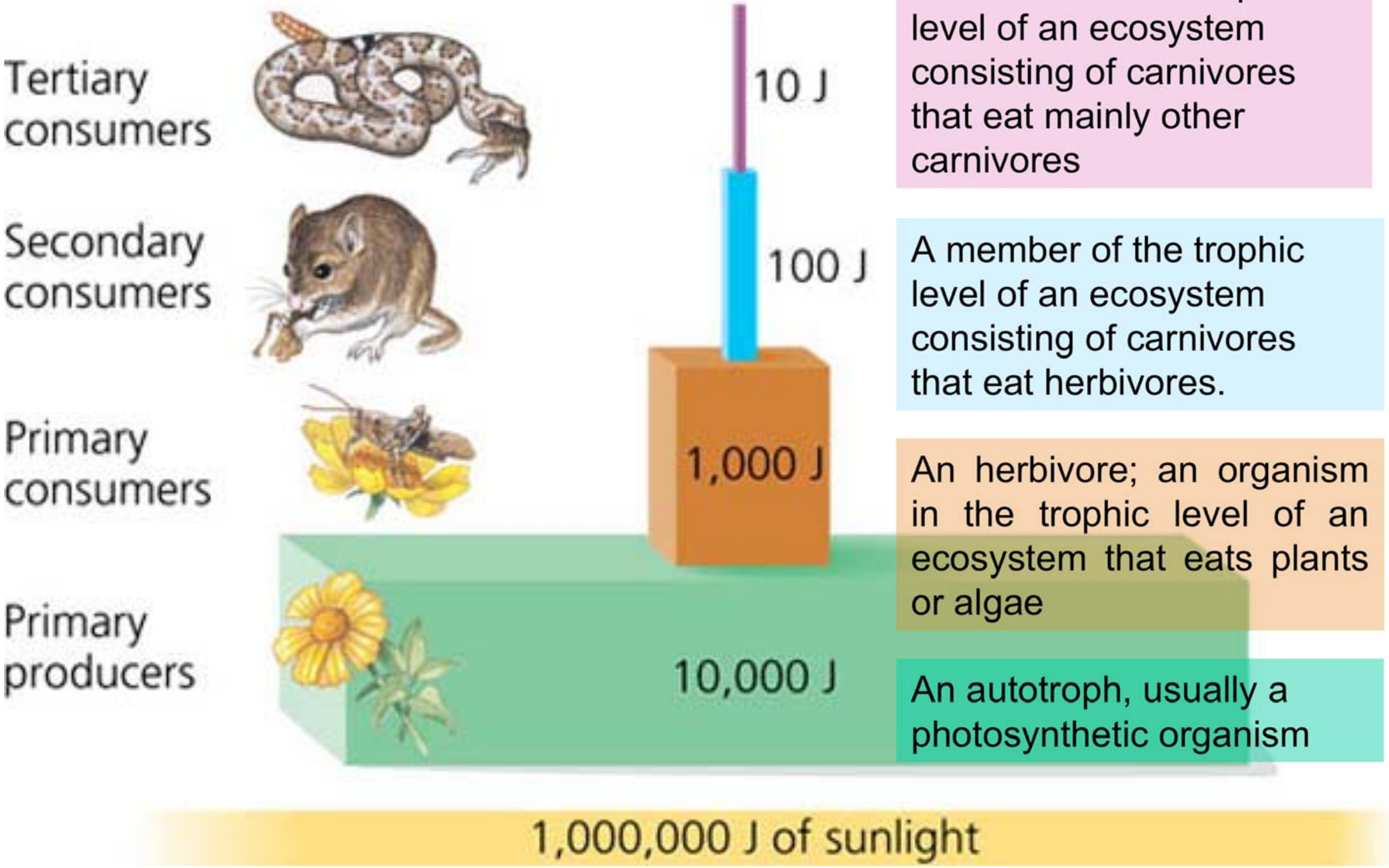
ANIMALS ARE INEFFICIENT

The amount of chemical energy in consumers' food that is converted to their own new biomass during a given time period is called the <u>secondary production</u>

$$\text{Production efficiency} = \frac{\text{Net secondary production}}{\text{Assimilation of primary production}}$$



FOOD WEBS ARE INEFFICIENT



A member of the trophic level of an ecosystem consisting of carnivores that eat mainly other carnivores

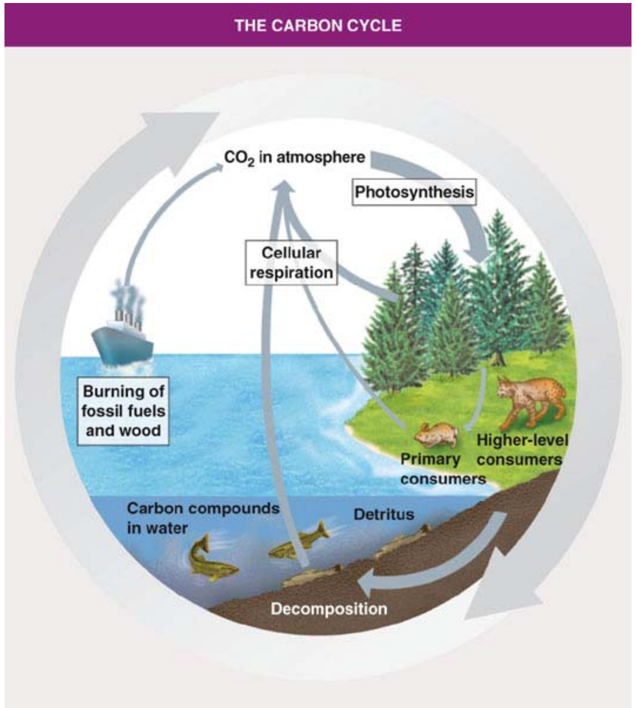
A member of the trophic level of an ecosystem consisting of carnivores that eat herbivores.

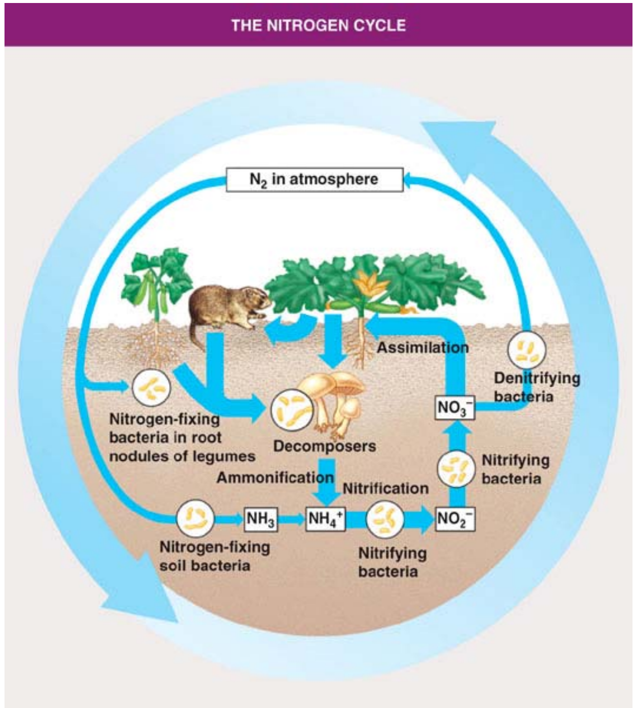
An herbivore; an organism in the trophic level of an ecosystem that eats plants or algae

An autotroph, usually a photosynthetic organism

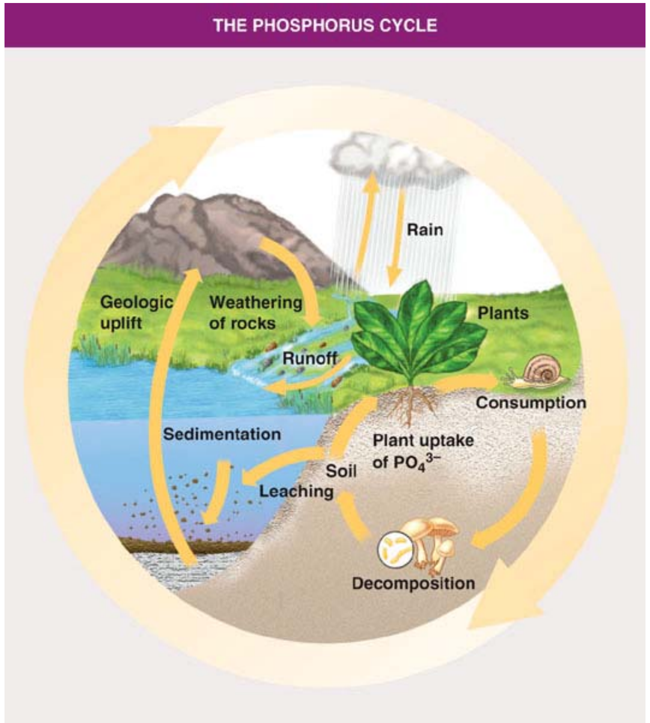
Biogeochemical cycles

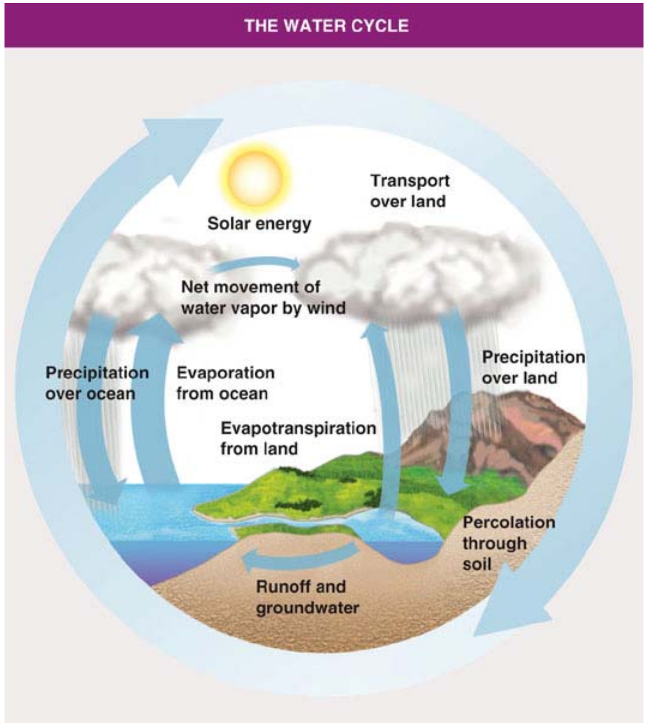
Pathways organic and inorganic molecules as they are cycled through the biotic and abiotic components of the earth’s ecosystems.

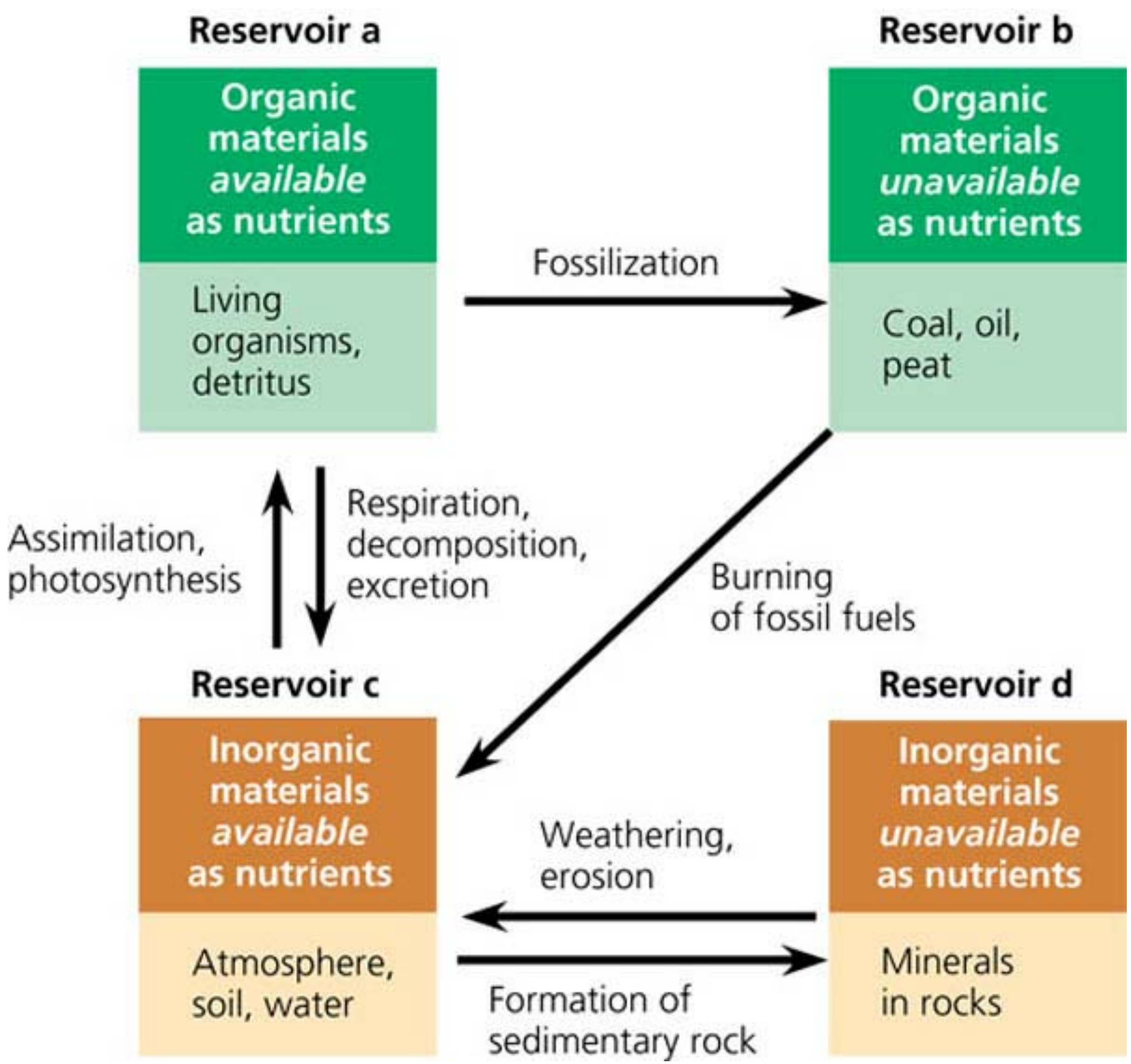




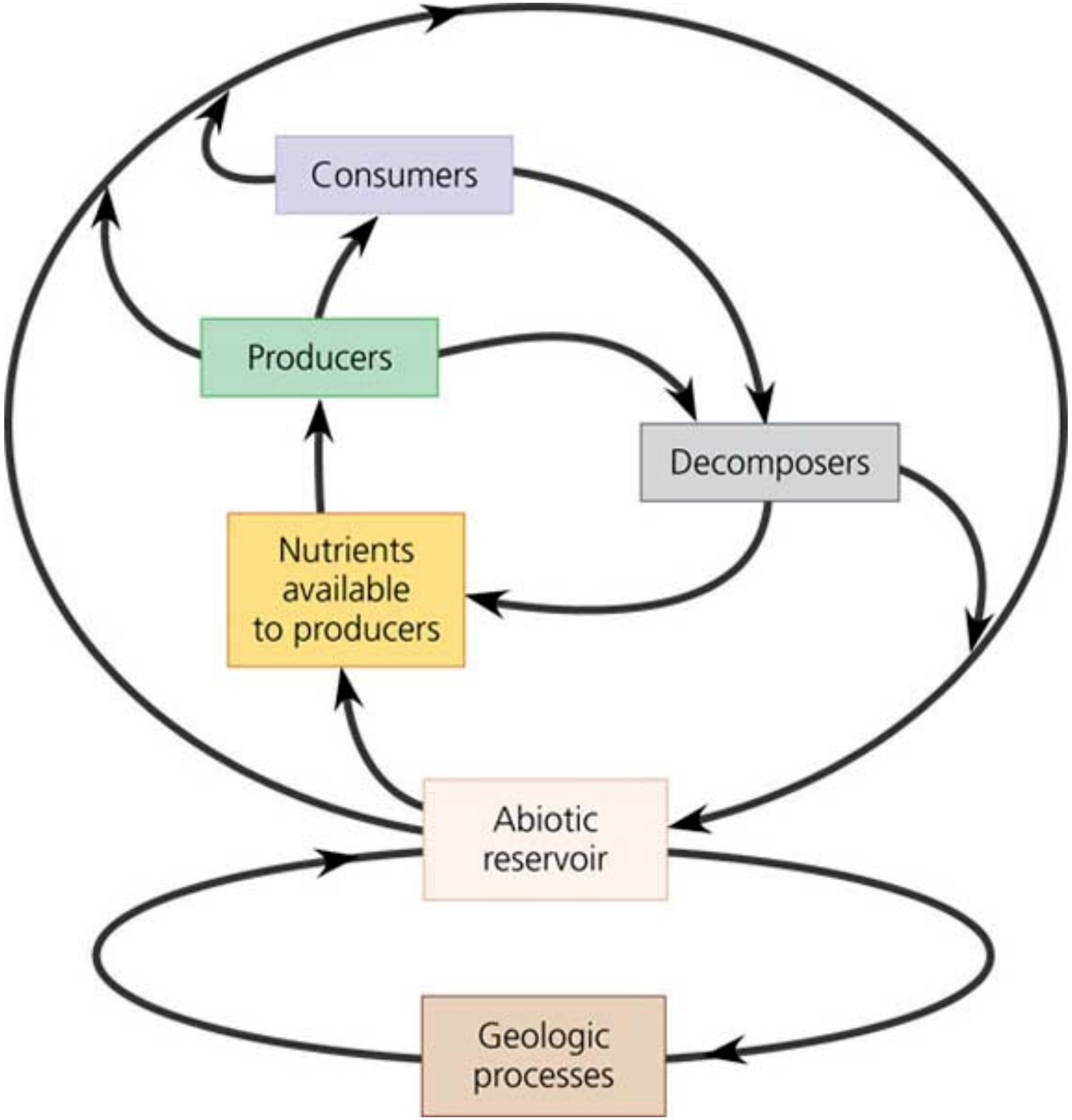
the four major cycles







Reservoir a
Organic materials *available* as nutrients
Living organisms, detritus
Reservoir b
Organic materials *unavailable* as nutrients
Coal, oil, peat
Fossilization
Assimilation, photosynthesis
Respiration, decomposition, excretion
Burning of fossil fuels
Reservoir c
Inorganic materials *available* as nutrients
Atmosphere, soil, water
Reservoir d
Inorganic materials *unavailable* as nutrients
Minerals in rocks
Weathering, erosion
Formation of sedimentary rock


Consumers
Producers
Decomposers
Nutrients available to producers
Abiotic reservoir
Geologic processes

AN EXPERIMENT TESTING FOR NUTRIENT LIMITATION IN PHYTOPLANKTON

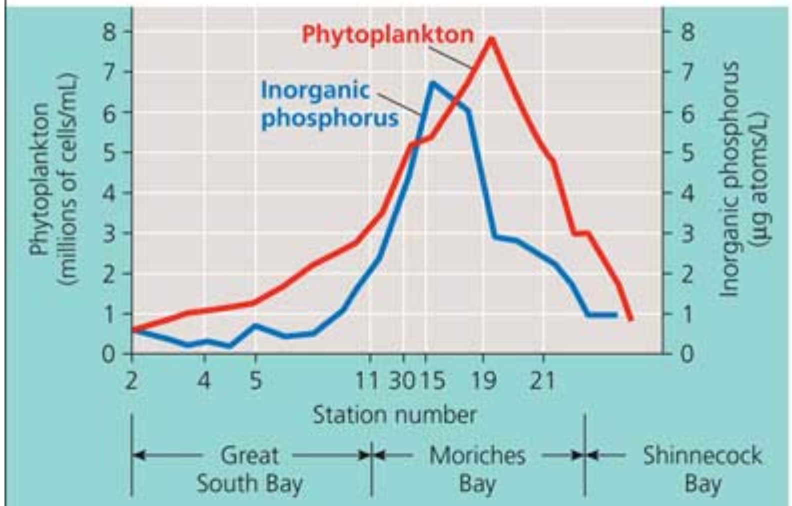
Figure 54.6

Inquiry Which nutrient limits phytoplankton production along the coast of Long Island?

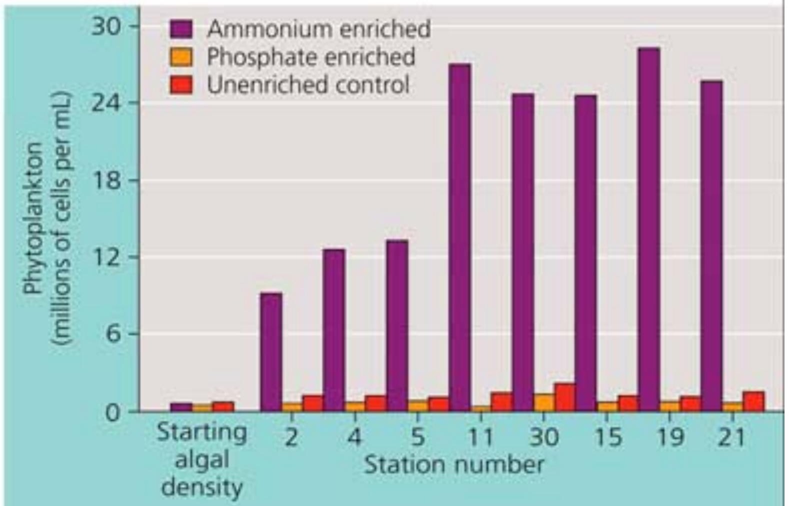
EXPERIMENT Pollution from duck farms concentrated near Moriches Bay adds both nitrogen and phosphorus to the coastal water off Long Island. Researchers cultured the phytoplankton *Nannochloris atomus* with water collected from several bays.

Coast of Long Island, New York. The numbers on the map indicate the data collection stations.

RESULTS Phytoplankton abundance parallels the abundance of phosphorus in the water (a). Nitrogen, however, is immediately taken up by algae, and no free nitrogen is measured in the coastal waters. The addition of ammonium (NH_4^+) caused heavy phytoplankton growth in bay water, but the addition of phosphate (PO_4^{3+}) did not induce algal growth (b).



(a) Phytoplankton biomass and phosphorus concentration

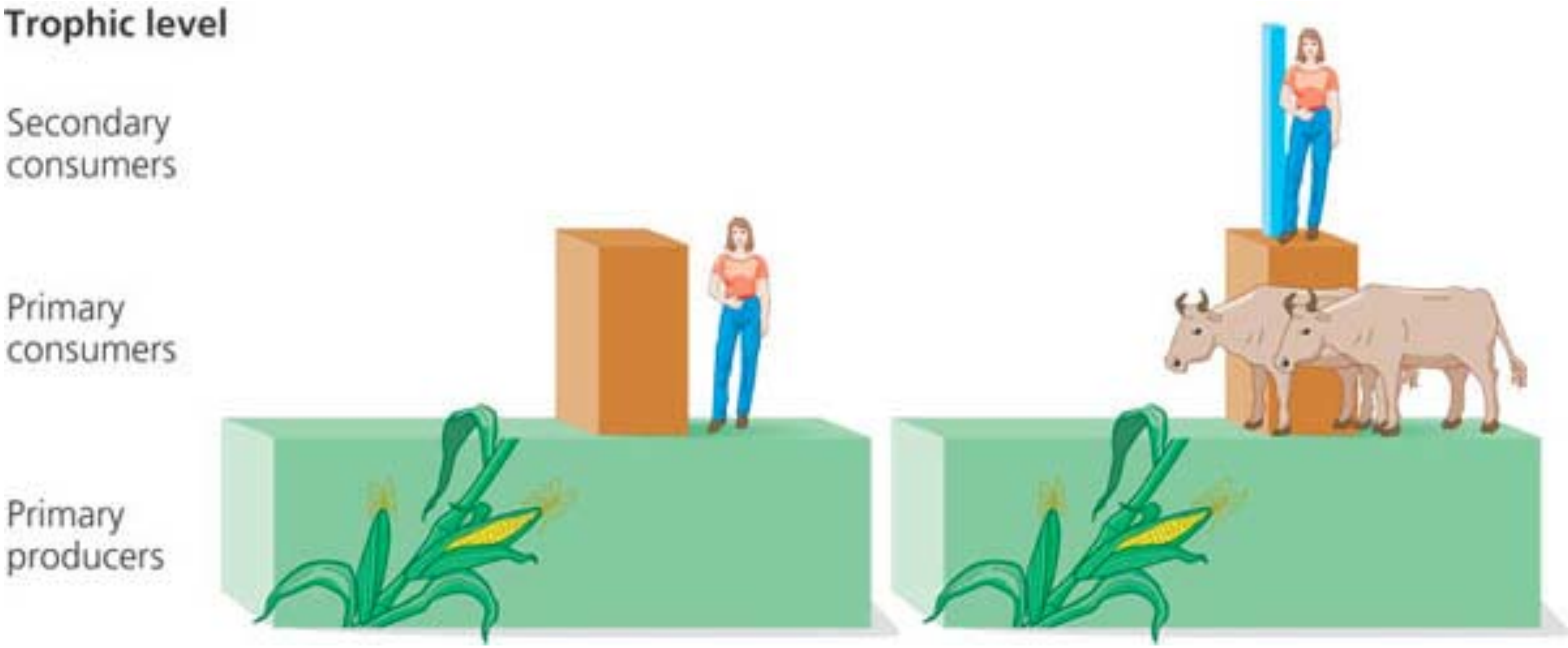


(b) Phytoplankton response to nutrient enrichment

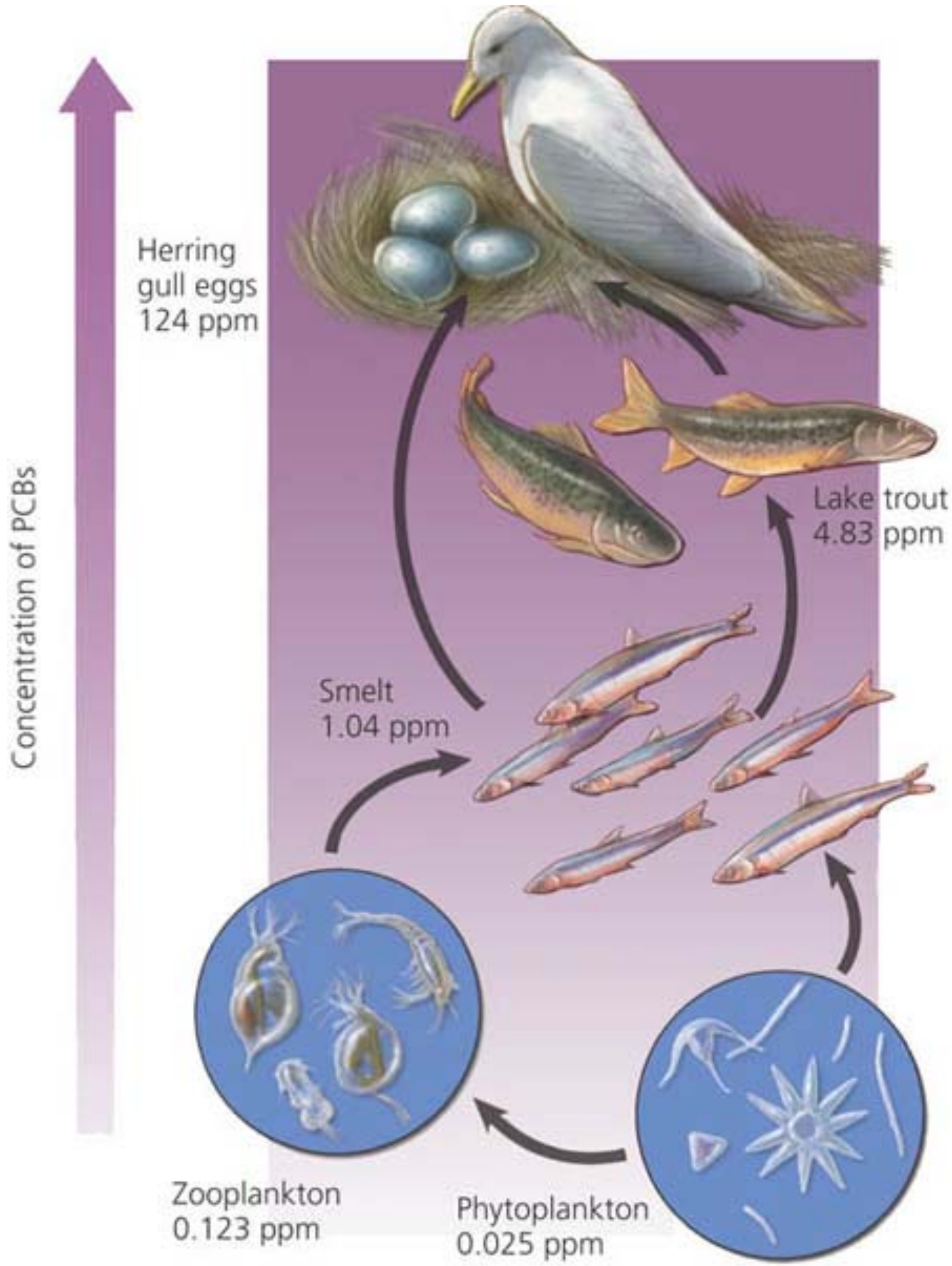
CONCLUSION Since adding phosphorus, which was already in rich supply, had no effect on *Nannochloris* growth, whereas adding nitrogen increased algal density dramatically, researchers concluded that nitrogen was the nutrient limiting phytoplankton growth in this ecosystem.

AND FINALLY...THINGS ARE BAD, BUT ALMOST OVER

Relative food energy available to the human population at different trophic levels. Most humans have a diet between these two extremes.



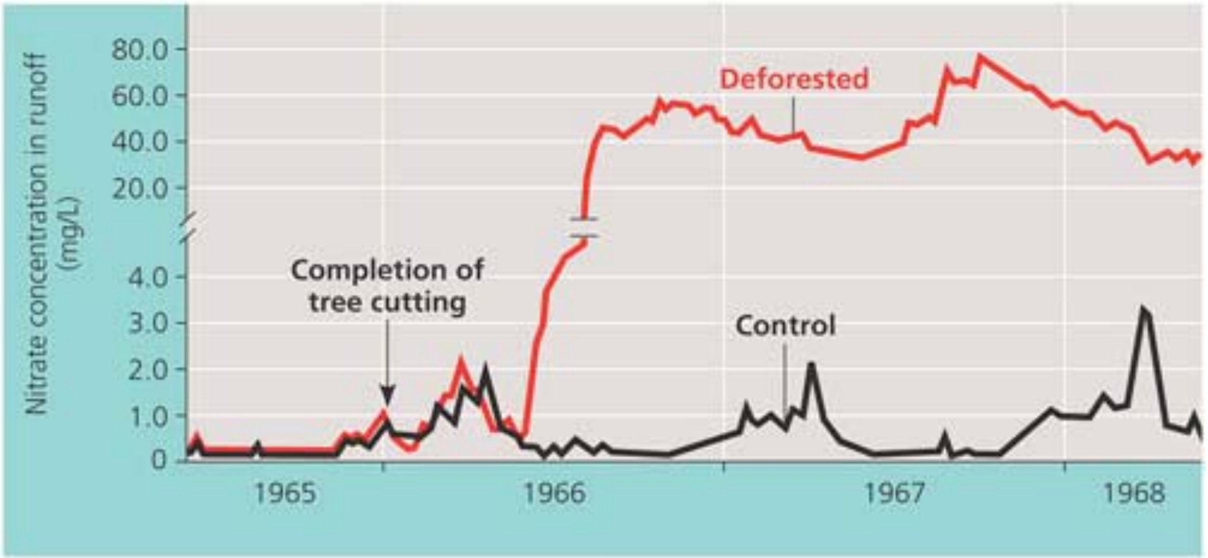
Biological magnification of PCBs in a Great Lakes food web.
(polychlorinated biphenyls)



Nutrient cycling in the Hubbard Brook Experimental Forest: an example of long–term ecological research.

(a) Concrete dams and weirs built across streams at the bottom of watersheds enabled researchers to monitor the outflow of water and nutrients from the ecosystem.

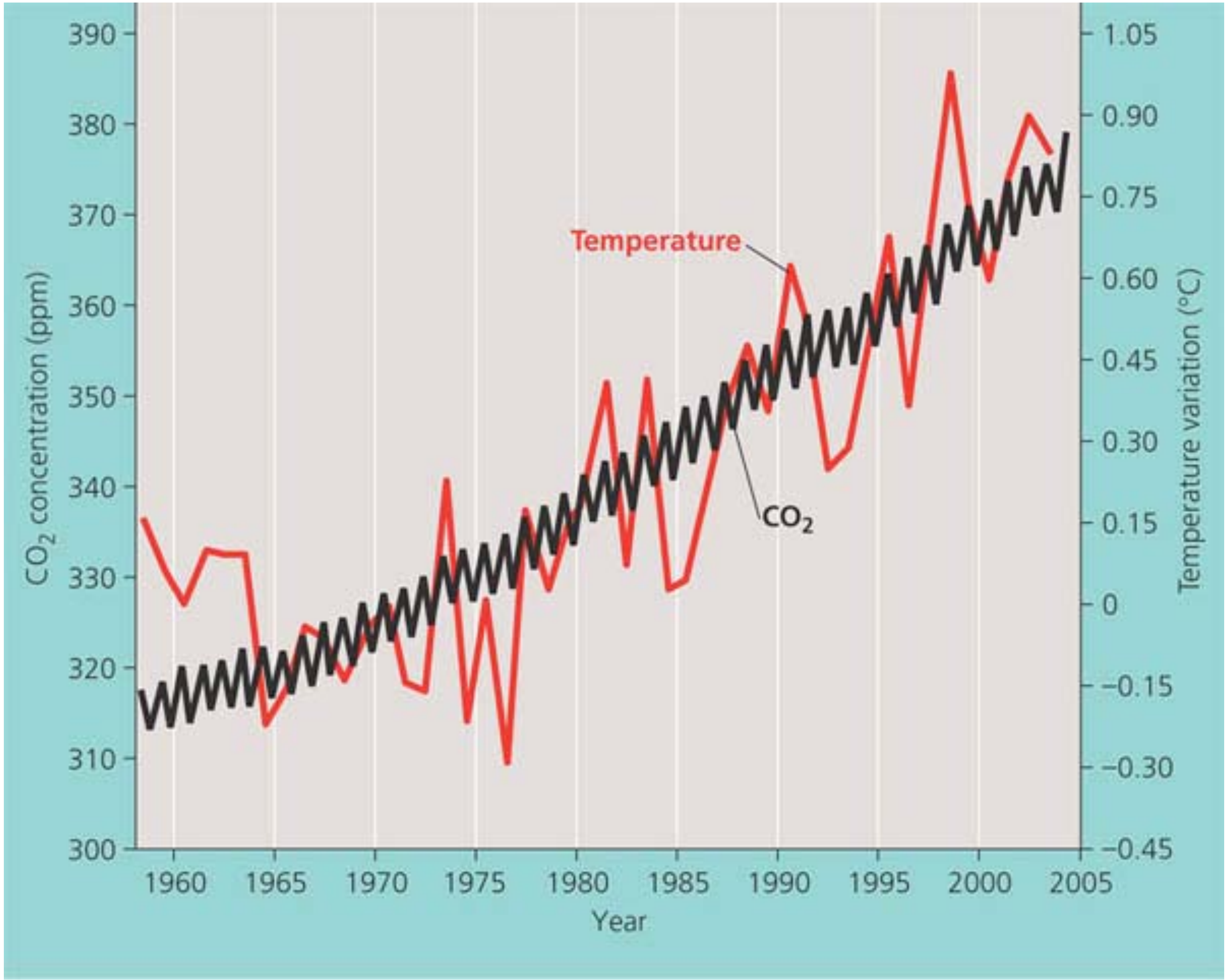
(b) One watershed was clear cut to study the effects of the loss of vegetation on drainage and nutrient cycling.



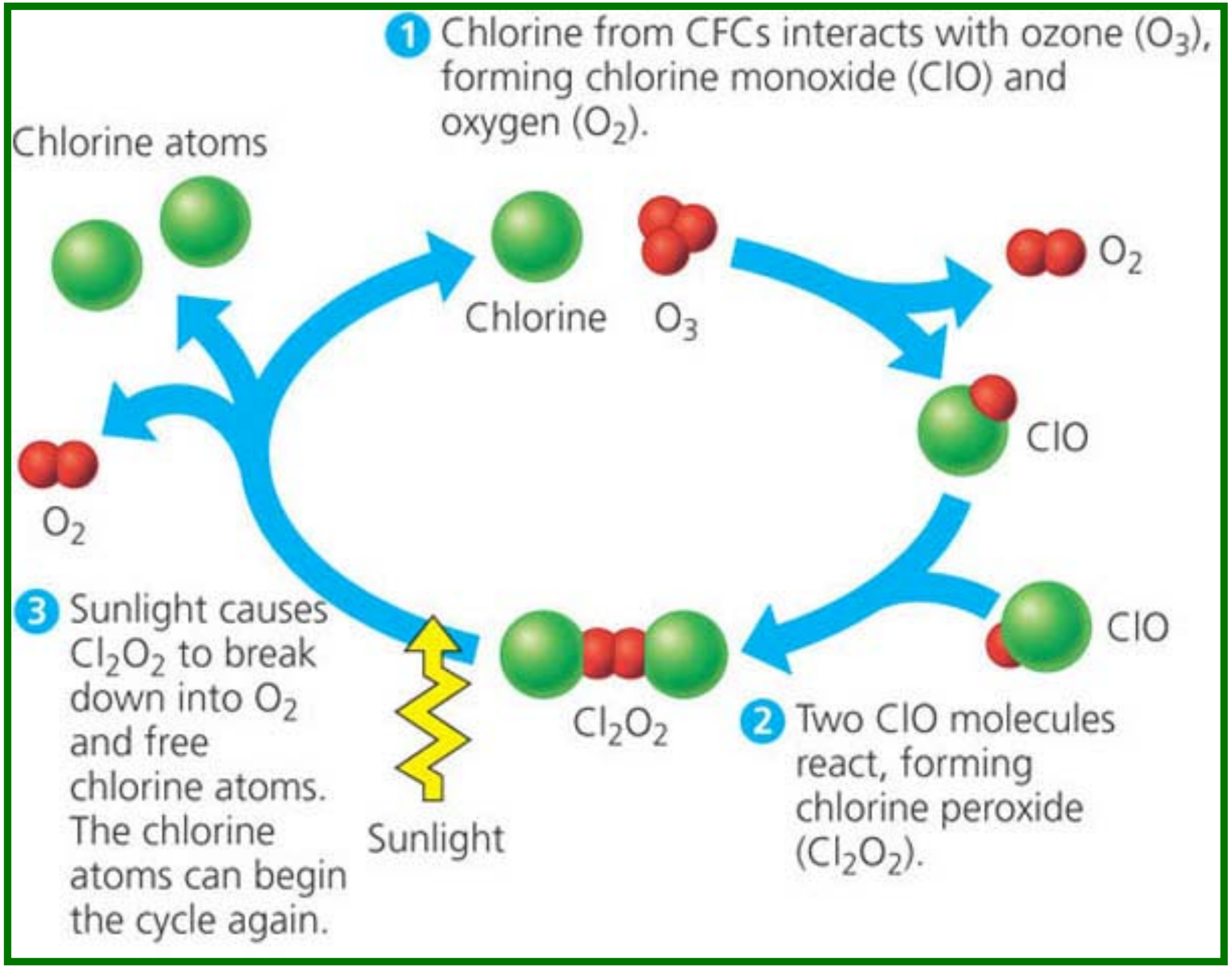
(c) The concentration of nitrate in runoff from the deforested watershed was 60 times greater than in a control (unlogged) watershed.

eutrophication (from the Greek eutrophos, well nourished), has a wide range of ecological impacts, including the eventual loss of all but the most tolerant fish species from the lakes

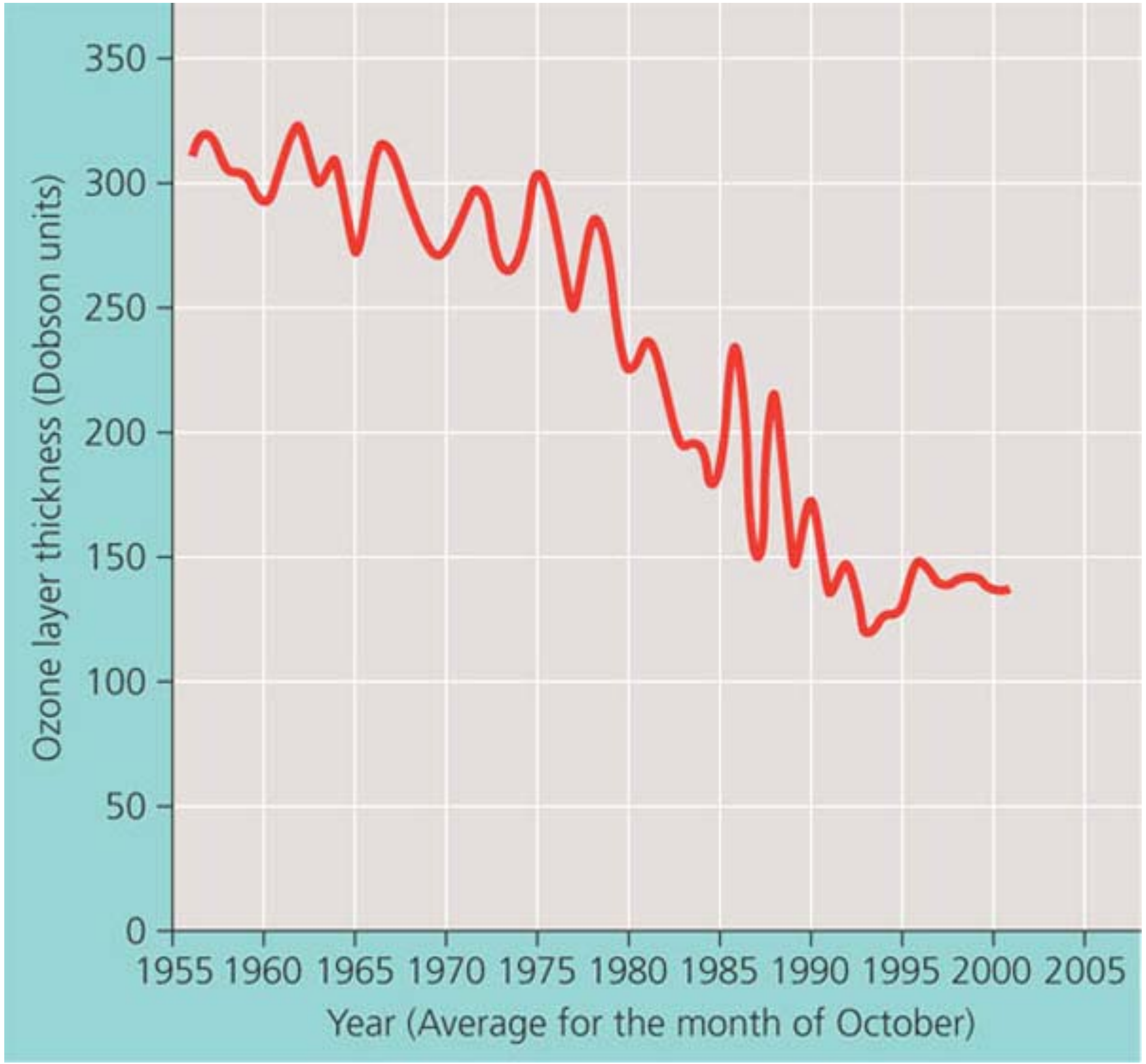
The increase in atmospheric carbon dioxide at Mauna Loa, Hawaii, and average global temperatures over land from 1958 to 2004.



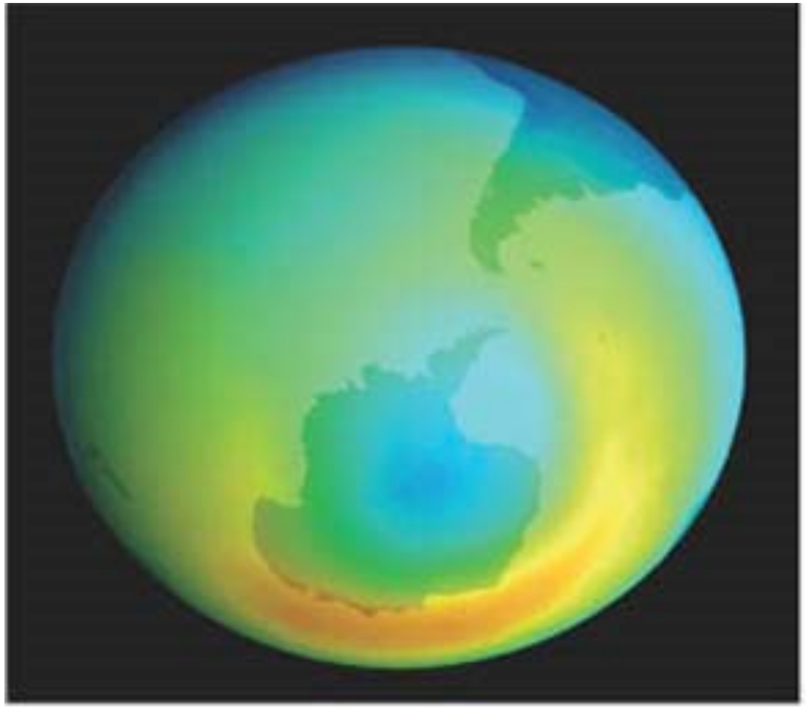
The destruction of atmospheric ozone probably results mainly from the accumulation of chlorofluorocarbons (CFCs), chemicals used for refrigeration, as propellants in aerosol cans, and in certain manufacturing processes.



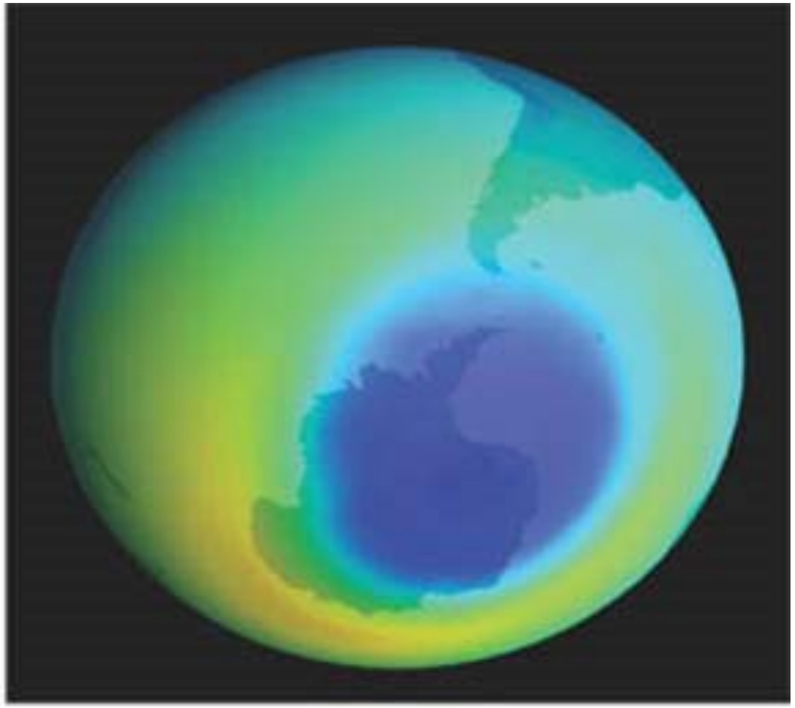
Satellite studies of the atmosphere suggest that the ozone layer has been gradually “thinning” since 1975



Erosion of Earth's ozone shield.



(a) October 1979



(b) October 2000

The ozone hole over Antarctica is visible as the blue patch in these images based on atmospheric data.