Visualizing Environmental Science

How Ecosystems Work

Chapter 5

What is Ecology?

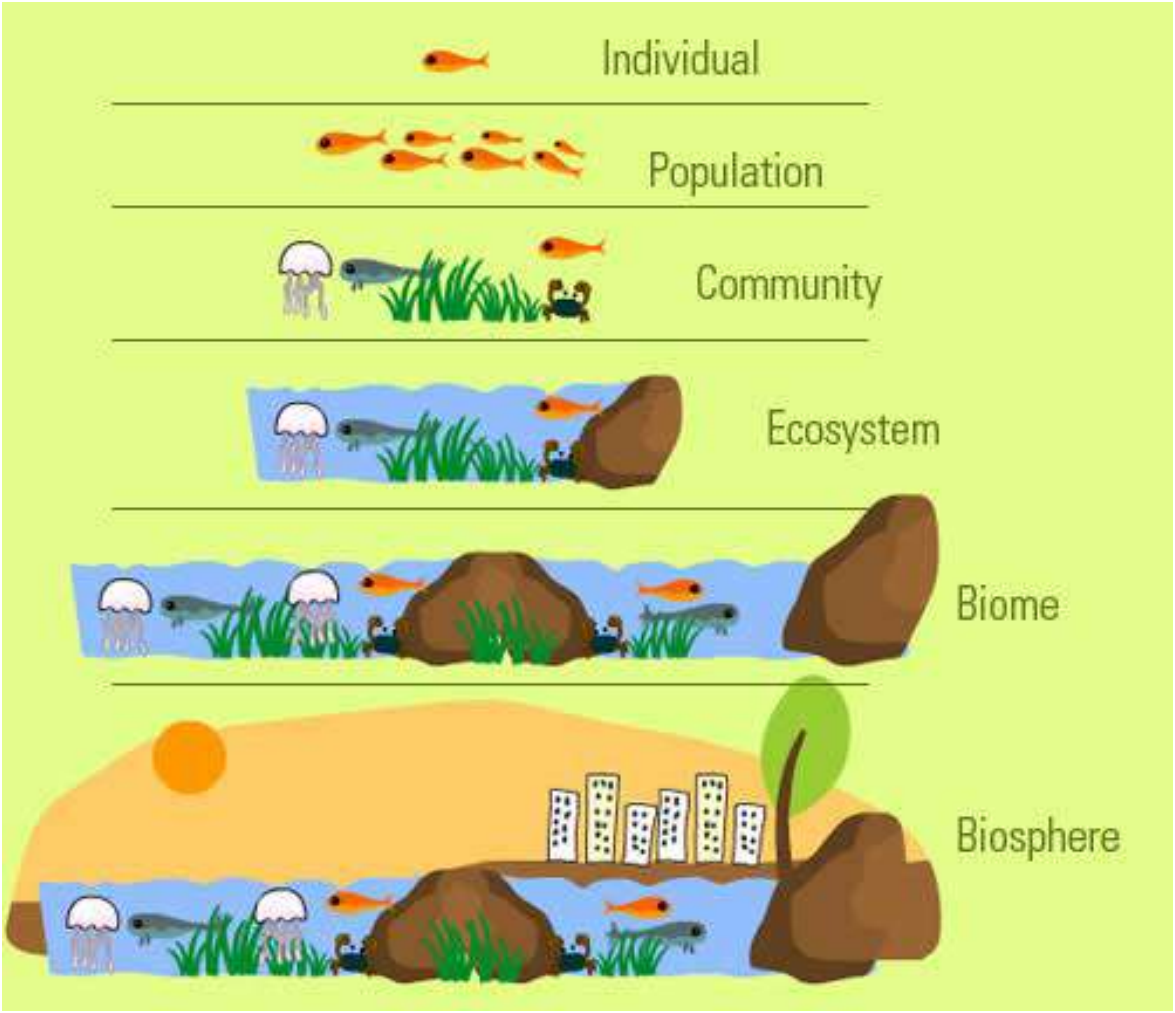
- The study of the interactions among organisms and between organisms and their abiotic environment
- Biotic = living (animals, plants, bacteria)
- Abiotic = nonliving (rocks, wind, precipitation)

George Grall/NG Image Collection

What is Ecology?

- Levels of organization
  - Organism: Any living thing
  - Population: A group of organisms of the same species that live in the same place at the same time
  - Communities: All the populations of different species that live and interact together within an area at the same time
  - Ecosystem: A community and its physical environment
  - Biome: A large region with similar climate, soil, plants, and animals
  - Biosphere: The parts of Earth's atmosphere, ocean, land surface, and soil that contain all living organisms

What is Ecology?



The Flow of Energy Through Ecosystems

- Energy—the ability to do work
  - Potential energy = stored energy
  - Kinetic energy = energy of motion

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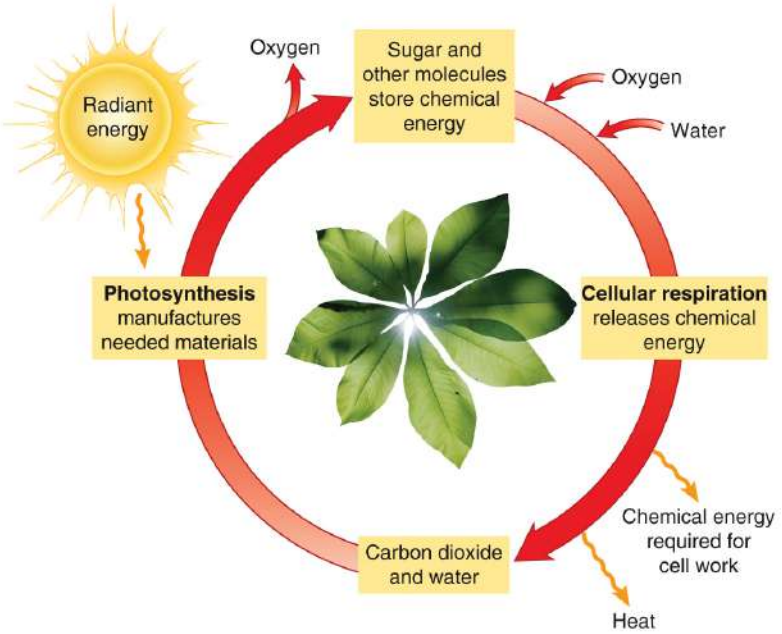
Potential energy is stored in the drawn bow (a) and is converted to kinetic energy (b) as the arrow speeds toward its target.

The First Law of Thermodynamics

- Energy cannot be created or destroyed
- Total energy content of an organism and its surroundings is always the same
- However, energy can change from one form to another
- In photosynthesis, plants capture light energy from the sun, and convert it into stored chemical energy



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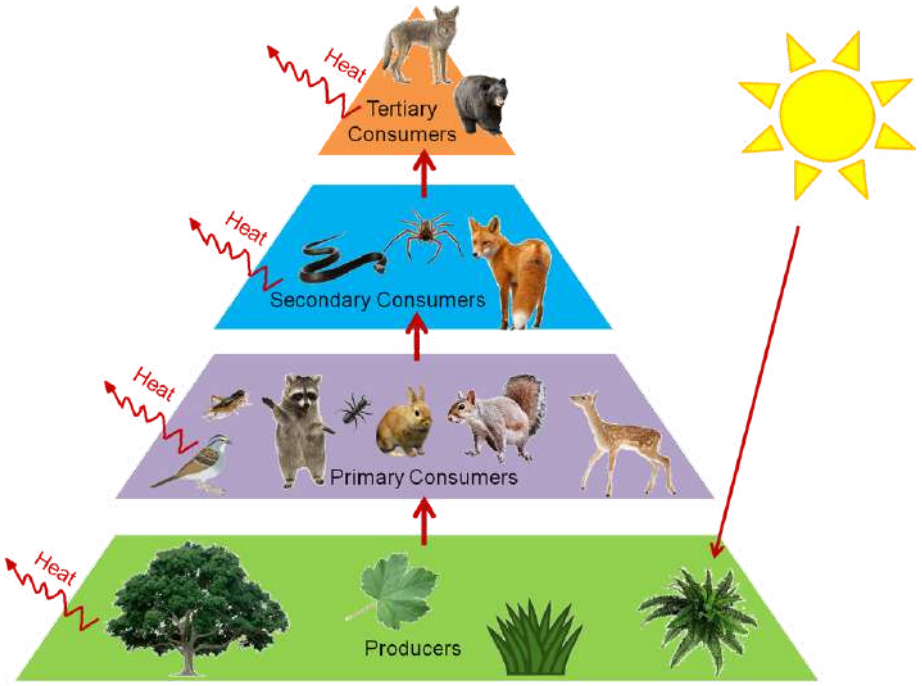
The Second Law of Thermodynamics

- The amount of usable energy in the universe decreases over time, as some is lost as heat
  - Heat: Less usable and more disorganized form of energy
- Within living organisms, during each energy transformation some energy is changed to heat
  - No organism can use this heat energy for biological work



Producers, Consumers, and Decomposers

- Producers, consumers and decomposers
  - Three categories based on how nourishment is obtained
- Producers manufacture large organic molecules using sunlight
  - Producers are potential food for other organisms
  - Plants, algae, and bacteria are the most significant producers

This moose is a herbivore, or primary consumer, utilizing the chemical energy stored in grasses

Producers, Consumers, and Decomposers

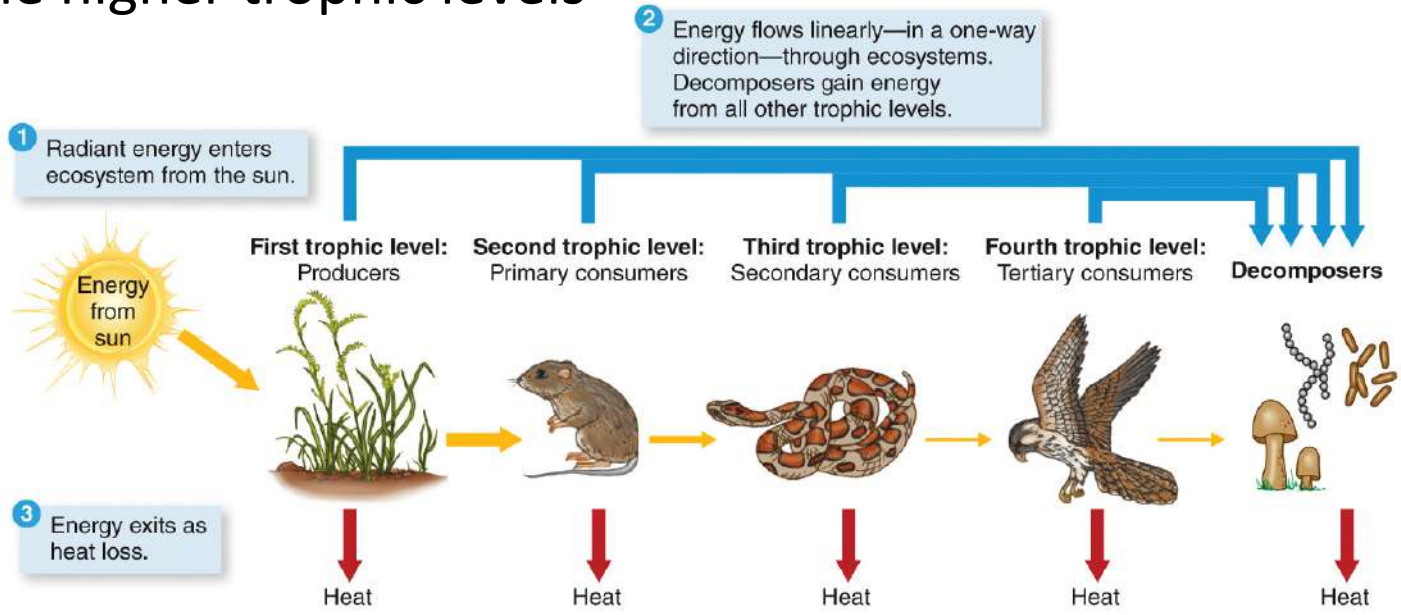
- Consumers are animals that consume other organisms
  - Primary consumers, or herbivores, eat producers
  - Secondary consumers eat primary consumers
  - Tertiary consumers eat secondary consumers
    - Secondary and tertiary consumers are carnivores
    - Consumers that eat both plants and animals are omnivores

Producers, Consumers, and Decomposers

- Detritivores—consumers, such as this crab, that eat waste organic matter
- Decomposers—bacteria and fungi that break down dead organisms
- Detritivores and decomposers are important for ecosystem health, and work together to prevent a build-up of organic waste

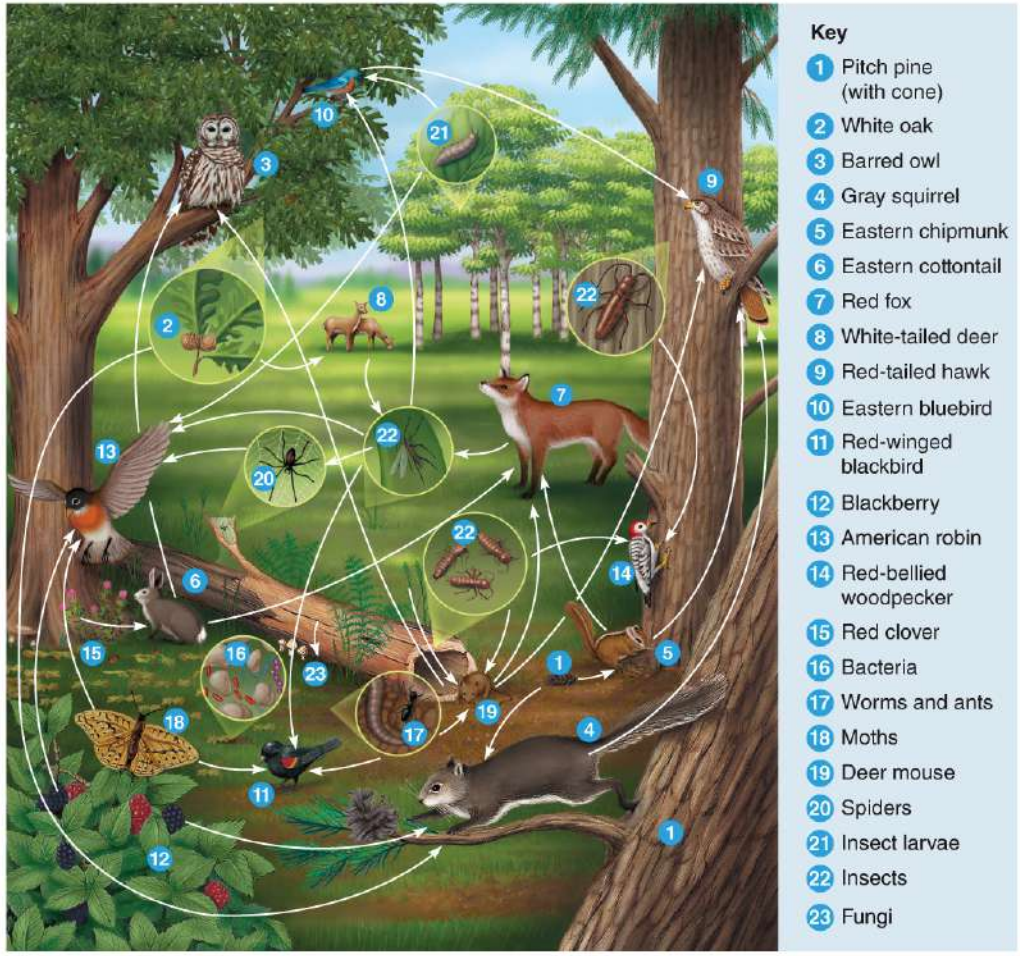
The Path of Energy Flow in Ecosystems

- Energy flow—the passage of energy in a one-way direction through an ecosystem, occurs in food chains
- Trophic level —each level in a food chain
- Energy is lost as heat along the way, thus the number of steps in a food chain is limited, and less energy is available for organisms at the higher trophic levels



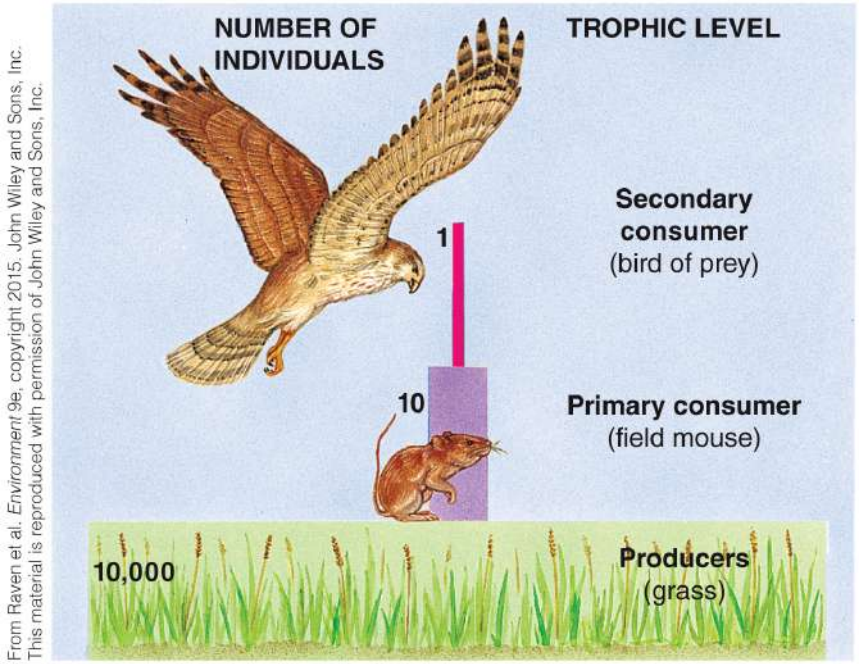
The Path of Energy Flow in Ecosystems

- A food web is a complex of interconnected food chains in an ecosystem
- A food web gives a more realistic view of the flow of energy in an ecosystem than the simple path shown in a food chain



The Path of Energy Flow in Ecosystems

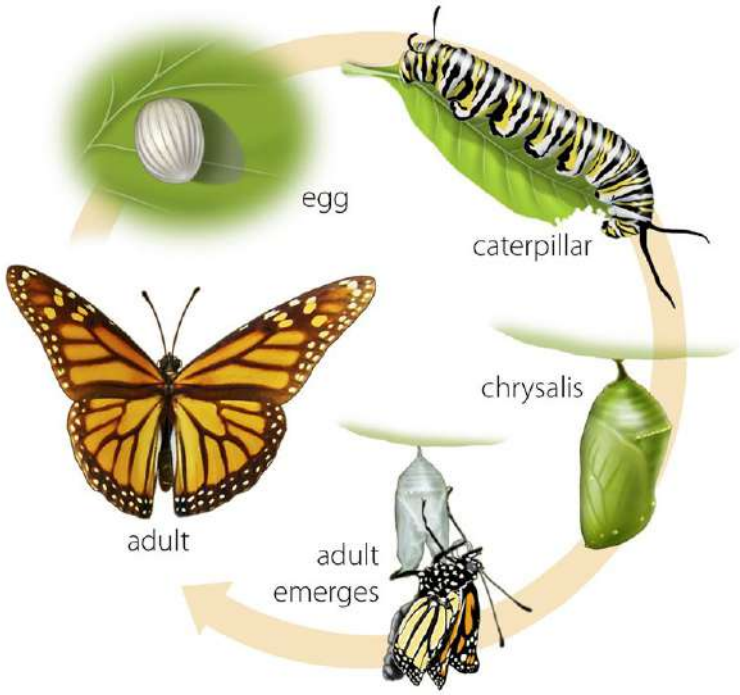
- Ecological pyramids graphically represent the relative energy values of each trophic level
- Pyramids of numbers show the number of organisms at each trophic level in a given ecosystem
- Pyramids of energy illustrate how energy dissipates into the environment as it moves from one trophic level to the next



This pyramid of numbers represents 10,000 grass plants supporting 10 mice, which support one bird of prey.

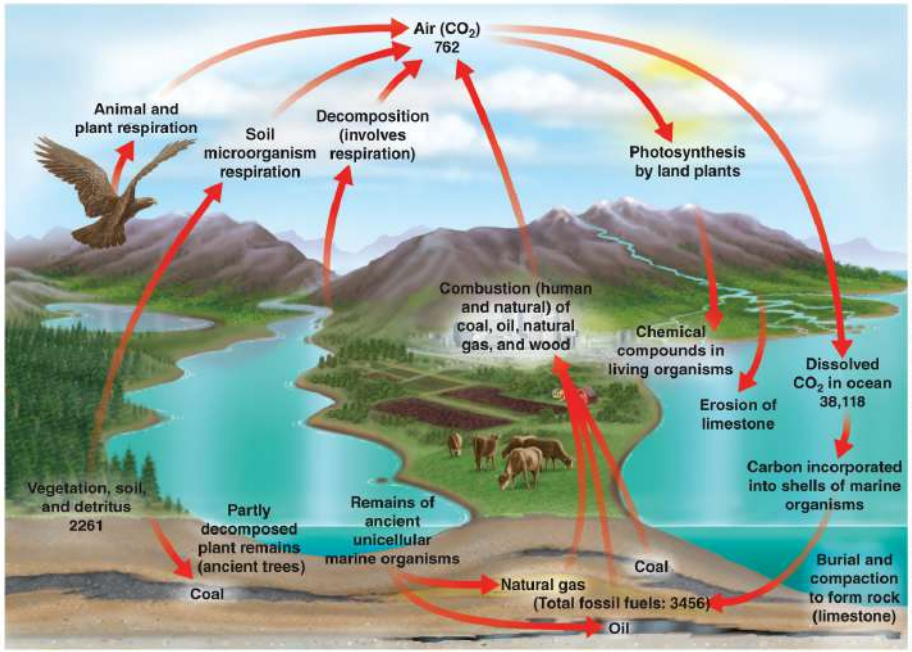
The Cycling of Matter in Ecosystems

- Biogeochemical cycles
  - Matter—the material of which organisms are composed (anything that has mass and takes up space)
  - Biogeochemical cycles involve biological, geological, and chemical processes
  - Carbon, hydrologic, nitrogen, oxygen, and phosphorus are all biogeochemical cycles



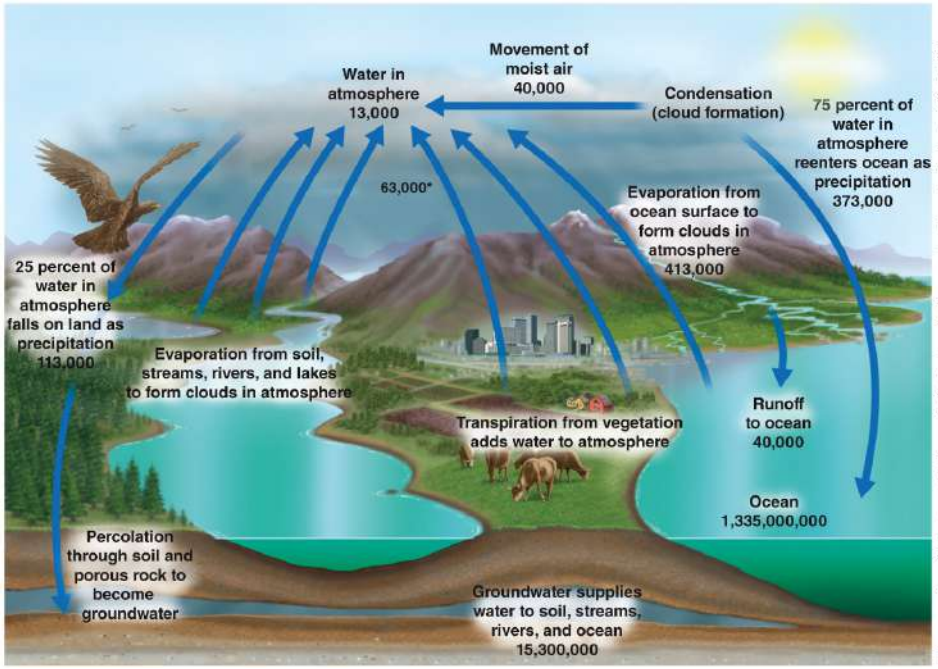
The Carbon Cycle

- The global movement of carbon between the abiotic environment (atmosphere, ocean) and organisms
  - Atmosphere/ocean → photosynthesis → cellular respiration/combustion/decomposition → atmosphere/ocean



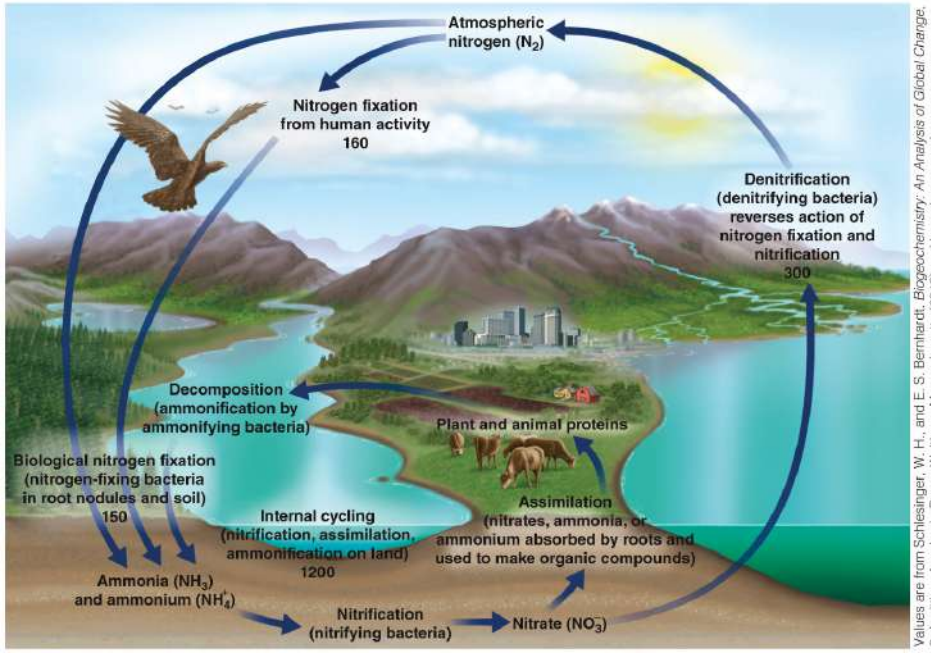
The Hydrologic Cycle

- Water circulates among the ocean, land, and atmosphere
- The hydrologic cycle provides a renewable supply of water for terrestrial organisms
  - Runoff is the movement of water from land to rivers and lakes
  - Watersheds are areas of land where runoff drains



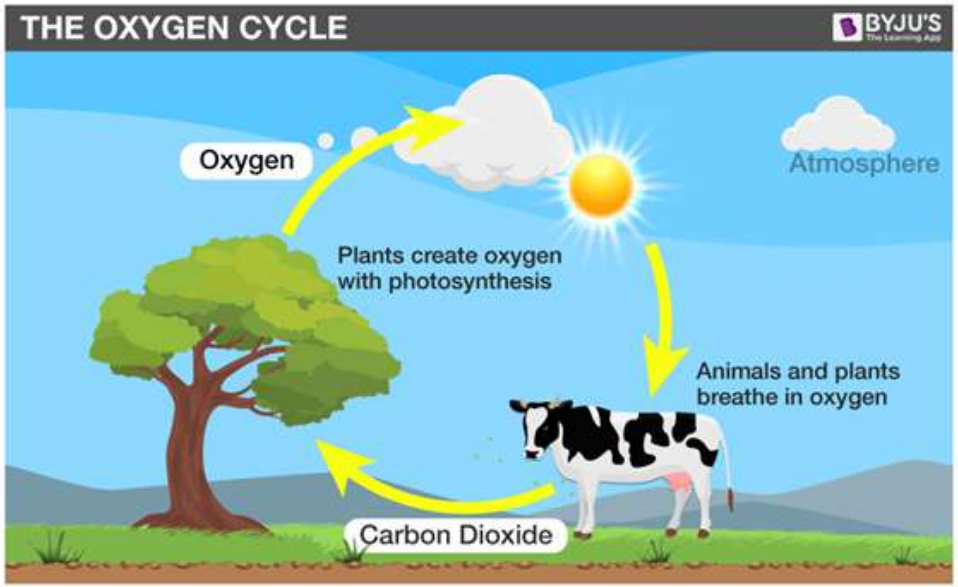
The Nitrogen Cycle

- Atmosphere is 78% nitrogen gas
- Five steps in which nitrogen cycles between the abiotic environment and organisms
  - Nitrogen fixation
    Nitrification
  - Assimilation
  - Ammonification
  - Denitrification



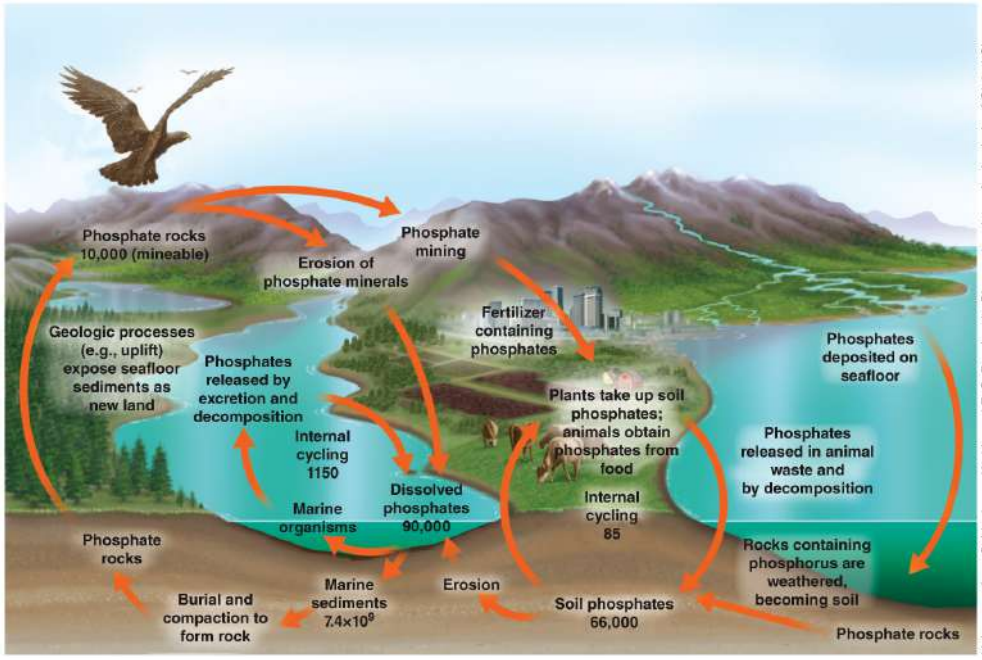
The Oxygen Cycle

- In the oxygen cycle, animals and humans breathe in oxygen from the atmosphere, then they breathe out carbon dioxide into the atmosphere.
- Plants convert the carbon dioxide back into oxygen with sunlight by a process called photosynthesis.



The Phosphorus Cycle

- No atmospheric component
- Phosphorus cycles between land and organisms
- Phosphorus in soil is absorbed by plant roots
- Humans accelerate loss of phosphorus from the land



Ecological Niches

- Ecological niche
  - The totality of an organism's adaptations, its use of resources, and the lifestyle to which it is fitted
    - Describes the place and function of an organism within the ecosystem
    - Takes into account all aspects of an organism's existence
    - The "way of life of an organism"
- Habitat
  - Part of an organism's niche, the place where the organism lives

Resource Partitioning

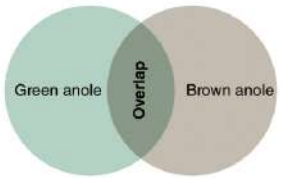
- One way species avoid or reduce niche overlap
- Serves to reduce competition for resources
- Can include timing of feeding, nest sites, and location of feeding


Exactostock/SuperStock

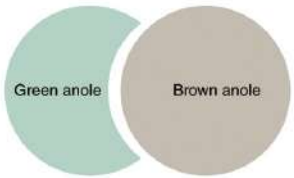
a. The green anole is native to Florida.


Alan Briere/SuperStock

b. The brown anole was introduced into Florida.



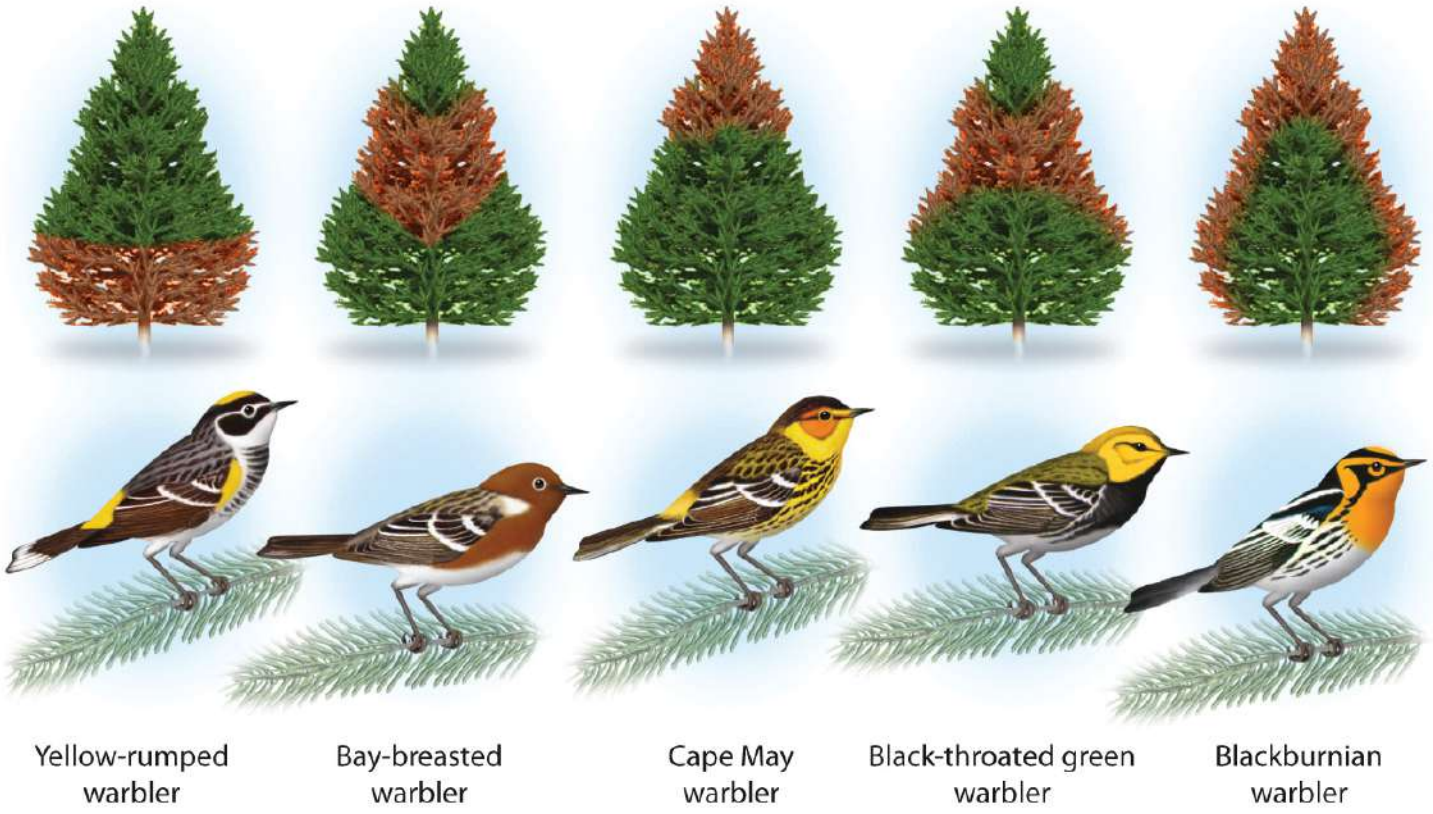
c. The fundamental niches of the two lizards initially overlapped.



d. The brown anole out-competed the green anole, restricting its realized niche.

Resource Partitioning

Resource partitioning of five warbler species
Each species spends most of their time feeding in different areas of the tree



Adapted from MacArthur, R. H. "Population ecology of some warblers of northeastern coniferous forests." Ecology, Vol. 39 (1958). This material is reproduced with permission of John Wiley & Sons.

Interactions Among Organisms

- Three main types of interactions occur between species in an ecosystem
  - Symbiosis
  - Predation
  - Competition
- Symbiosis is a relationship between members of two or more species.

Symbiosis

- There are three main types of symbiosis
  - Mutualism, where both organisms benefit
  - Commensalism, where one benefits but the other is unaffected—neither harmed nor helped
  - Parasitism, one benefits at the expense of the other

	Organism 1	Organism 2	Characteristic of relationship
Mutualism	Benefits	Benefits	Each organism depends on the other
Commensalism	Benefits	Not affected	Only one organism depends on the other
Parasitism	Benefits	Harmed	Host harmed, rarely killed; host usually much larger than parasite

Predation

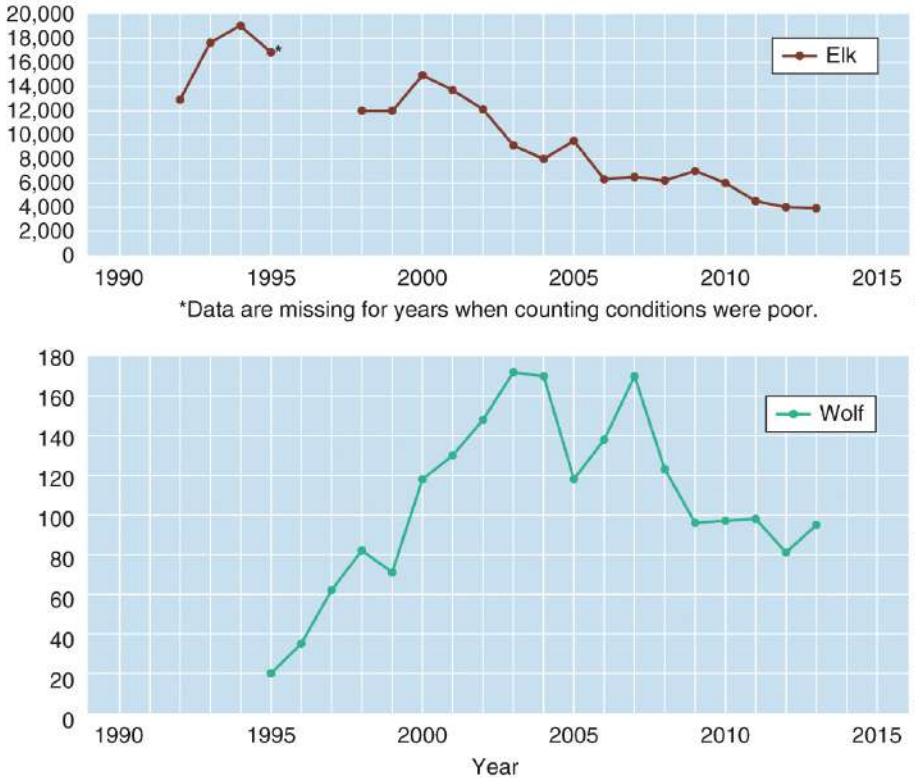
- Predation—the consumption of one species (prey) by another species (predator)
  - Coevolutionary "arms race" as predators evolve to better catch prey and prey evolve to better escape predator
  - The cheetah sprints at high speeds to catch prey
  - The goldenrod spider uses camouflage to ambush prey

Competition

- Competition
  - The interaction among organisms that vie for the same resources in an ecosystem, such as food or living space
  - Can be complex

Keystone Species

- Keystone species are crucial to the maintenance and function of an ecosystem
  - Not the most abundant species, but have influence on entire ecosystem
  - May be the top predator in an ecosystem
  - Often affect the available amount of food, water, or other resources



The gray wolf is considered a keystone species in its ecosystem.

Case Study: Global Climate Change: How Does it Affect the Carbon Cycle?

- Biggest culprit in climate change is the increasing atmospheric CO_2, which has increased 20% in last 50 years
  - Generated by burning of fossil fuels, clearing and burning forests

Raymond Boyd/Corbis Images