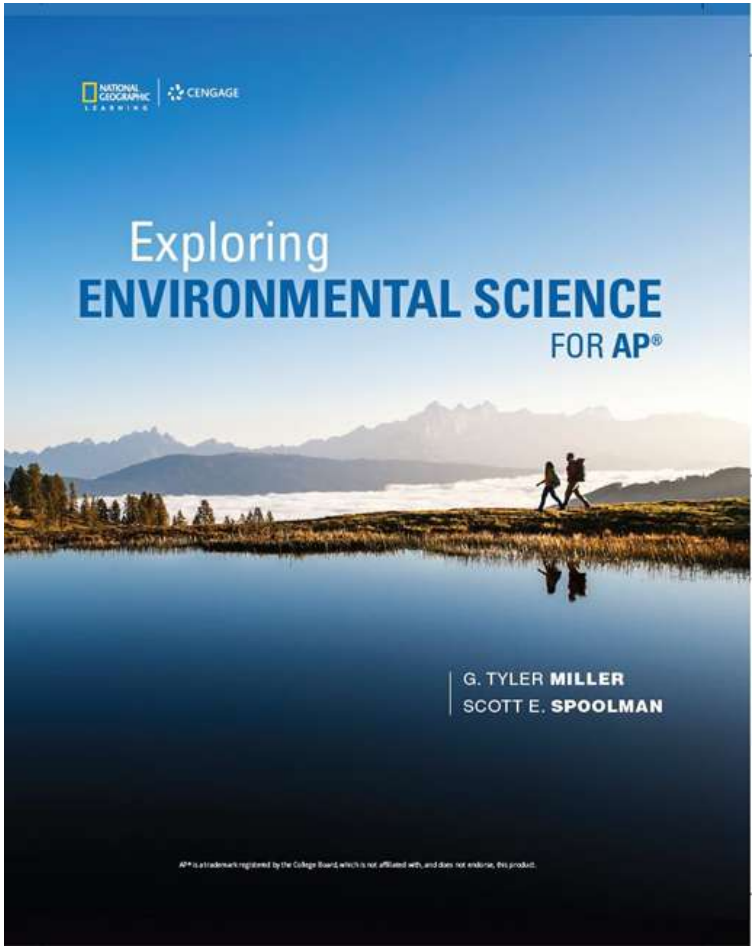
Exploring Environmental Science for AP®

1st Edition



Chapter 3

Ecosystems: What Are They and How Do They Work?

Core Case Study: Tropical Rain Forests Are Disappearing

- Tropical rain forests near the earth's equator
  - Cover only about 2% of the earth's land
  - Contain up to one-half of the world's known terrestrial plant and animal species
- Major harmful effects of disruption
  - Reduces biodiversity
  - Accelerates climate change
  - Changes regional weather patterns

Natural Capital Degradation

Left: United Nations Environment Programme; Right: United Nations Environment Programme

3.1 How Does the Earth's Life-Support System Work?

- Major components of the earth's life-support system
  - Atmosphere (air)
  - Hydrosphere (water)
  - Geosphere (rocks, minerals, and soil)
  - Biosphere (living things)

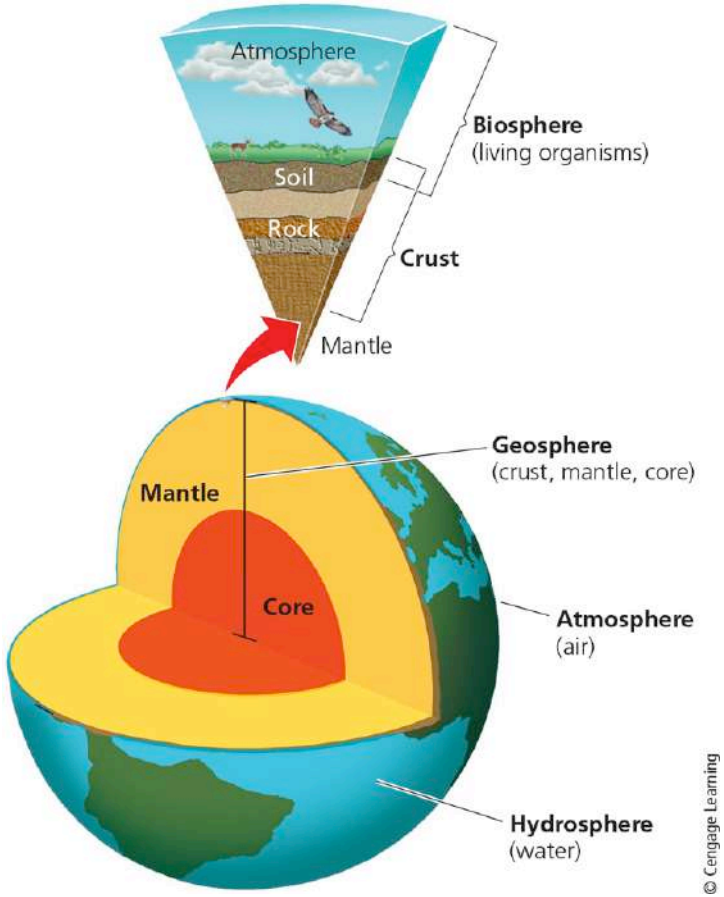
Earth's Life-Support System Has Four Major Components (1 of 3)

- Atmosphere
  - Innermost layer is the troposphere
    - Contains the air we breathe
  - Stratosphere: contains ozone layer
    - Filters sun's harmful UV radiation
- Hydrosphere
  - All water vapor, liquid water, and ice
  - Oceans contain 97% of the planet's water

Earth's Life-Support System Has Four Major Components (2 of 3)

- Geosphere
  - Upper portion of crust contains nutrients organisms need to live, grow, and reproduce
  - Contains nonrenewable fossil fuels
- Biosphere
  - Parts of atmosphere, hydrosphere, and geosphere where life is found

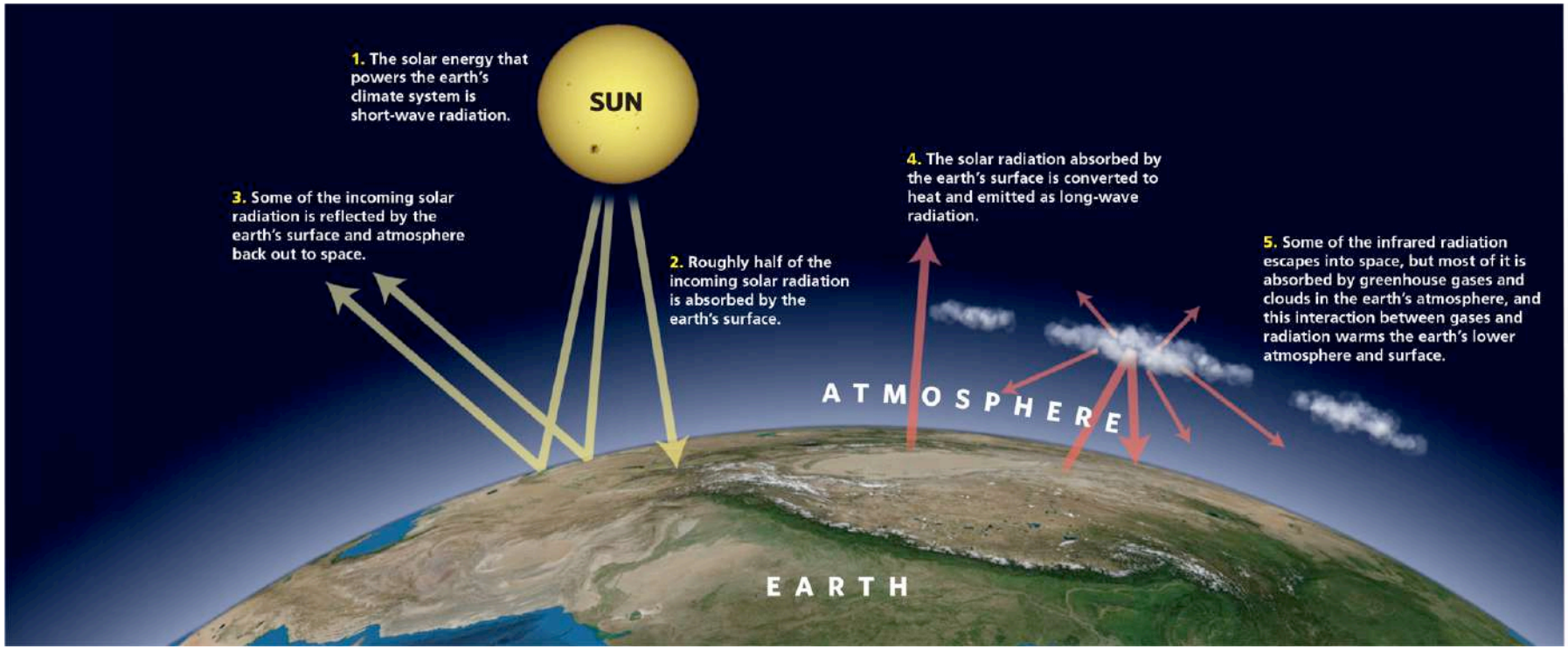
Earth's Life-Support System Has Four Major Components (3 of 3)



Three Factors Sustain the Earth's Life (1 of 2)

- One-way flow of high-quality energy from the sun
  - Supports plant growth and warms troposphere
- Cycling of nutrients through parts of the biosphere
- Gravity holds the earth's atmosphere
  - Enables movement and cycling of chemicals through air, water, soil, and organisms

Three Factors Sustain the Earth's Life (2 of 2)

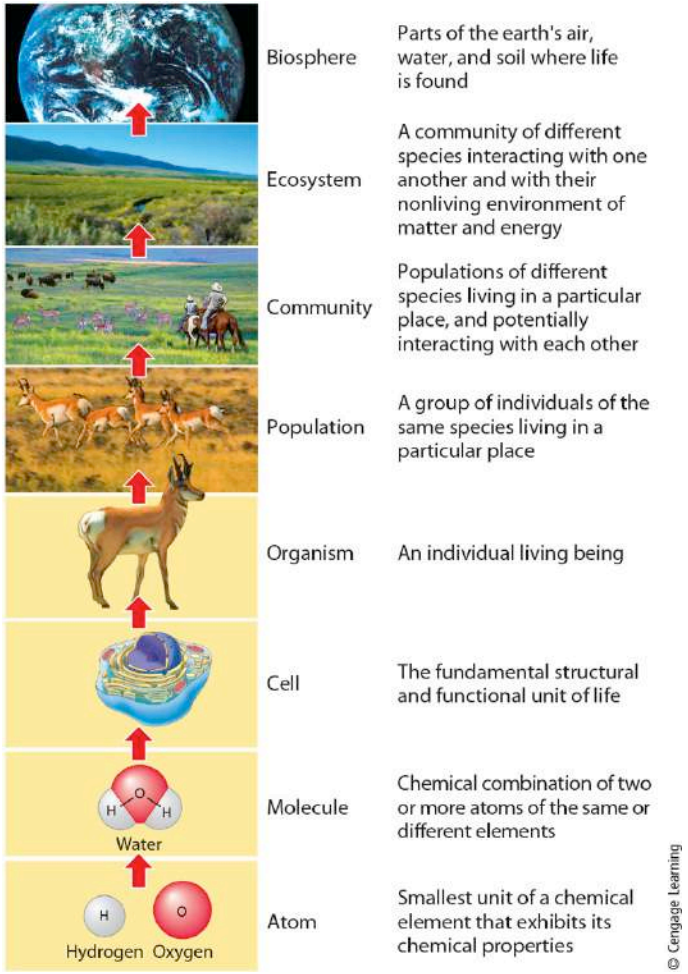


National Geographic Visual Atlas of the World. Washington, DC: National Geographic Society, 2008.

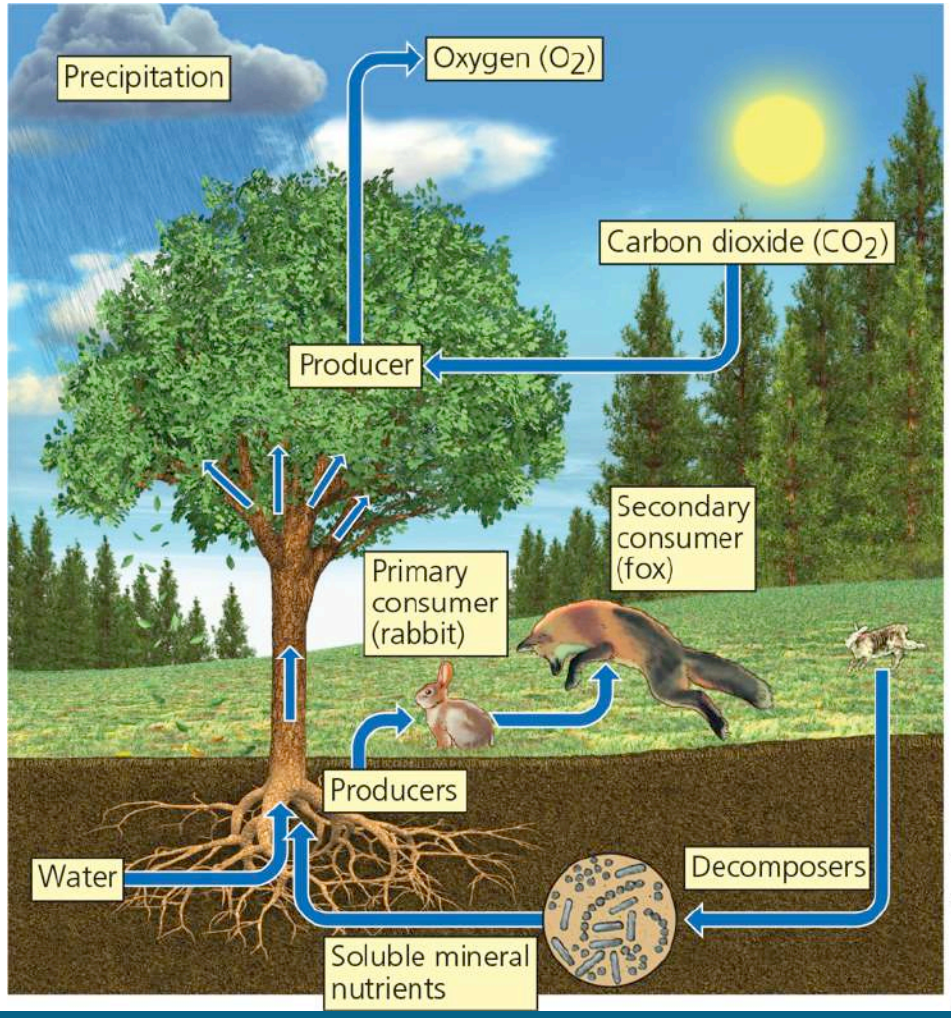
3.2 What Are the Major Components of an Ecosystem? (1 of 3)

- Ecologists study five levels of matter
  - Biosphere, ecosystems, communities, populations, and organisms
- Feeding level (trophic level)
  - Organisms classified as producers or consumers based on source of nutrients
- Producers (autotrophs) make needed nutrients from their environment

3.2 What Are the Major Components of an Ecosystem? (2 of 3)



3.2 What Are the Major Components of an Ecosystem? (3 of 3)



Ecosystems Have Several Important Components (1 of 7)

- During photosynthesis, plants generate energy and emit oxygen
  - $CO_2 + H_2O + \text{sunlight} \rightarrow \text{glucose} + \text{oxygen}$
- Consumers (heterotrophs) cannot produce the nutrients they need
  - Primary consumers (herbivores) eat plants
  - Carnivores feed on flesh of other animals
    - Secondary and tertiary (or higher) consumers
  - Omnivores eat both plants and animals

Ecosystems Have Several Important Components (2 of 7)

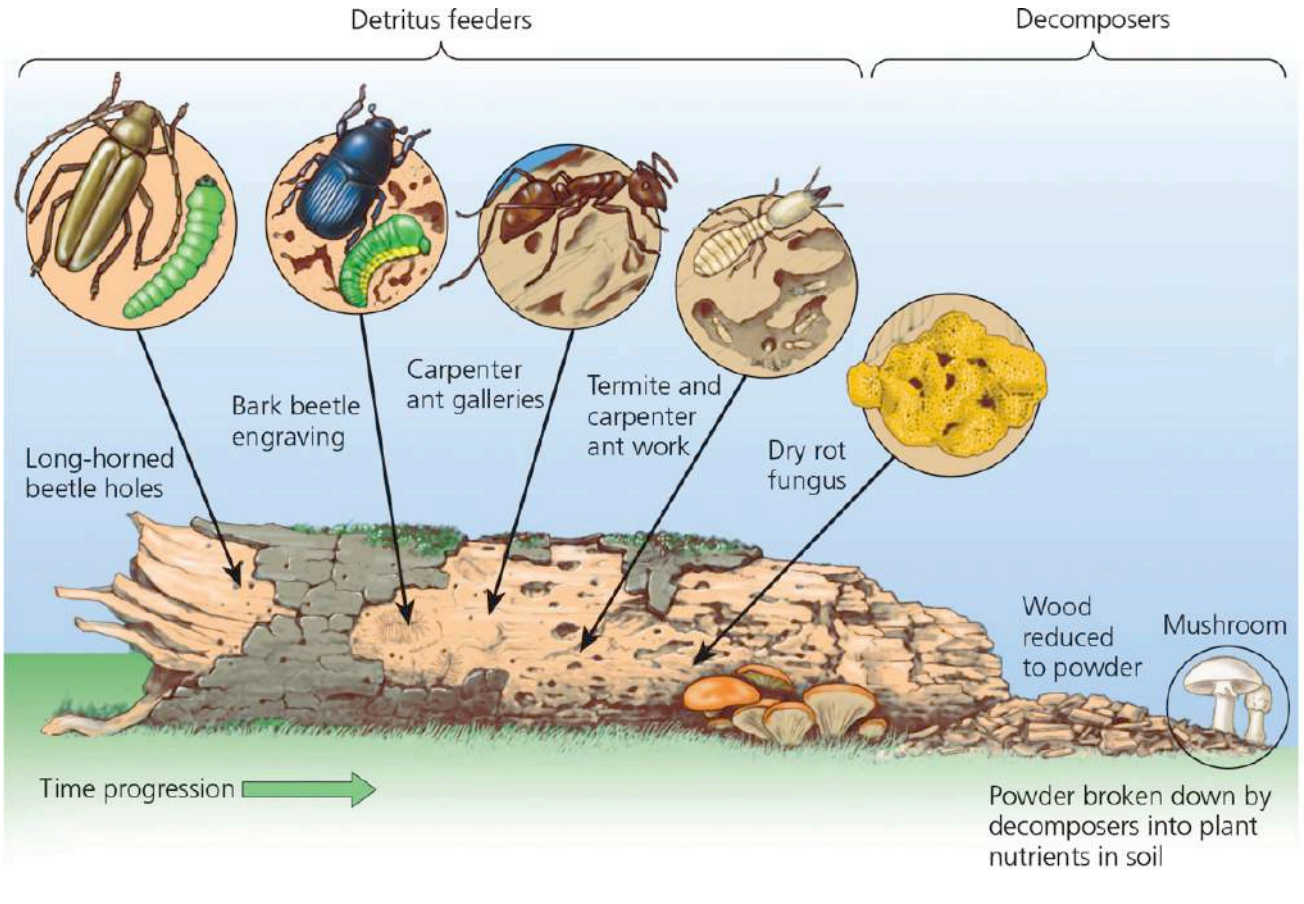
Nelik/Shutterstock.com

Ecosystems Have Several Important Components (3 of 7)

- Decomposers
  - Consumers that release nutrients from wastes or remains of plants or animals
  - Nutrients return to soil, water, and air for reuse
  - Bacteria, fungi
  - Detritivores

Ecosystems Have Several Important Components (4 of 7)

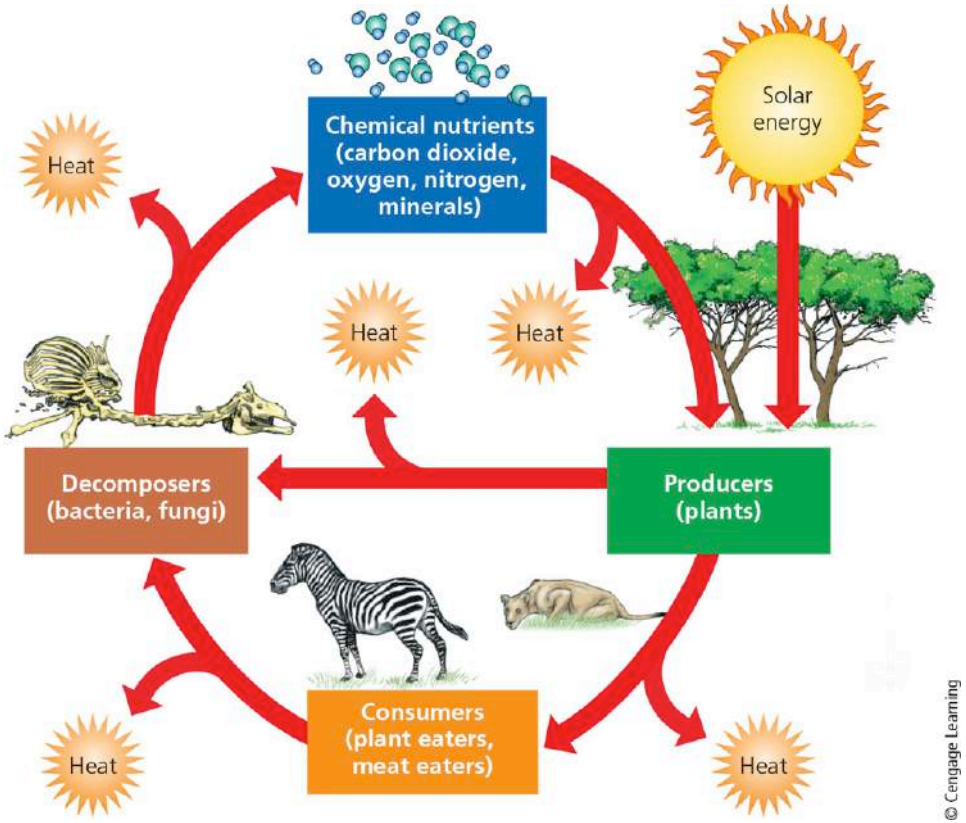
Ecosystems Have Several Important Components (5 of 7)



Ecosystems Have Several Important Components (6 of 7)

- Producers, consumers, and decomposers use chemical energy stored in glucose
  - In most cells, energy is released by aerobic respiration
    - Using oxygen to turn glucose back to carbon dioxide and water

Ecosystems Have Several Important Components (7 of 7)



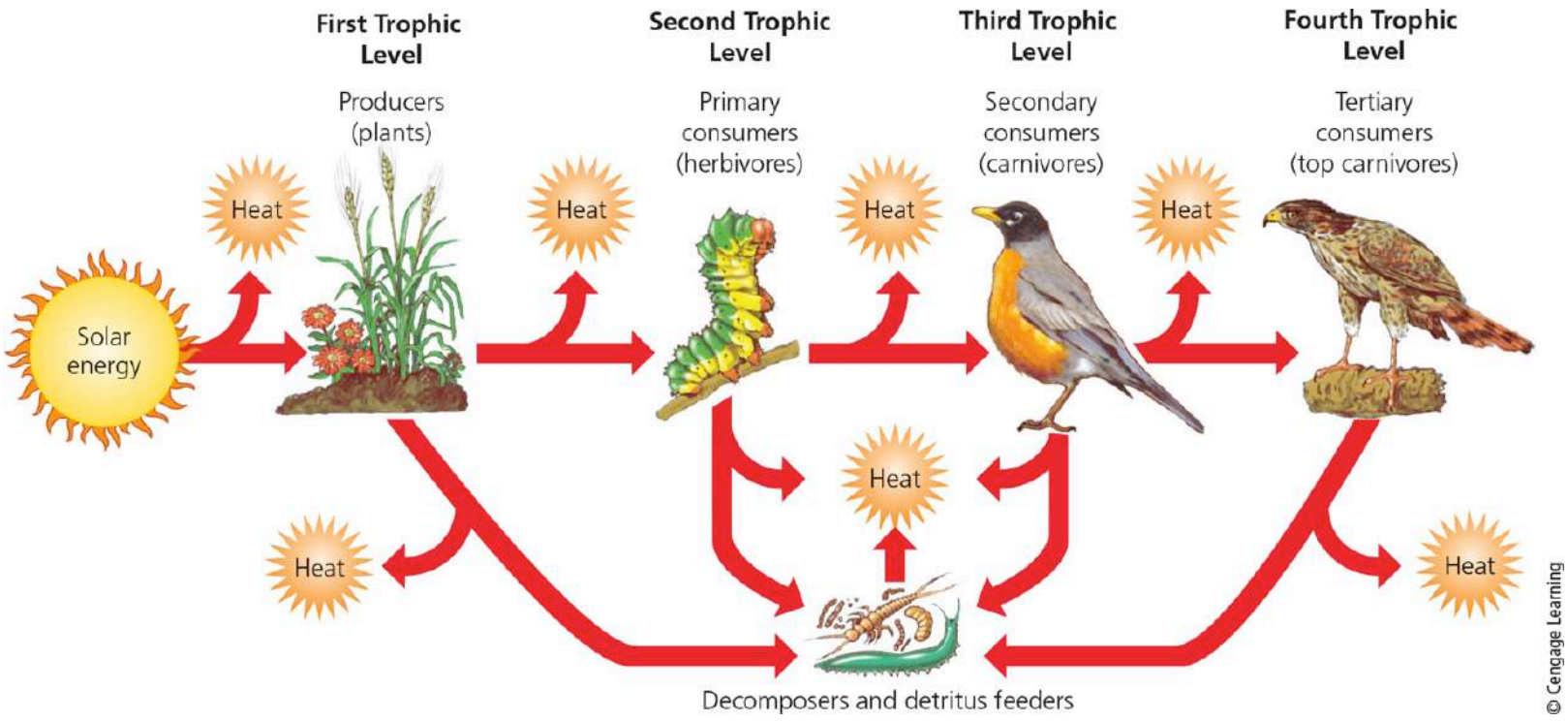
Soil Is the Foundation of Life on Land

- Soil
  - Complex mixture of rock, particles, mineral nutrients, organic matter, water, air, and living organisms
- Soil is a renewable resource, but renewed very slowly

3.3 What Happens to Energy in an Ecosystem? (1 of 6)

- Energy flows through ecosystems in food chains and webs
- Food chain
  - Movement of energy and nutrients from one trophic level to the next
- Food web
  - Network of interconnected food chains

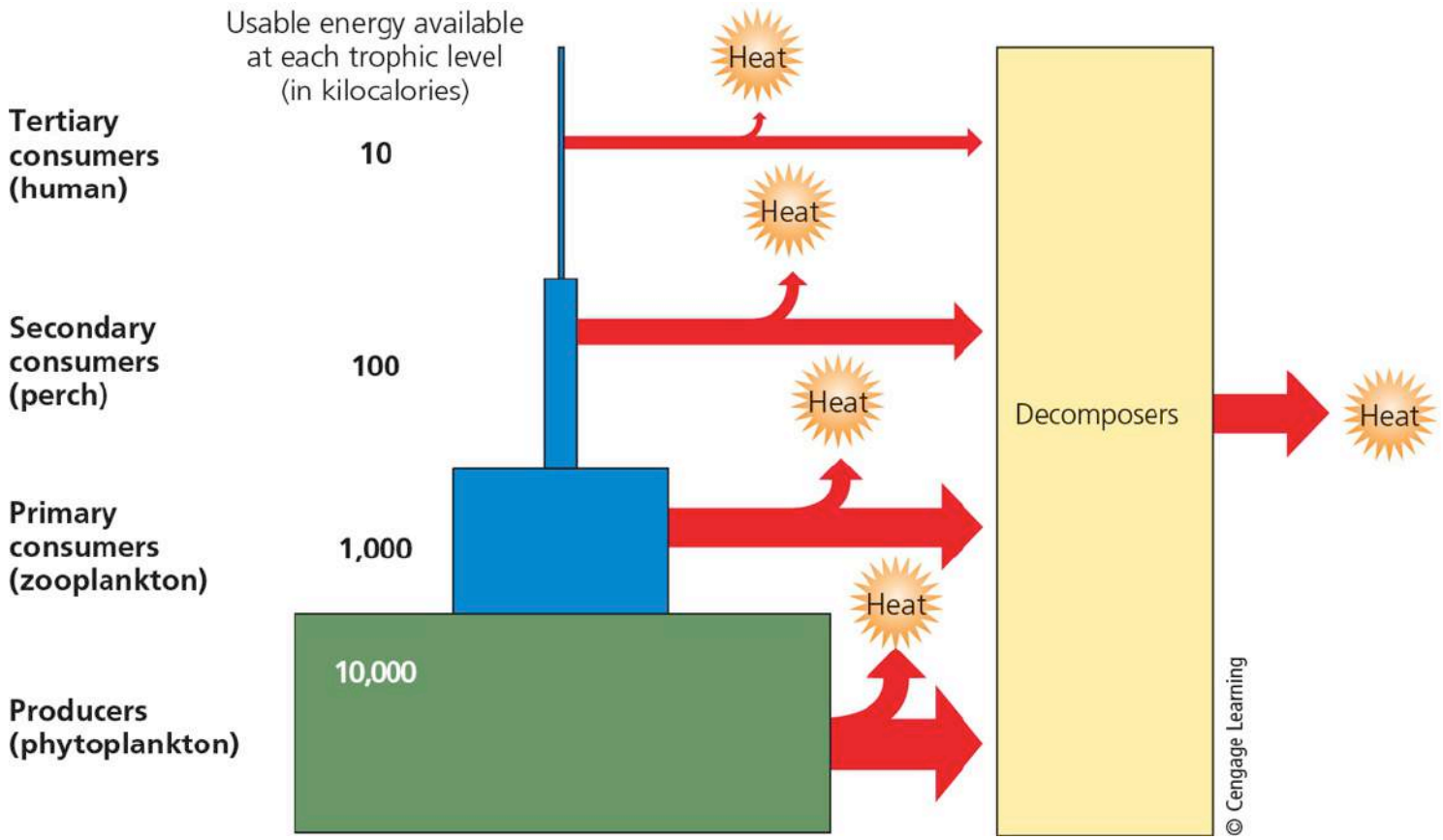
What Happens to Energy in an Ecosystem? (2 of 6)



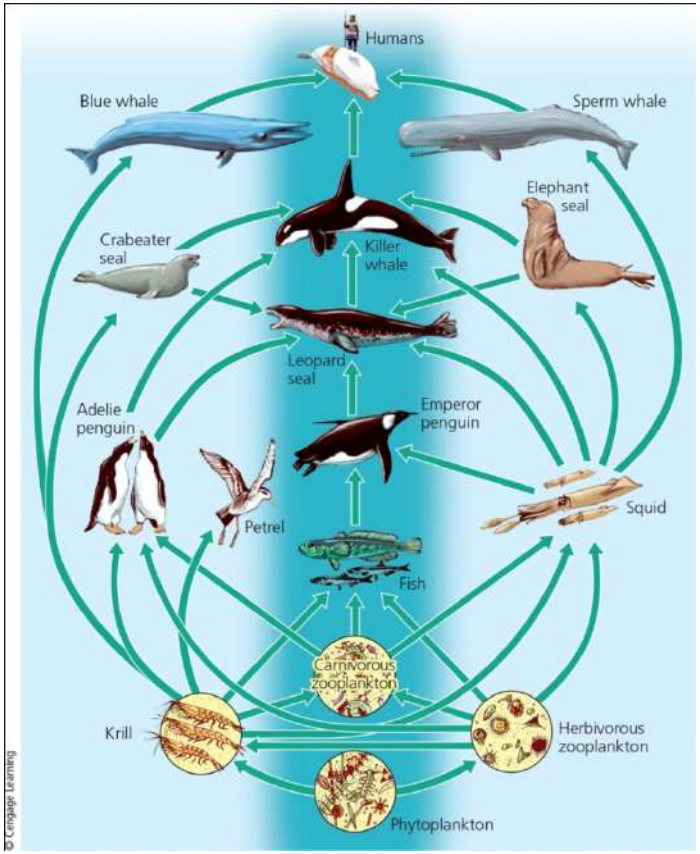
What Happens to Energy in an Ecosystem? (3 of 6)

- Every use and transfer of energy involves energy loss as heat
- Pyramid of energy flow
  - 90% of usable energy lost with each transfer
  - Less chemical energy for higher trophic levels
- Biomass
  - Total mass of organisms in a given trophic level

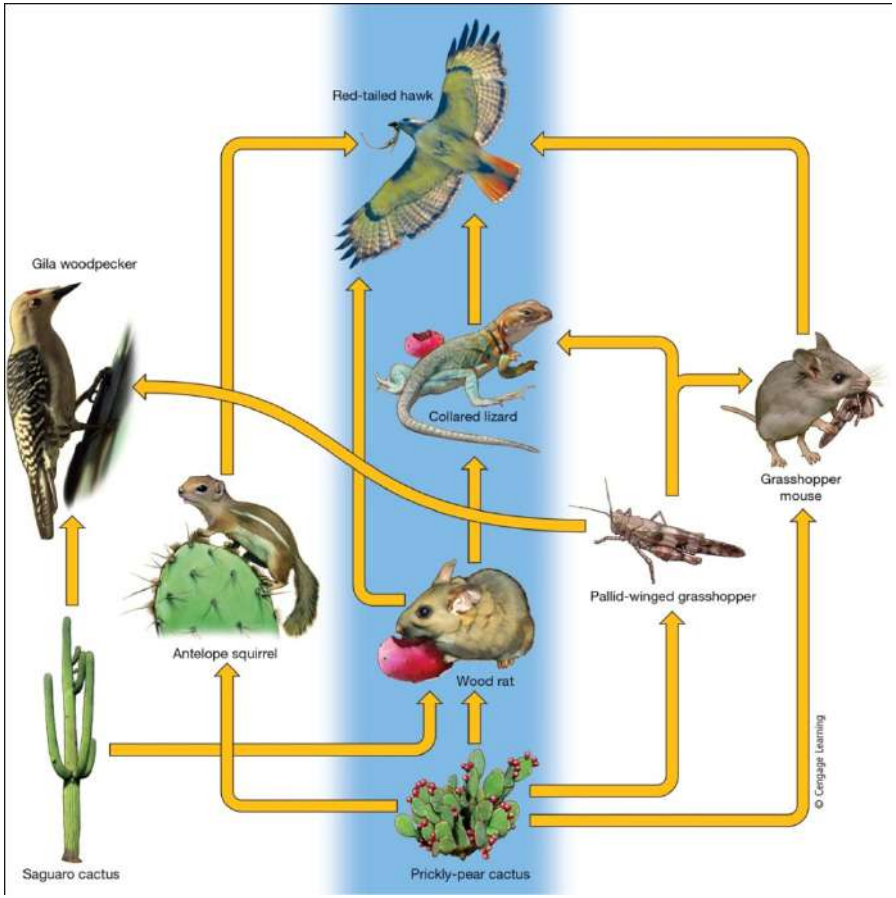
What Happens to Energy in an Ecosystem? (4 of 6)



What Happens to Energy in an Ecosystem? (5 of 6)



What Happens to Energy in an Ecosystem? (6 of 6)



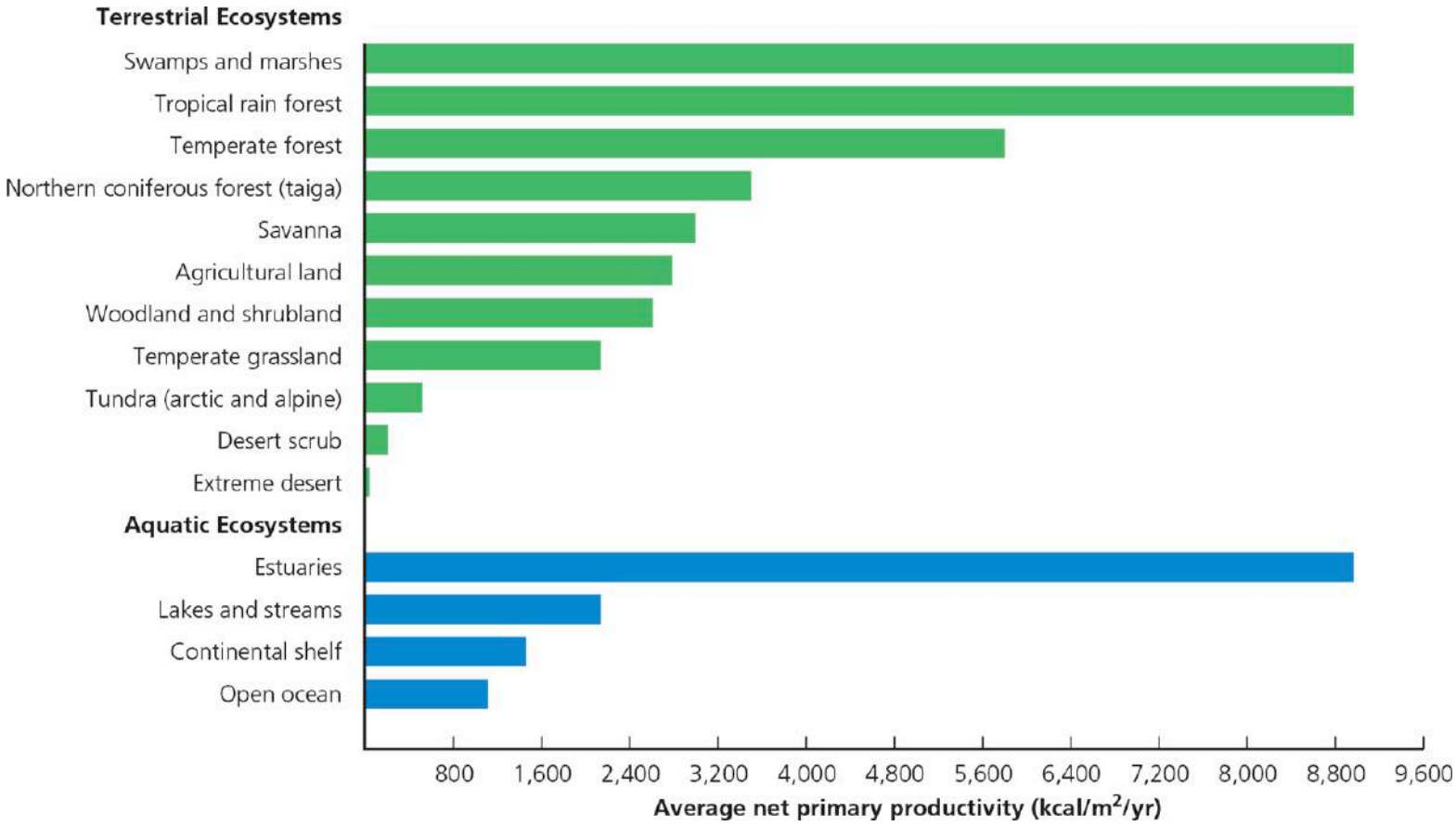
Some Ecosystems Produce Plant Matter Faster than Others Do (1 of 3)

- Gross primary productivity (GPP)
  - Rate at which an ecosystem's producers convert solar energy to stored chemical energy
  - Measured in units such as kcal/m^2/year

Some Ecosystems Produce Plant Matter Faster than Others Do (2 of 3)

- Net primary productivity (NPP)
  - Rate at which an ecosystem's producers convert solar energy to chemical energy, minus the rate at which they use the stored energy for aerobic respiration
  - Terrestrial ecosystems and aquatic life zones differ in their NPP
  - The planet's NPP ultimately limits the number of consumers (including humans) that can survive on the earth

Some Ecosystems Produce Plant Matter Faster than Others Do (3 of 3)



Critical Concept: What Happens to Energy in a Food Chain?

- Ecological Efficiency is the percentage of energy transferred from one trophic level to the next in an ecosystem.
  - 10% rule
  - Most lost as waste heat
  - Some energy contained in detritus and metabolic waste provides energy for decomposers and detritivores

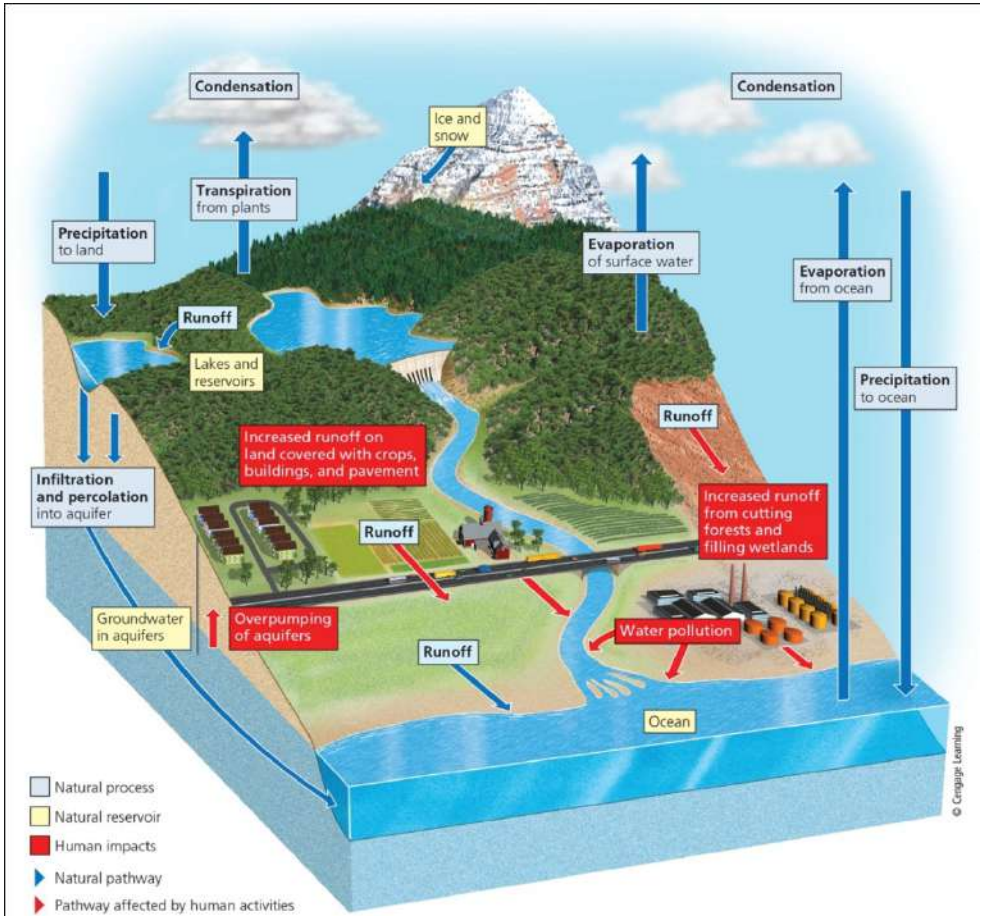
3.4 What Happens to Matter in an Ecosystem?

- Nutrients cycle within and among ecosystems
  - Cycles driven by incoming solar energy and gravity
  - Can be altered by human activity
- Cycles
  - Water, carbon, nitrogen, and phosphorus

Water Cycle Sustains all Life (1 of 3)

- Hydrologic cycle collects, purifies, and distributes earth's fixed supply of water
- Incoming solar energy causes evaporation
- Gravity draws water back as precipitation
  - Surface runoff evaporates to complete the cycle
  - Some precipitation stored as groundwater

Water Cycle Sustains all Life (2 of 3)



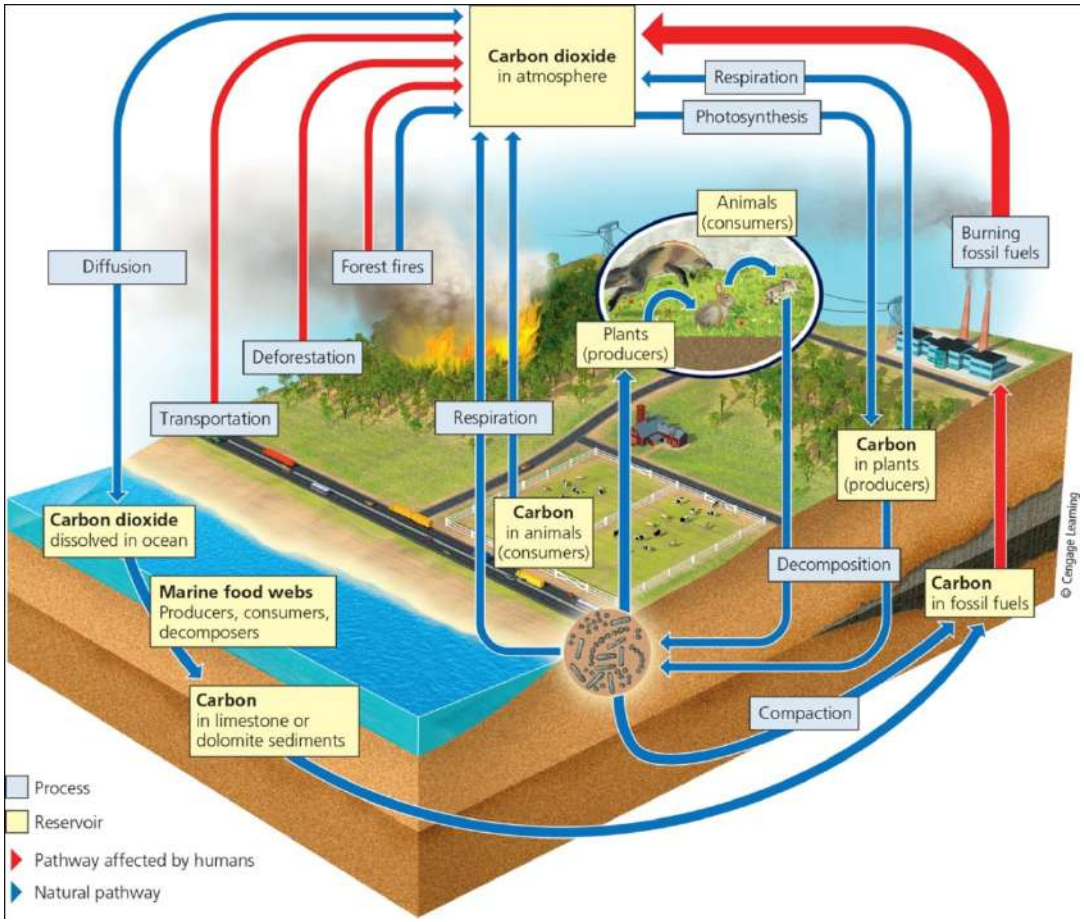
Water Cycle Sustains all Life (3 of 3)

- Ways humans alter the water cycle
  - Withdrawing large amounts of freshwater at rates faster than nature can replace it
  - Clearing vegetation
    - Increases runoff
  - Draining and filling wetlands for farming and urban development
    - Wetlands provide flood control
    - Absorb and hold overflows of water

Carbon Cycles among Living and Nonliving Things (1 of 2)

- Carbon basic building block of carbohydrates, fats, proteins, DNA, and other organic compounds
- Photosynthesis from producers removes CO_2 from the atmosphere
  - Aerobic respiration by producers, consumers, and decomposers adds CO_2
- Some CO_2 dissolves in the ocean
  - Stored in marine sediments

Carbon Cycles among Living and Nonliving Things (2 of 2)



Human Disruption of the Carbon Cycle

- Humans have added large quantities of CO_2 to the atmosphere
  - Faster rate than natural processes can remove
    - Levels have been increasing sharply since about 1960
    - Result: warming atmosphere and changing climate
- Clearing vegetation reduces ability to remove excess CO_2 from the atmosphere

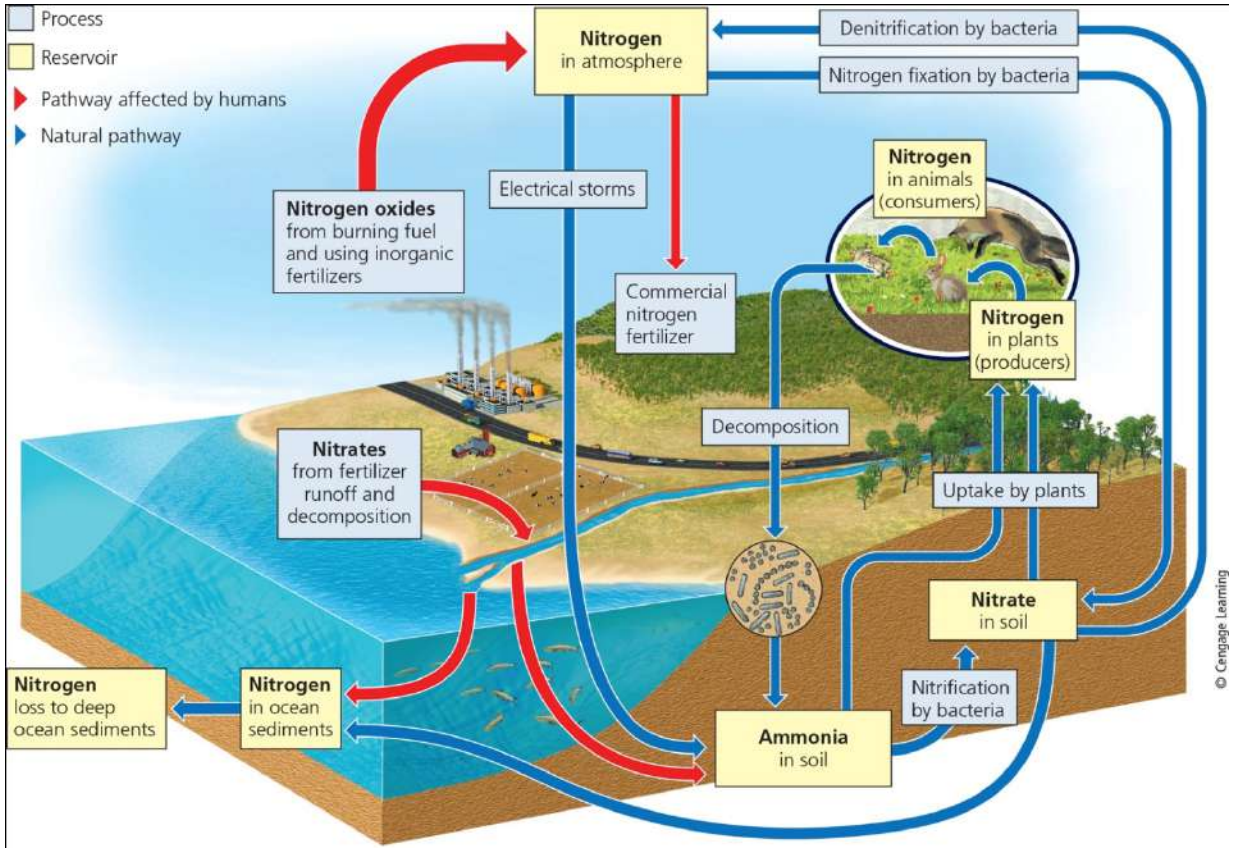
Nitrogen Cycle: Bacteria in Action (1 of 3)

- Useful forms of nitrogen
  - Created by lightning and specialized bacteria in topsoil and bottom sediment of aquatic systems
  - Used by plants to produce proteins, nucleic acids, and vitamins
- Bacteria convert nitrogen compounds back into nitrogen gas

Nitrogen Cycle: Bacteria in Action (2 of 3)

- Human alteration of the nitrogen cycle
  - Burning gasoline and other fuels create nitric oxide, which can return as acid rain
  - Removing large amounts of nitrogen from the atmosphere to make fertilizers
  - Adding excess nitrates in aquatic ecosystems
- Human nitrogen inputs to the environment have risen sharply and are expected to continue rising

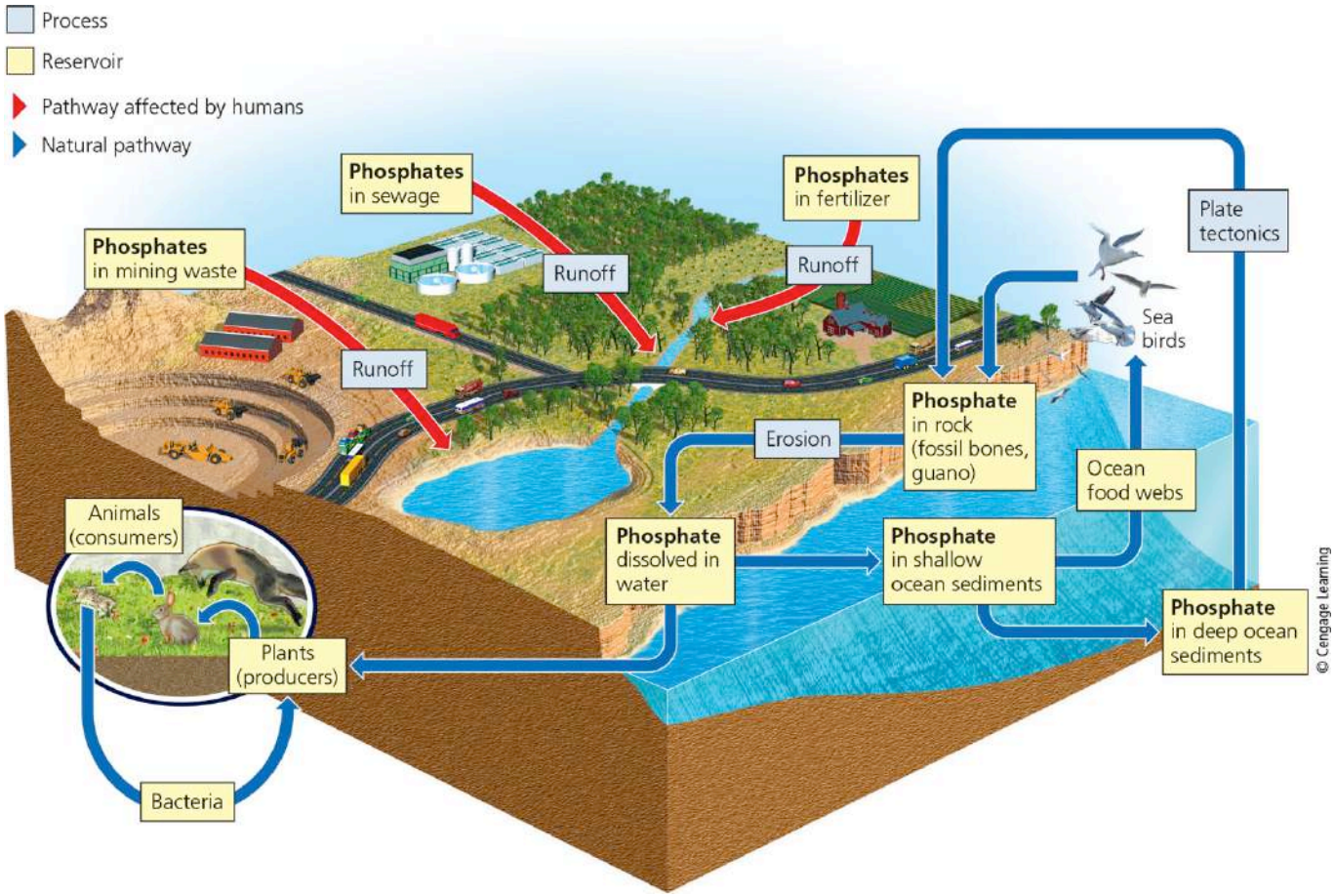
Nitrogen Cycle: Bacteria in Action (3 of 3)



Phosphorous Cycles through Water, Rock, and Food Webs (1 of 2)

- Phosphorus cycles through water, the earth's crust, and living organisms
  - Major reservoir is phosphate rocks
  - Cycles slowly
- Human activities and impacts
  - Clearing forests
  - Removing large amounts of phosphate from the earth to make fertilizers
  - Erosion leaches phosphates into streams

Phosphorous Cycles through Water, Rock, and Food Webs (2 of 2)



3.5 How Do Scientists Study Ecosystems? (1 of 2)

- Methods of study
  - Field research
    - Going into forests and natural settings
  - Laboratory research
  - Mathematical and other models
- Other study tools
  - Aircraft, satellites, GIS software, GPS systems to track where animals go

Ecologists Do Laboratory Research and Use Models

- Model ecosystems and populations under laboratory conditions
  - Simplified systems with controlled temperature, light, humidity, and other variables
  - Supported by field research
- Mathematical models can simulate ecosystems
  - Way to study large and complex systems