Chapter 14

Ecological Interactions

Systems Ecology

- Ecosystem
  - Community of organisms linked by a flow of energy and materials
    - Interaction among organisms
    - Interaction of organisms with the physical environment
  - From an aquarium to the planet Earth
  - Diversity in biological and abiotic compositions and physical features
  - Common features
    - Energy input and flow
    - Cycling of materials

Input of Energy to Ecosystems

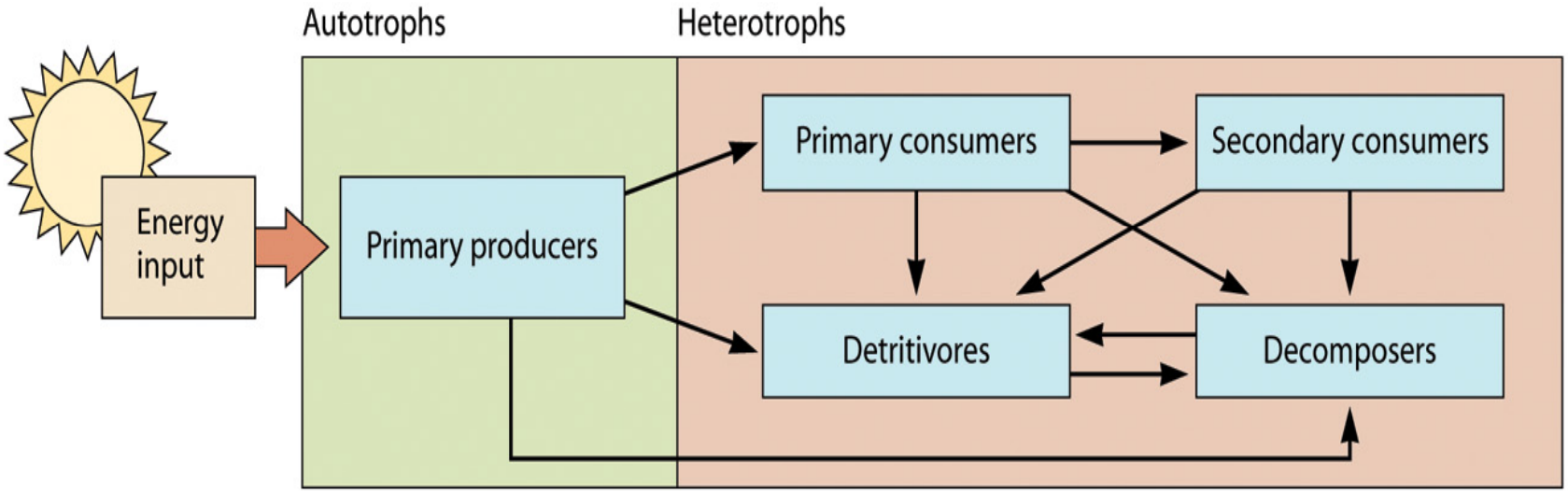
- Primary producers : autotrophs
  - Synthesis of organic molecules from external energy source
    - Photosynthesis : plant, phytoplankton, photosynthetic bacteria
    - Solar energy is transformed into chemical energy
- Primary productivity of ecosystem
  - Gross primary productivity
    - Sun light → chemical energy (1-3% of the sun light)
  - Net primary productivity
    - Chemical energy available to the rest of the organisms (the energy left over)
      - 15-50% of chemical energy is used for their own metabolism
    - Establishes an upper limit for total amount of energy
      - Biomass : total weight or volume of organisms in a community

Direction of Energy Flow in Ecosystem

- Heterotrophs
  - Use other organisms as source of energy and building blocks
    - Consumers: use living food
    - Detritivores: use nonliving food
      - Scavengers: vultures and earthworms
      - Decomposers:
        - » A few species of bacteria and fungi
        - » use biological molecules unavailable to other organisms, such as cellulose and N-containing waste products

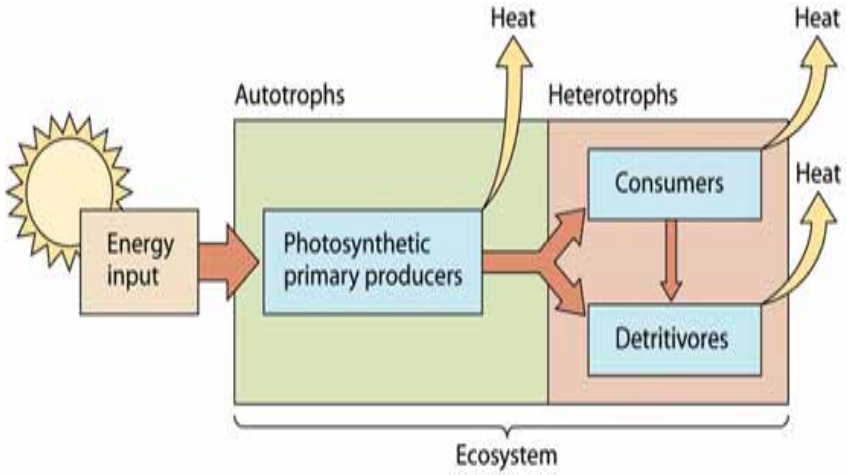
Direction of Energy Flow in Ecosystem

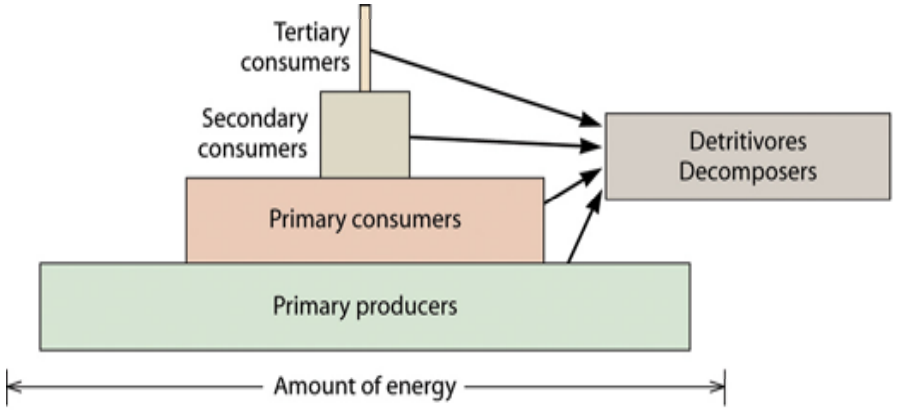
- Trophic levels
  - Arrangement of food chains



Direction of Energy Flow in Ecosystem

- Loss of energy during transfer
  - The second law of thermodynamics





Material Cycle within Ecosystems

- Different in the composition of elements between earth's crust and living organisms

Table 14.3 Relative abundances of elements

Earth's crust			Humans	Plants	Bacteria
Oxygen	46%	Oxygen	64%	79%	72%
Silicon	28%	Carbon	19%	8%	11%
Aluminum	8%	Hydrogen	9%	9%	9%
Iron	5%	Nitrogen	4%	1%	3%
Calcium	3.5%	Phosphorus	1%	0.5%	0.6%
Sodium	3%	Potassium	0.5%	0.3%	0.3%
Potassium	2%	Sulfur	0.4%	0.1%	0.3%

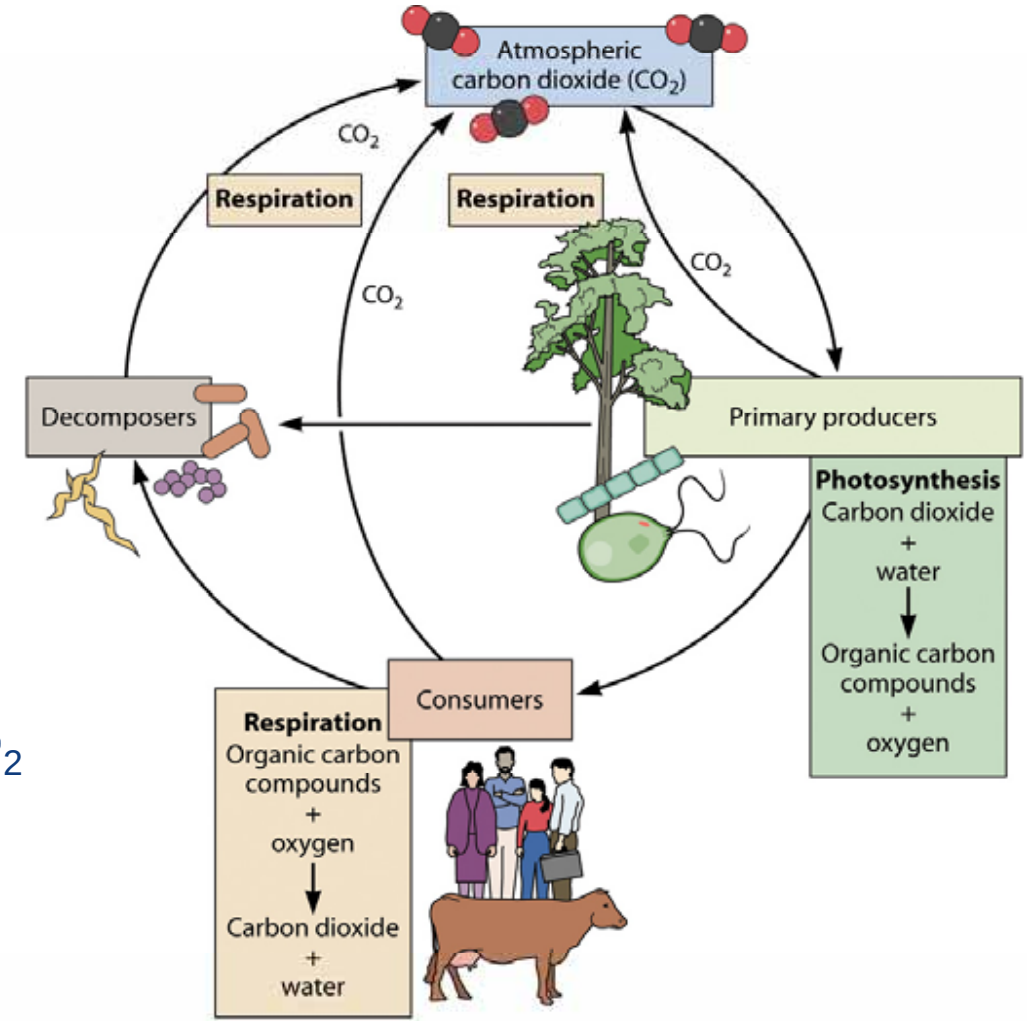
- Minimum necessity for a functional ecosystem
  - Autotrophs
  - Decomposer

The Carbon Cycle

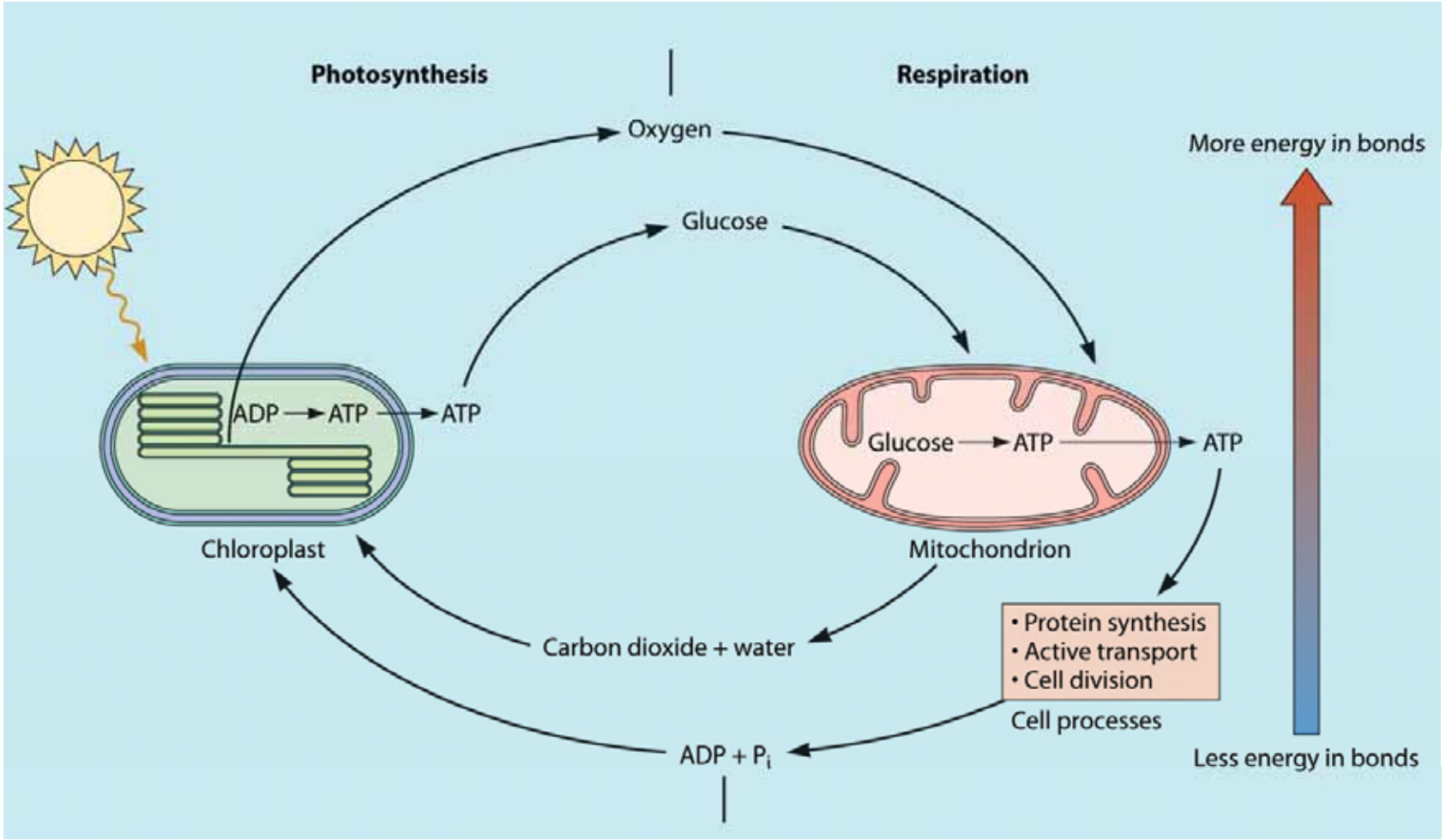
- Life is based on carbon.
- Carbon flow parallels with energy flow.
- Deforestation, Burning of fossil fuel:

  Exhaled CO_2 > inhaled CO_2

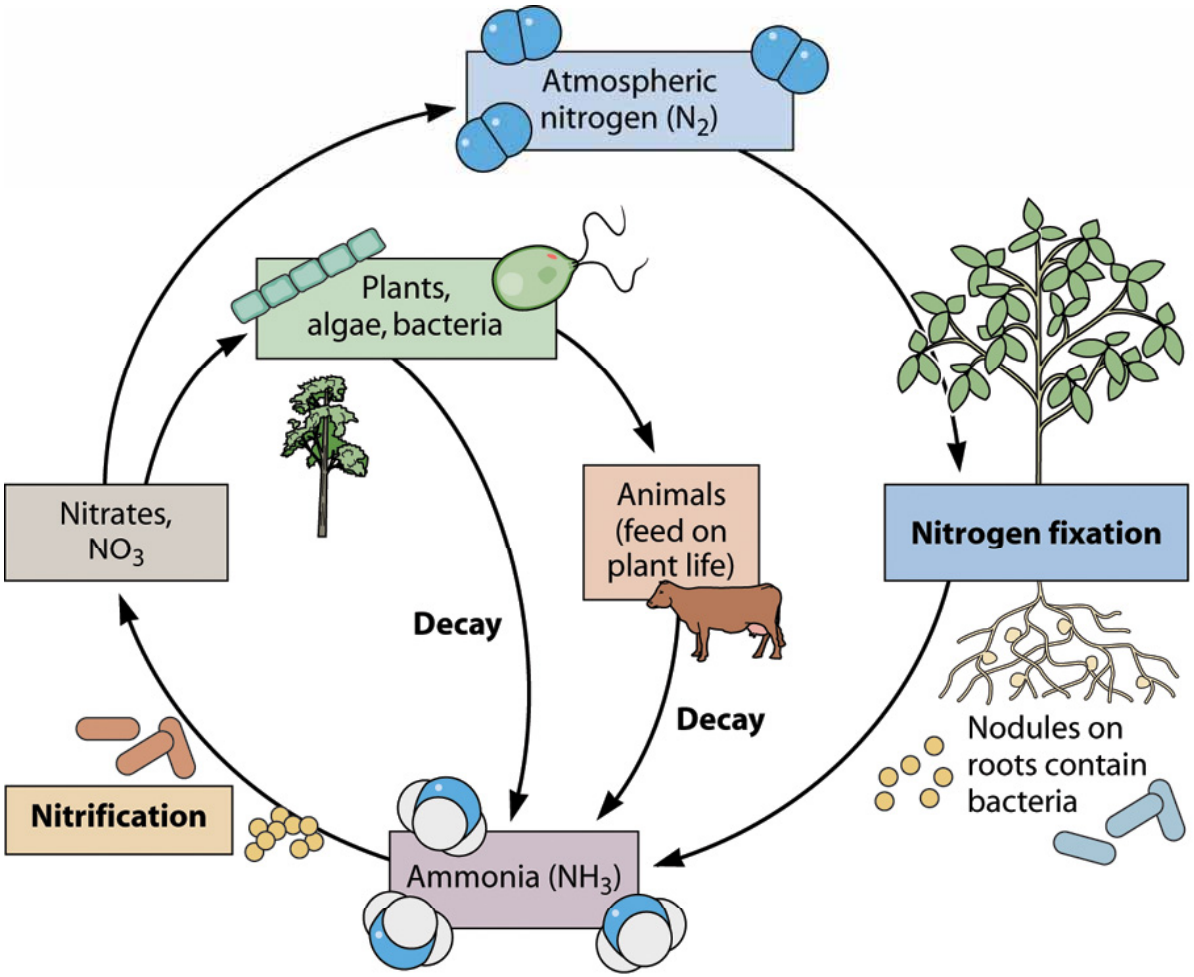
  → Global warming



Photosynthesis



Nitrogen Cycle



Nitrogen Cycle

- Nitrogen fixation
  - Nitrogen-fixing bacteria
    - Nitrogenase: $N_2 + 6H_2 \rightarrow 2\ NH_3$
    - High energy consuming: 15 ~ 20 molecules of ATP
  - Symbiosis between nitrogen-fixing bacteria and plant
    - Formation of nodules in plant roots
    - Mutual benefits (glucose vs. nitrogen source) : mutualism
- Loss of N from the cycle
  - Harvesting crops and timber
  - Soil erosion
  - Chemically synthesized nitrogen fertilizer
    - Use high E to break N_2