Chapter 14

Ecological Interactions

Ecology

- Investigation of interactions occurring at the highest levels of biological organization
  - Population
  - Community
    - Relationship of population with its environment
  - Ecosystem
    - Abiotic factors
- Ecologists vs. environmentalists

Systems Ecology

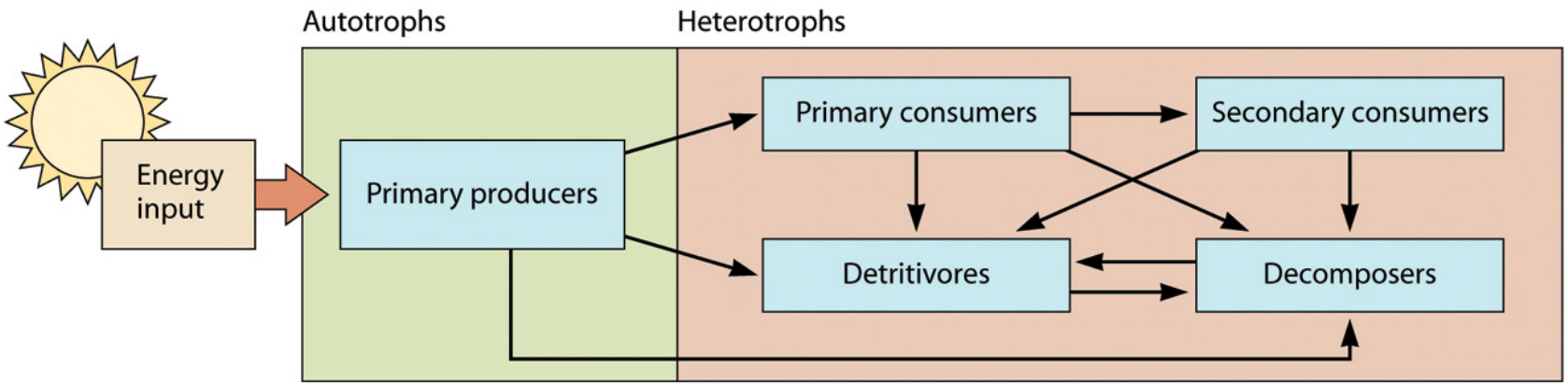
- Ecosystem
  - Community of organisms linked by a flow of energy and materials
    - Interaction among organisms
    - Interaction of organisms with the physical environment
  - From aquarium to earth
  - Diversity in biological and abiotic compositions and feature
  - Common features
    - Energy input 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
    - Energy from chemicals
- Primary productivity of ecosystem
  - 1-3% sun light used for photosynthesis
  - 15-50% of chemical energy is used for their own metabolism
  - Net primary productivity : chemical energy available
    - Establishes an upper limit for
      - Total amount of energy
      - Biomass : total weight or volume of organisms in a community

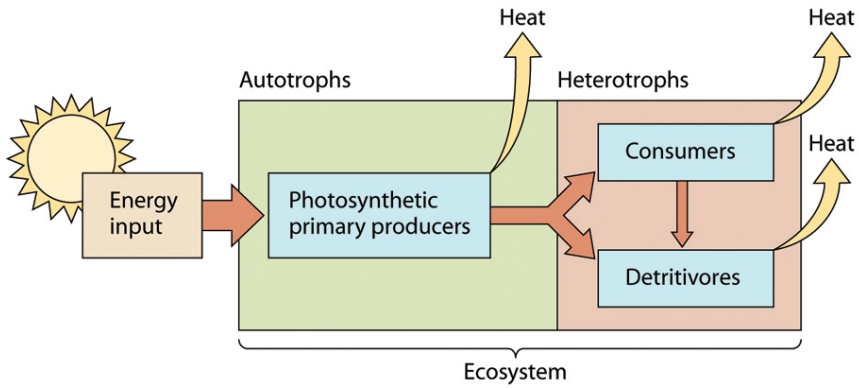
Direction of Energy Flow in Ecosystem

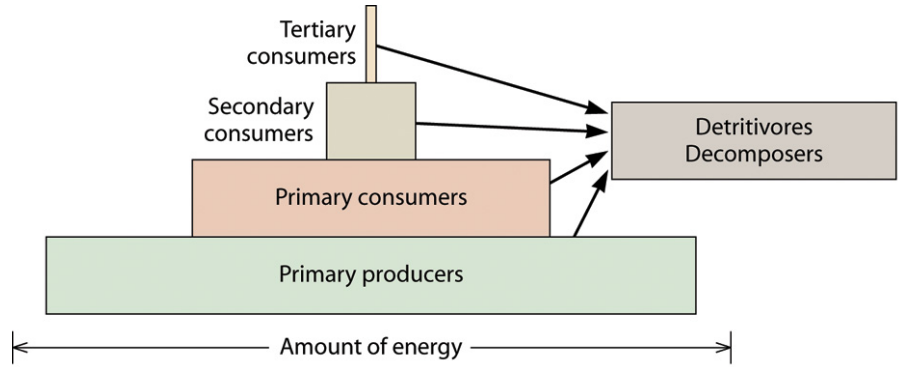
- Heterortophs
  - Use other organisms as source of energy and building blocks
    - Consumer: use living food
    - Detritivores: use nonliving food
      - Scavengers: vultures and earthworms
      - Decomposers: use biologically unavailable molecules such as cellulose and N-containing waste products
- 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

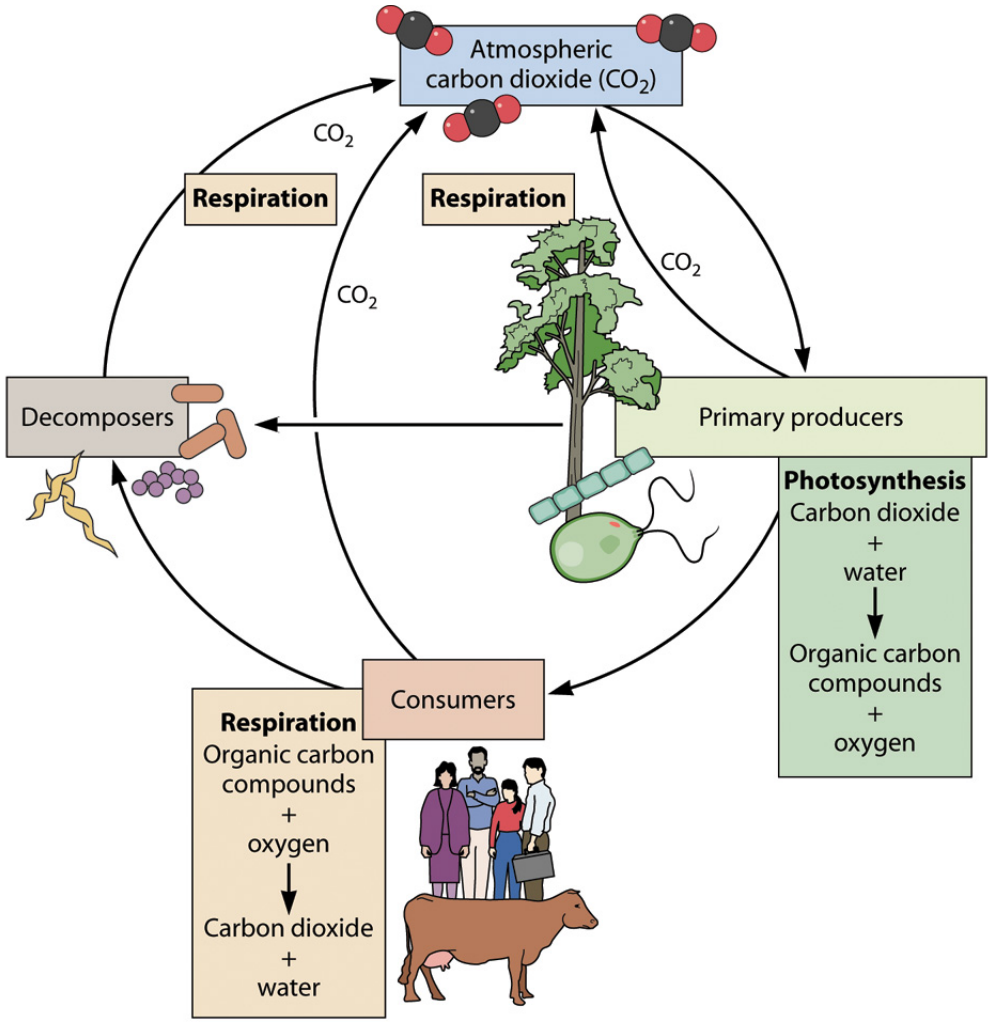
- Different in the composition of elements between earth's crust and loving organisms

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%

  - Autotrophs
  - Decomposer

The Carbon Cycle

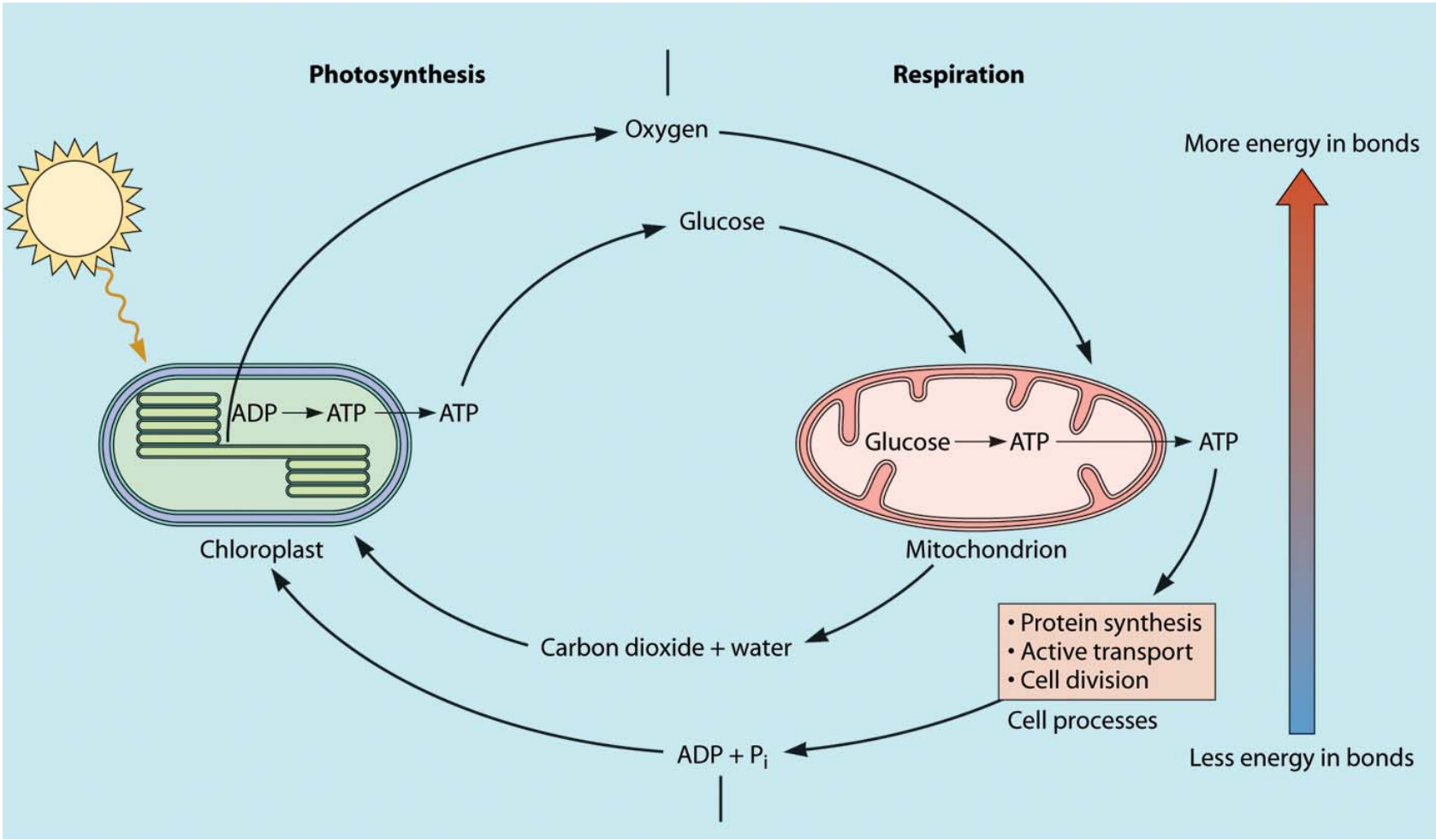


- Life is based on carbon
- Carbon flow parallels with energy flow
- Human activity, burning of fossil fuel:

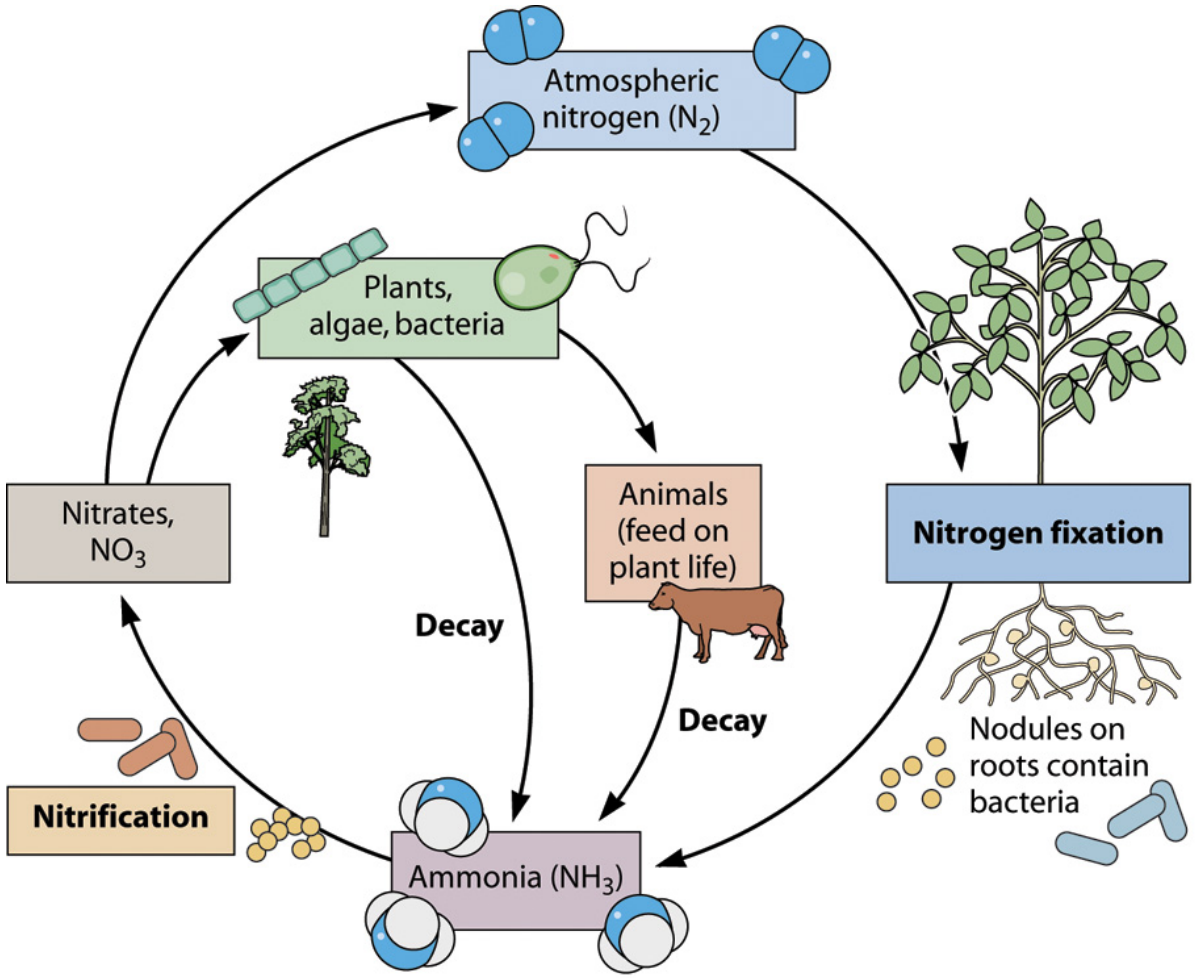
Exhaled CO_2 > inhaled CO_2

→ 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

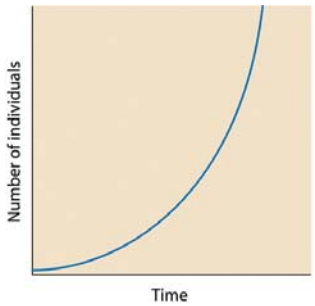
Population of Communities

- Population
  - Determines the health and stability of ecosystems
  - Reproductive potential : inherent capacity to increase in number
    - Inherent reproductive potential
      - Growth rate

        Population growth rate = (# of births + immigrants)/time period - (# of deaths + emigrants)/ time period
      - Intrinsic growth rate

        r = average birth rate (b) – average death rate (d)
      - Change in the number of individuals in a population (G)

        G = rN, N= # of individuals in a population
      - Exponential growth of population



Exponential Growth

- Implications of the exponential growth
  - Even with constant r, G increases
  - With positive r, population increases exponentially
- Factors determining r
  - Age a first reproduction : most effective
  - # of birth/ individual
  - Birth interval
  - # of offspring surviving to reproductive age
- Opportunistic species
  - Exponential growth by colonizing new sites or invading disturbed habitats
  - Small rodents, weedy plants

Regulation of Population Size and Growth

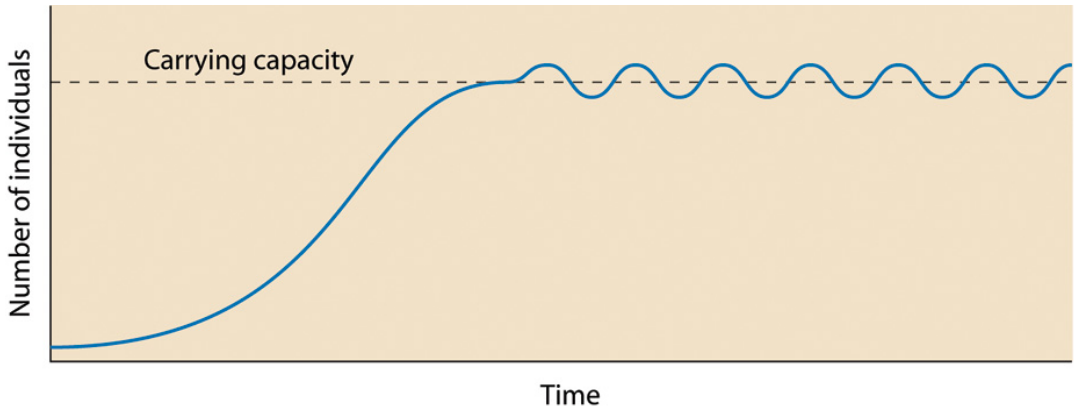
- Limiting factors

  : Determine the abundance and distribution of species

  - Density-dependent factors
    - Competition for resources
    - Predation
    - Disease
    - Habitat degradation
  - Density-independent Ecological factors
    - Temperature, salinity, rainfall

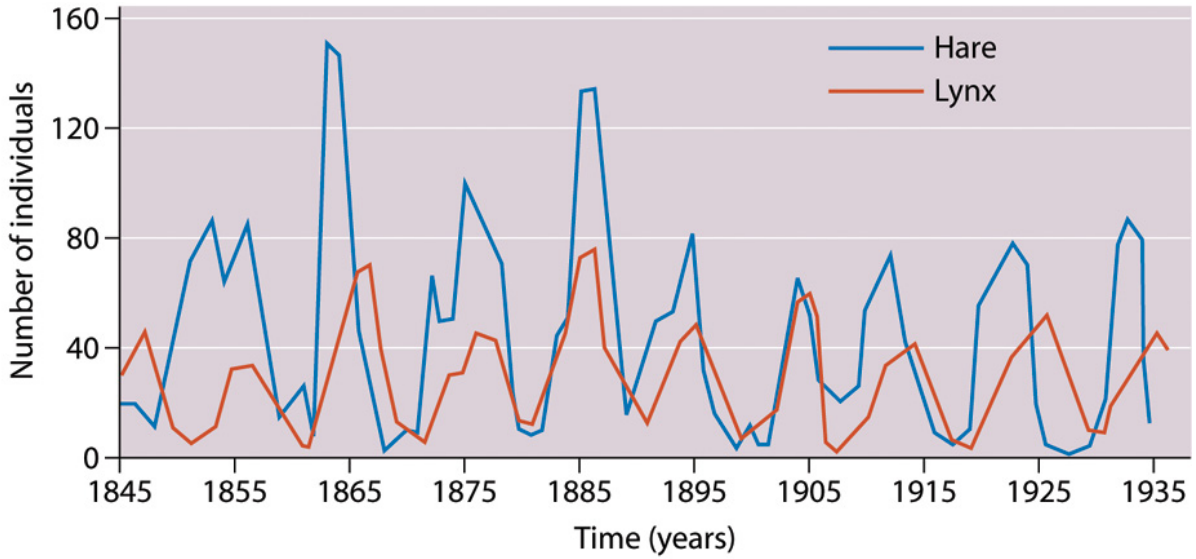
Resource Competition and Environmental Carrying capacity

- Carrying capacity (K)
  - Maxomum # of individuals of the species that the environment can support at a particular point in time
- Logistic growth
  - G = rN X (K-N)/K
  - Small N: exponential growth
  - K=N: No growth



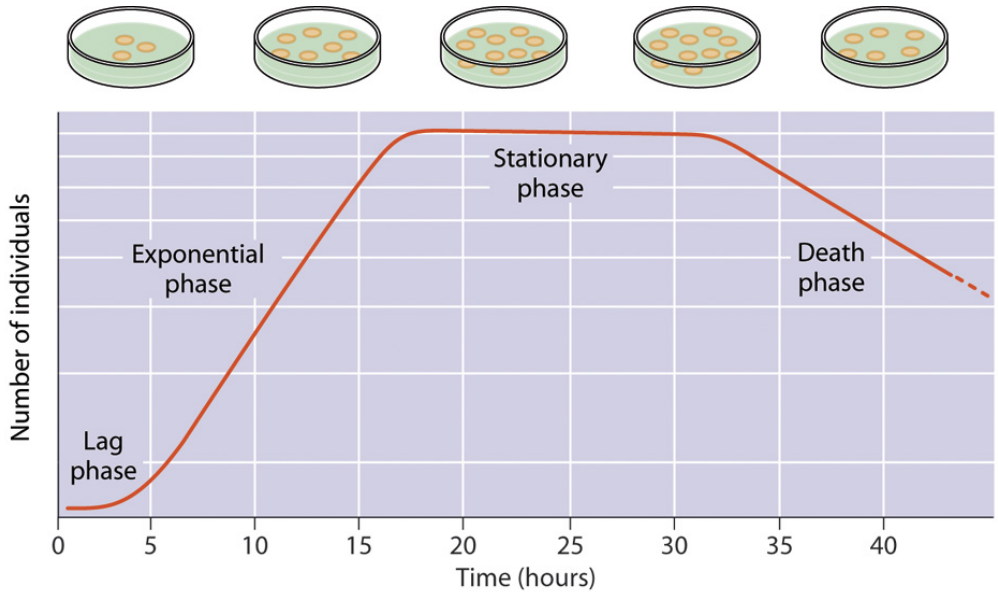
Predation, Parasitism, and Disease

- Population size of prey or host
  - Regulated below K by predator, parasite, or pathogen
- Population size of predator, parasite, or pathogen
  - Tracks the population size of prey or host



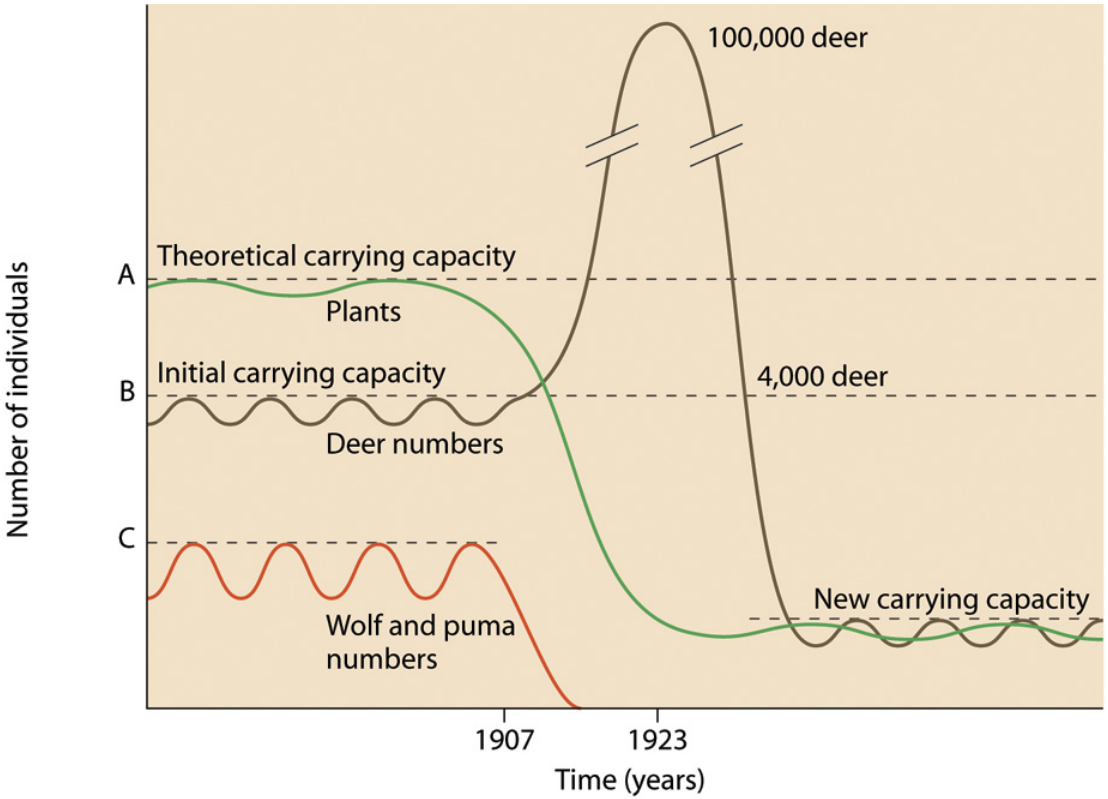
Environmental Degradation and Carrying Capacity

- Increasing population → decrease in population growth
  - Competing for limited resources
  - Environmental degradation



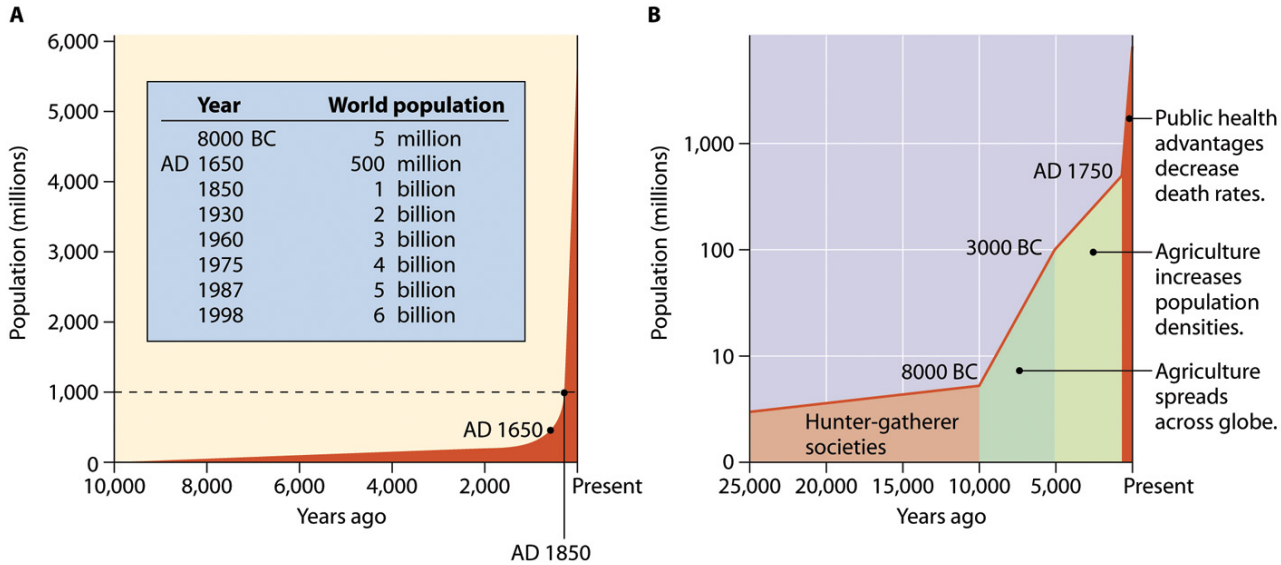
Environmental Degradation and Carrying Capacity

- Ecological release
  - Environmental degradation → lowering K



Human Population Growth

- Exponential growth for 200 years
- Early humans eliminated limiting factors
  - Clothes, fires, shelters, hunting etc.
- Hunter-gatherers (40,000 BP)
  - Low r
- Agriculture (10,000 BP)
  - Higher r
  - Increasing population and environmental degradation
    - Density-dependent regulation slow r by increasing death rate



Lowering d Leads to Exponential Growth

- Dramatic increase in population by decreasing death rate
  - Around 1750 : Infectious disease control
  - Mid- to late 1800s
    - Biological understanding of infection and disease
      - Louis Pasteur and Robert Koch
    - Vaccines and antibiotics

Agricultural Technology Slows r in the Industrialized World

- From hunter-gatherer to agriculture society
  - Increase in population was the driving force
- Positive feed back
  - Need more labors for agriculture → increase in population
- Industrialized countries
  - Advanced agricultural productivity by science and technology can replace the man power → decrease in population