Ecosystems: What Are They and How Do They Work?

Chapter 3

3-1 What Is Ecology?

- ***Concept 3-1*** *Ecology is the study of how organisms interact with one another and with their physical environment of matter and energy.*

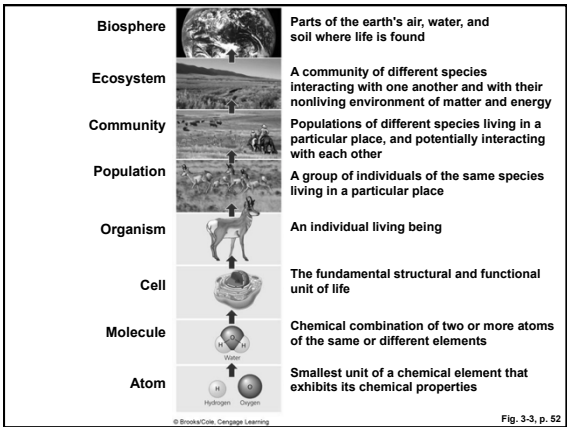
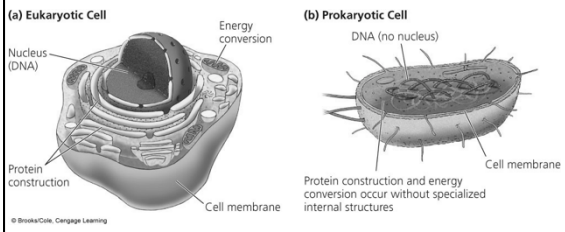


Fig. 3-3, p. 52

Structure of a Eukaryotic Cell and a Prokaryotic Cell



Species Make Up the Encyclopedia of Life

- **Species**
- 1.75 Million species identified
- Insects make up most of the known species
- Perhaps 10–14 million species not yet identified

Ecologists Study Connections in Nature

- **Ecology**
- Levels of organization (Fig. 3-3)
  - **Population**
    - Genetic diversity
  - **Community**
  - **Ecosystem**
  - **Biosphere**

3-2 What Keeps Us and Other Organisms Alive?

- ***Concept 3-2*** *Life is sustained by the flow of energy from the sun through the biosphere, the cycling of nutrients within the biosphere, and gravity.*

The Earth's Life-Support System Has Four Major Components

- **Atmosphere**
  - Troposphere
  - Stratosphere
- **Hydrosphere**
- **Geosphere**
- **Biosphere**

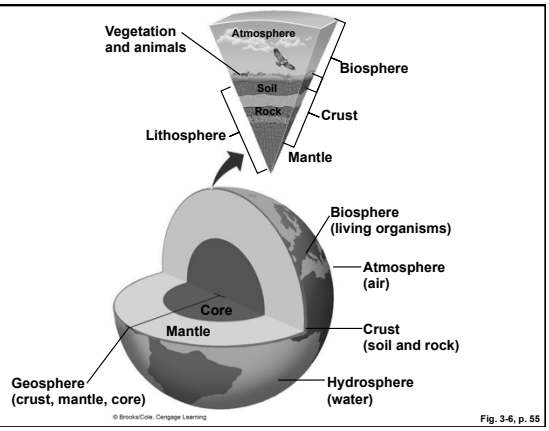


Fig. 3-6, p. 55

Life Exists on Land and in Water

- **Biomes (Fig. 3-7)**
- **Aquatic life zones**
  - Freshwater life zones
    - Lakes and streams
  - Marine life zones
    - Coral reefs
    - Estuaries
    - Deep ocean

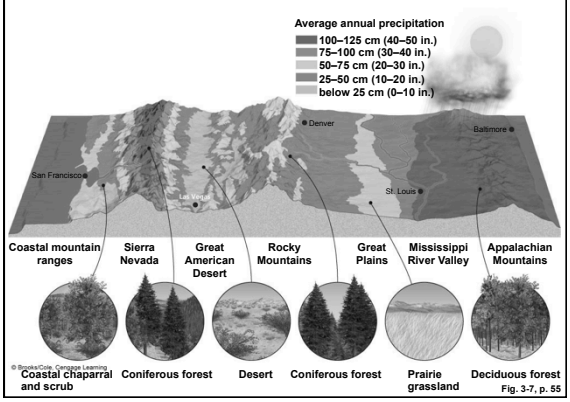


Fig. 3-7, p. 55

Three Factors Sustain Life on Earth

- One-way flow of high-quality energy beginning with the sun (Laws of Thermodynamics)
- Cycling of matter or nutrients (Conservation of matter)
- Gravity

What Happens to Solar Energy Reaching the Earth?

- UV, visible, and IR energy
- Radiation
  - Absorbed by ozone
  - Absorbed by the earth
  - Reflected by the earth
  - Radiated by the atmosphere as heat
- **Natural greenhouse effect (Fig. 3-8)**

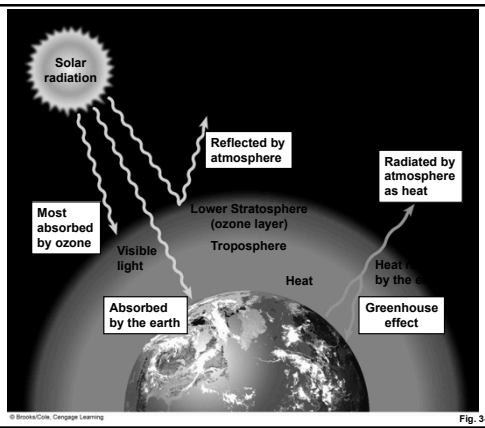


Fig. 3-8, p. 56

Active Figure: Energy flow from the Sun to Earth

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3-3 What Are the Major Components of an Ecosystem?

- ***Concept 3-3A*** *Ecosystems contain living (biotic) and nonliving (abiotic) components.*
- ***Concept 3-3B*** *Some organisms produce the nutrients they need, others get their nutrients by consuming other organisms, and some recycle nutrients back to producers by decomposing the wastes and remains of organisms.*

Ecosystems Have Living and Nonliving Components

- **Abiotic**
  - Water
  - Air
  - Nutrients
  - Rocks
  - Heat
  - Solar energy
- **Biotic**
  - Living and once living

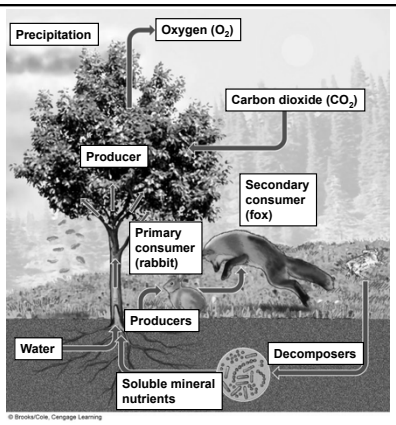


Fig. 3-9, p. 57

Several Abiotic Factors Can Limit Population Growth

- **Limiting factor principle**
  - Too much or too little of any abiotic factor can limit or prevent growth of a population, even if all other factors are at or near the optimal range of tolerance

Range Tolerance for a Population of Organisms

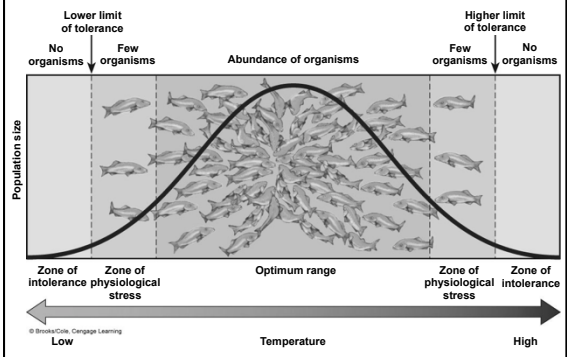


Fig. 3-10, p. 58

Producers and Consumers Are the Living Components of Ecosystems (1)

- **Producers, autotrophs**
  - Photosynthesis
  - Chemosynthesis
- **Consumers, heterotrophs**
  - Primary
  - Secondary
  - Third and higher level
- **Decomposers**

Producers and Consumers Are the Living Components of Ecosystems (2)

- **Detritivores (Fig. 3-11)**
- **Aerobic respiration**
- **Anaerobic respiration, fermentation**

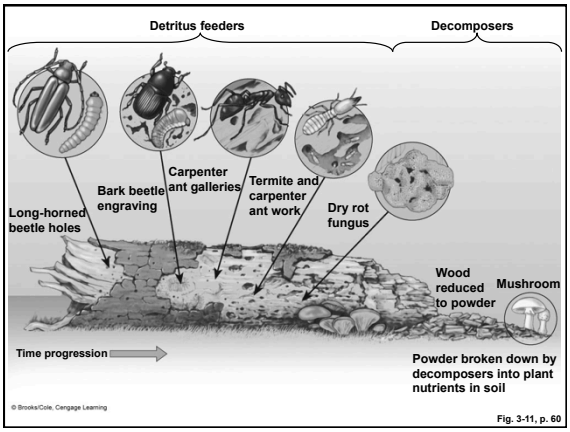
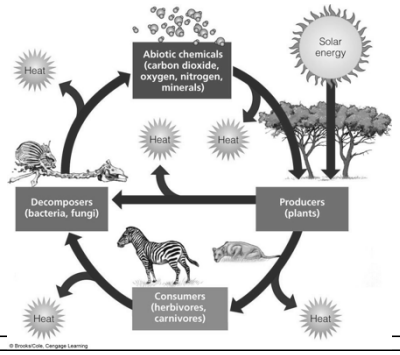


Fig. 3-11, p. 60

Energy Flow and Nutrient Cycling Sustain Ecosystems and the Biosphere

- One-way energy flow (Laws of thermodynamics)
- Nutrient cycling of key materials (Conservation of matter)

The Main Structural Components of an Ecosystem



Active Figure: Roles of organisms in an ecosystem

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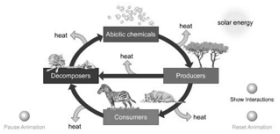
Active Figure: Matter recycling and energy flow



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3-4 What Happens to Energy in an Ecosystem?

- ***Concept 3-4A*** *Energy flows through ecosystems in food chains and webs.*
- ***Concept 3-4B*** *As energy flows through ecosystems in food chains and webs, the amount of chemical energy available to organisms at each succeeding feeding level decreases.*

Example of a Simple Food Chain

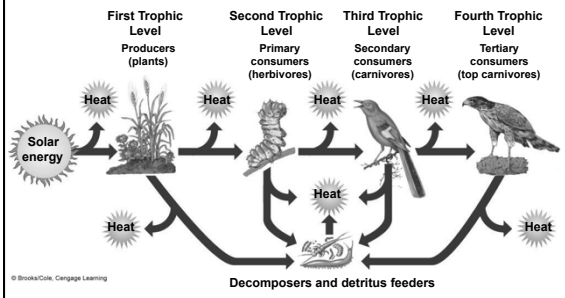


Fig. 3-13, p. 62

… and a Simplified Food Web (where would you find this food web?)

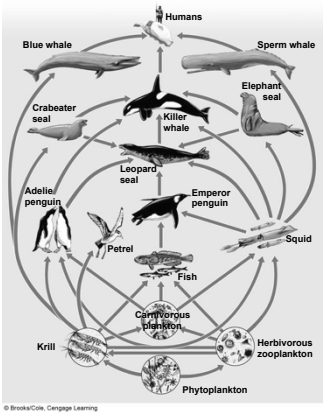
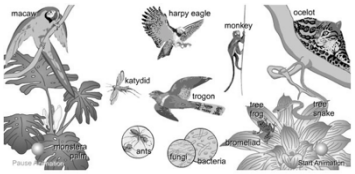


Fig. 3-14, p. 63

Active Figure: Rainforest food web



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Usable Energy Decreases with Each Link in a Food Chain or Web

- Biomass
- Ecological efficiency
- Pyramid of energy flow

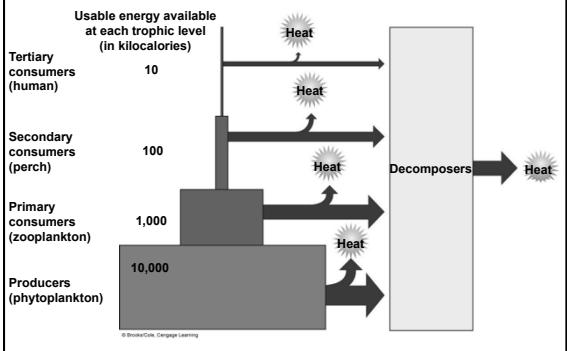


Fig. 3-15, p. 63

Some Ecosystems Produce Plant Matter Faster Than Others Do

- **Gross primary productivity (GPP) is the rate at which producers convert solar energy into chemical energy as biomass found in their tissue**
- **Net primary productivity (NPP) is the GPP minus energy used for respiration**
  - Ecosystems and life zones differ in their NPP

Estimated Annual Average NPP in Major Life Zones and Ecosystems

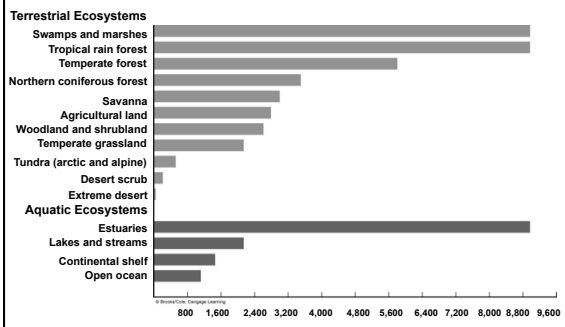


Fig. 3-16, p. 64

3-5 What Happens to Matter in an Ecosystem?

- ***Concept 3-5*** *Matter, in the form of nutrients, cycles within and among ecosystems and the biosphere, and human activities are altering these chemical cycles.*

Nutrients Cycle in the Biosphere

- **Biogeochemical cycles, nutrient cycles**
  - Hydrologic
  - Carbon
  - Nitrogen
  - Phosphorus
  - Sulfur
- Connect past, present , and future forms of life

Water Cycles through the Biosphere

- Natural renewal of water quality: three major processes
  - Evaporation
  - Precipitation
  - Transpiration
- Alteration of the hydrologic cycle by humans
  - Withdrawal of large amounts of freshwater at rates faster than nature can replace it
  - Clearing vegetation
  - Increased flooding when wetlands are drained

Hydrologic Cycle Including Negative Human Impacts

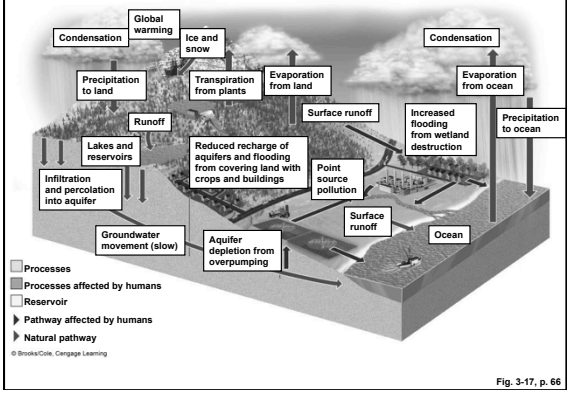
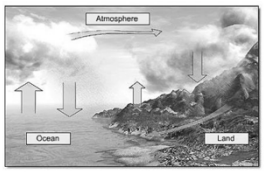


Fig. 3-17, p. 66

Active Figure: Hydrologic cycle



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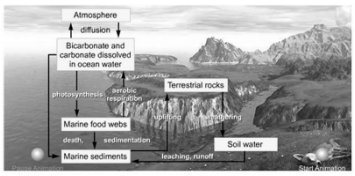
Science Focus: Water's Unique Properties

- Properties of water due to **hydrogen bonds** between water molecules:
  - Exists as a liquid over a large range of temperature
  - Changes temperature slowly
  - High boiling point: 100˚C
  - Adhesion and cohesion
  - Expands as it freezes
  - Solvent
  - Filters out harmful UV

Carbon Cycle Depends on Photosynthesis and Respiration

- Link between photosynthesis in producers and respiration in producers, consumers, and decomposers
- Additional CO_2 added to the atmosphere
  - Tree clearing
  - Burning of fossil fuels

Active Figure: Carbon cycle



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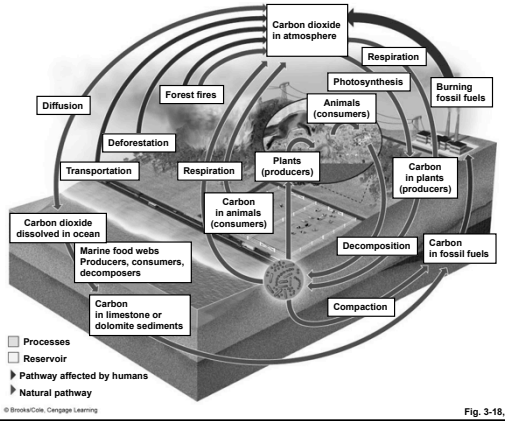
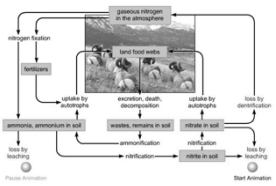


Fig. 3-18, p. 68

Nitrogen Cycles through the Biosphere: Bacteria in Action (1)

- Nitrogen fixed (combined with hydrogen)
  - Lightning
  - Nitrogen-fixing bacteria
- Nitrification (combined with oxygen)
- Denitrification

Active Figure: Nitrogen cycle



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Nitrogen Cycles through the Biosphere: Bacteria in Action (2)

- Human intervention in the nitrogen cycle
  - Additional NO (nitric oxide from burning fossil fuels) and N_2O (nitrous oxide from agriculture)
  - Destruction of forest, grasslands, and wetlands
  - Add excess nitrates to bodies of water
  - Remove nitrogen from topsoil (with crop harvest)

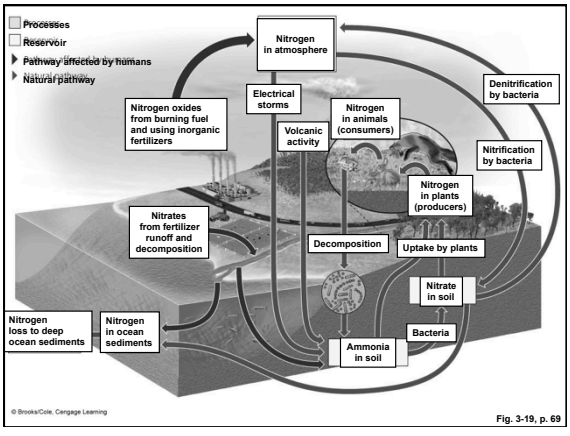
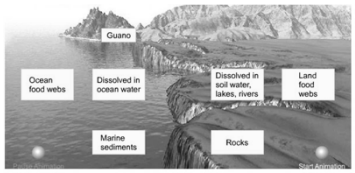


Fig. 3-19, p. 69

Phosphorus Cycles through the Biosphere

- Cycles through water, the earth's crust, and living organisms
- May be limiting factor for plant growth
- Impact of human activities
  - Clearing forests
  - Removing large amounts of phosphate from the earth to make fertilizers

Animation: Phosphorus cycle



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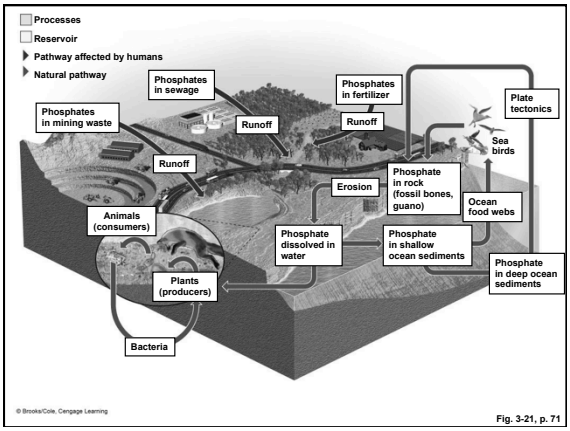
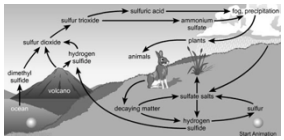


Fig. 3-21, p. 71

Sulfur Cycles through the Biosphere

- Sulfur found in organisms, ocean sediments, soil, rocks, and fossil fuels
- SO_2 (sulfur dioxide) in the atmosphere
- H_2SO_4 (sulfuric acid) and SO_4^{2-}
- Human activities affect the sulfur cycle
  - Burn sulfur-containing coal and oil
  - Refine sulfur-containing petroleum
  - Convert sulfur-containing metallic mineral ores

Active Figure: Sulfur cycle



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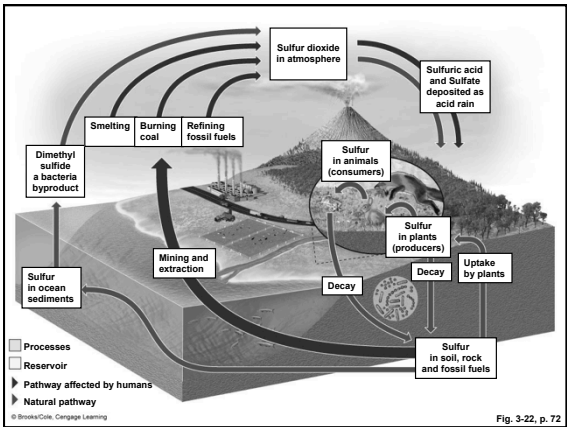

Fig. 3-22, p. 72

Animation: Linked processes

3-6 How Do Scientists Study Ecosystems?

- ***Concept 3-6*** *Scientists use field research, laboratory research, and mathematical and other models to learn about ecosystems.*

Some Scientists Study Nature Directly

- Field research: "muddy-boots biology"
- New technologies available
  - Remote sensors
  - Geographic information system (GIS) software
  - Digital satellite imaging
- 2005, Global Earth Observation System of Systems (GEOSS)

Some Scientists Study Ecosystems in the Laboratory

- Simplified systems carried out in
  - Culture tubes and bottles
  - Aquaria tanks
  - Greenhouses
  - Indoor and outdoor chambers
- Supported by field research

Some Scientists Use Models to Simulate Ecosystems

- Computer simulations and projections
- Field and laboratory research needed for baseline data