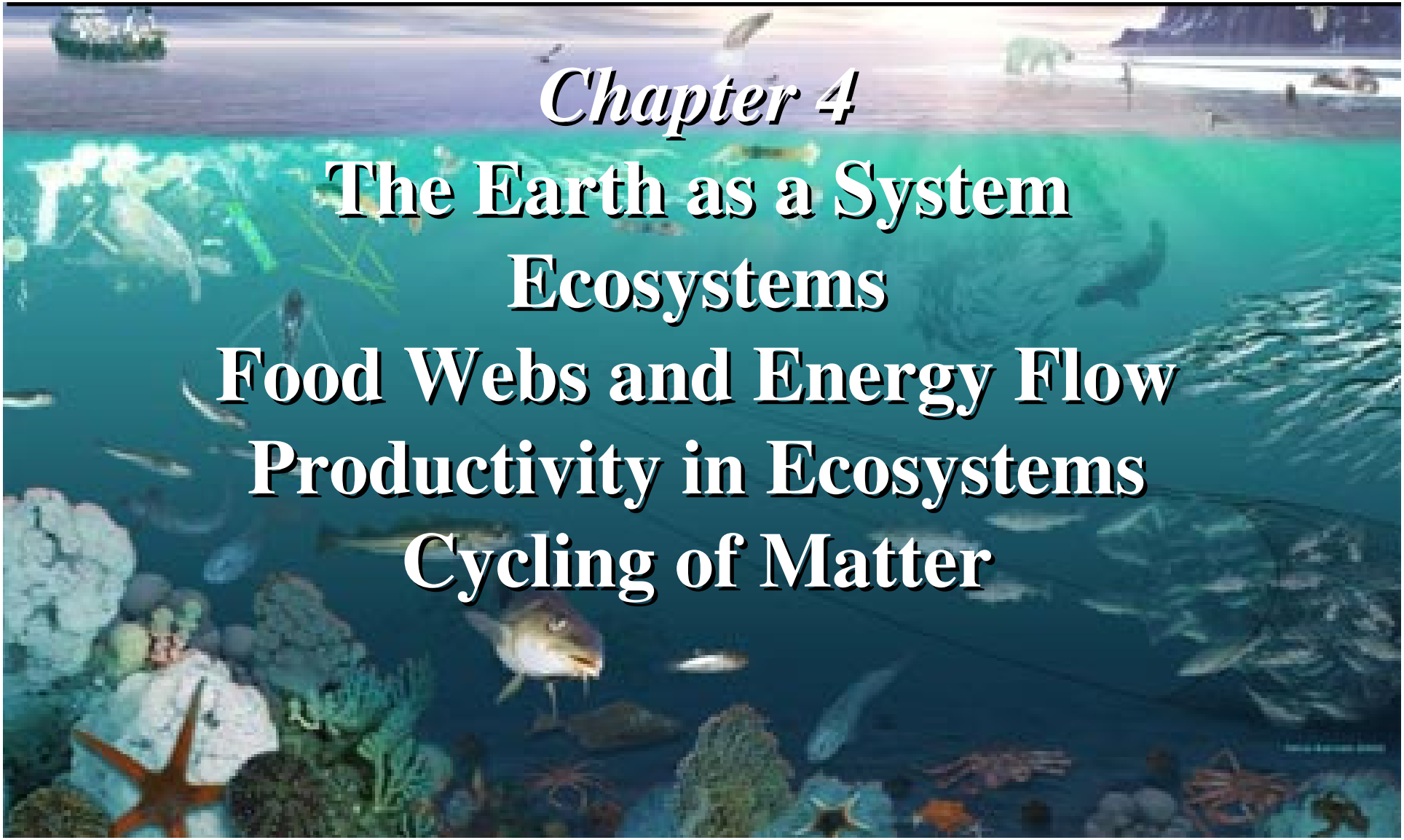
Ecosystems: Components, Energy Flow, and Matter Cycling



Chapter 4

The Earth as a System

Ecosystems

Food Webs and Energy Flow

Productivity in Ecosystems

Cycling of Matter

- Describe one specific ecosystem. What are its major components; name some biotic and abiotic factors that affect it.
- How is energy used in an ecosystem? What happens to it as it is used (or not used)?
- A bumper sticker reads, “Have you thanked a green plant today?” Give two reasons for appreciating a green plant. Trace the sources of the materials that make up the bumper sticker, and decide whether the sticker itself is a sound application of the slogan.

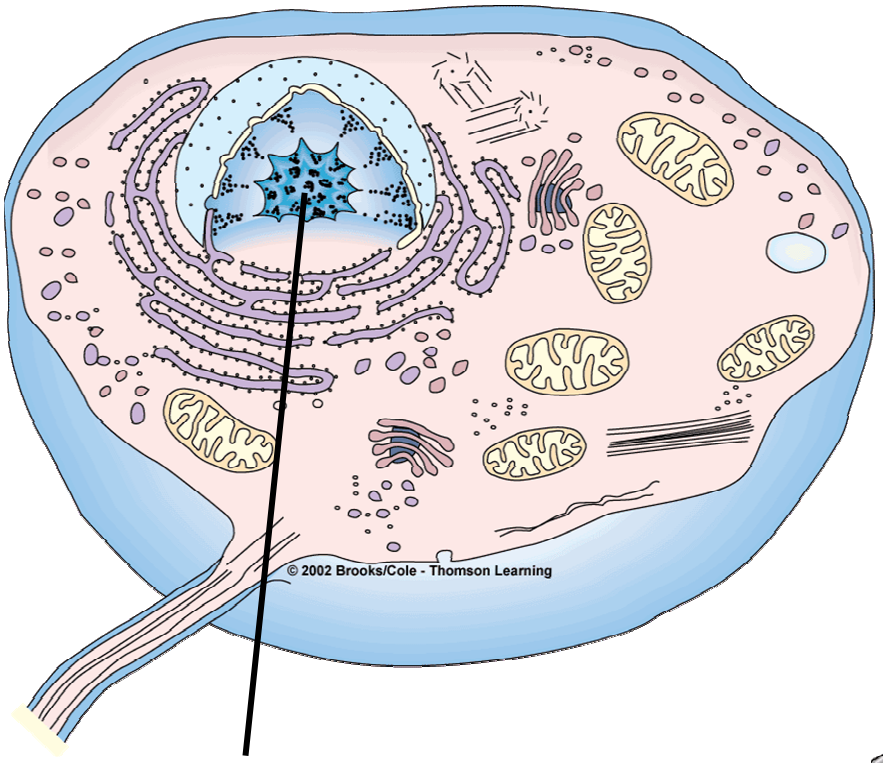
Key Concepts

- Basic ecological principles
- Major components of ecosystems
- Matter cycles and energy flow
- Ecosystem studies
- Ecological services

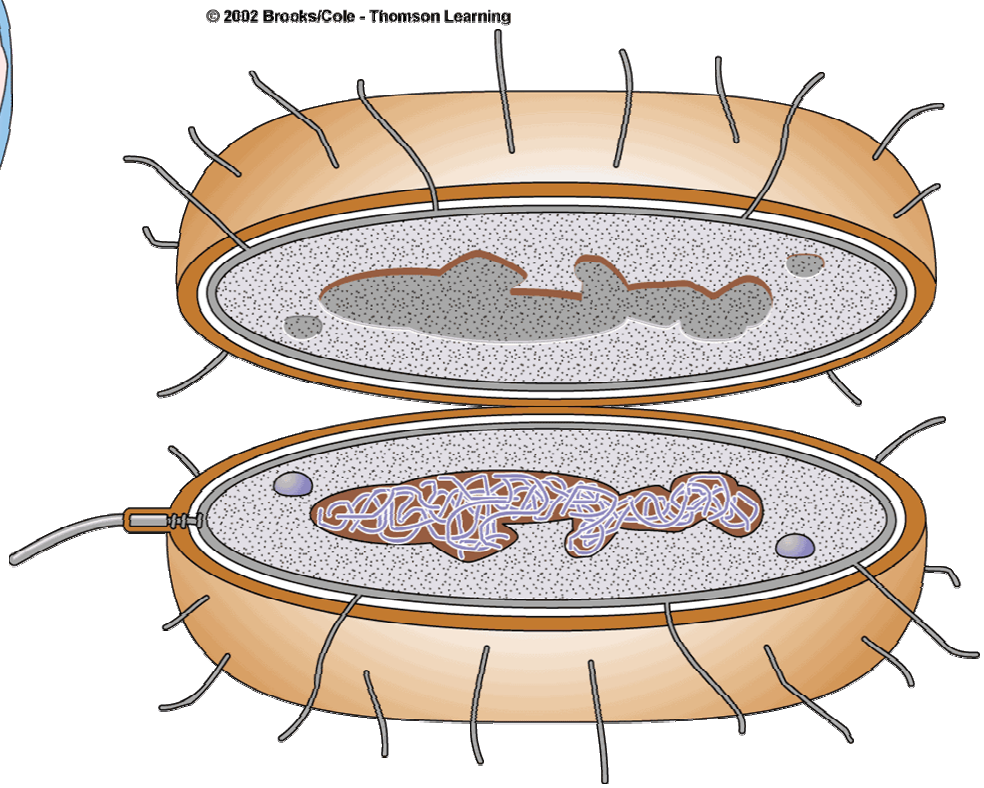
The Nature of Ecology

- **Ecology**- the study of how organisms interact with their environment
- **Organisms**- any life form
  - **Cells**- the basic unit of life; come in two flavors
    - ***Prokaryote***- cells with no defined nucleus; bacteria
    - ***Eukaryote***- cells with a defined nucleus that contains DNA; most familiar organisms and multicellular organisms
- **Species**- groups of organisms that share similar DNA; can produce fertile offspring.
  - ***Asexual Reproduction***-cellular division to produce identical offspring (clones)
  - ***Sexual Reproduction***- production of offspring by combining sex cells (gametes) to create progeny that are a combination of each of the parents' characteristics

Types of Cells p.72



Nucleus



Populations

- **<u>Population</u>**- all of the organisms within a species that interact in a specific area and at a specific time
  - ***Genetic Diversity***- similar but different due to DNA
  - Affected by:
    - ***Size***
    - ***Age distribution***
    - ***Density***
    - ***Genetic composition***

The Nature of Ecology

- Ecosystem organization
- Organisms
- Populations
- Communities
- Ecosystems
- Biosphere

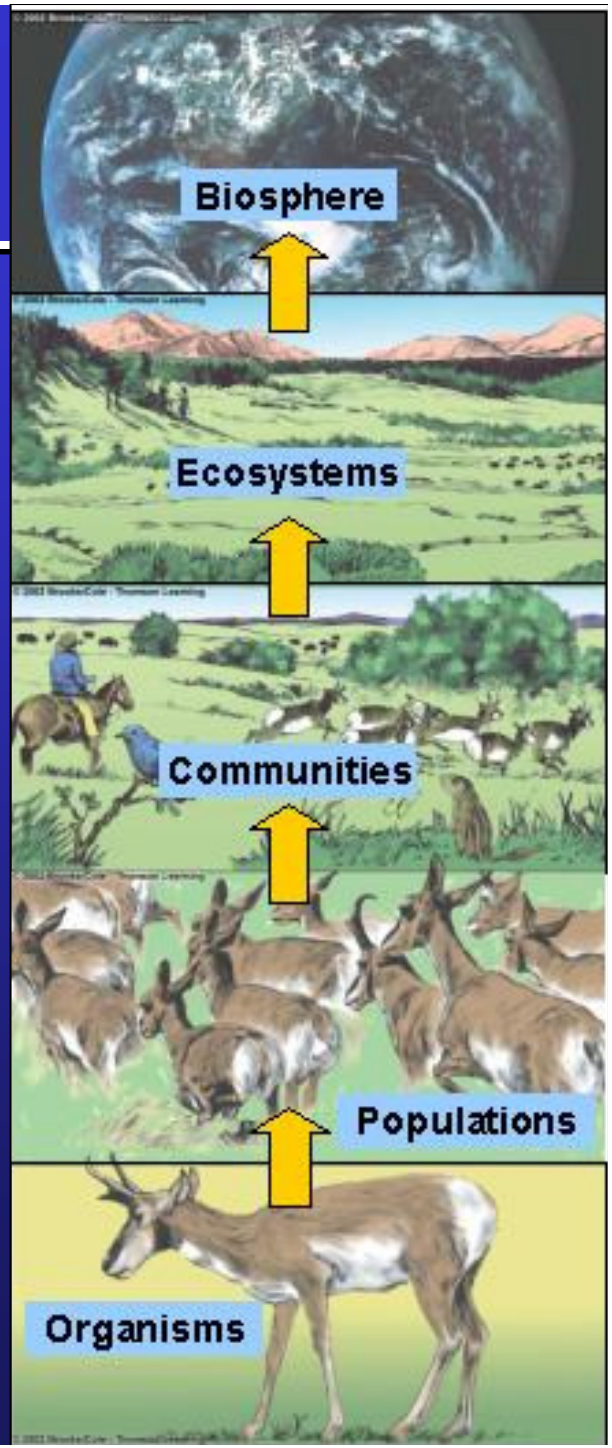
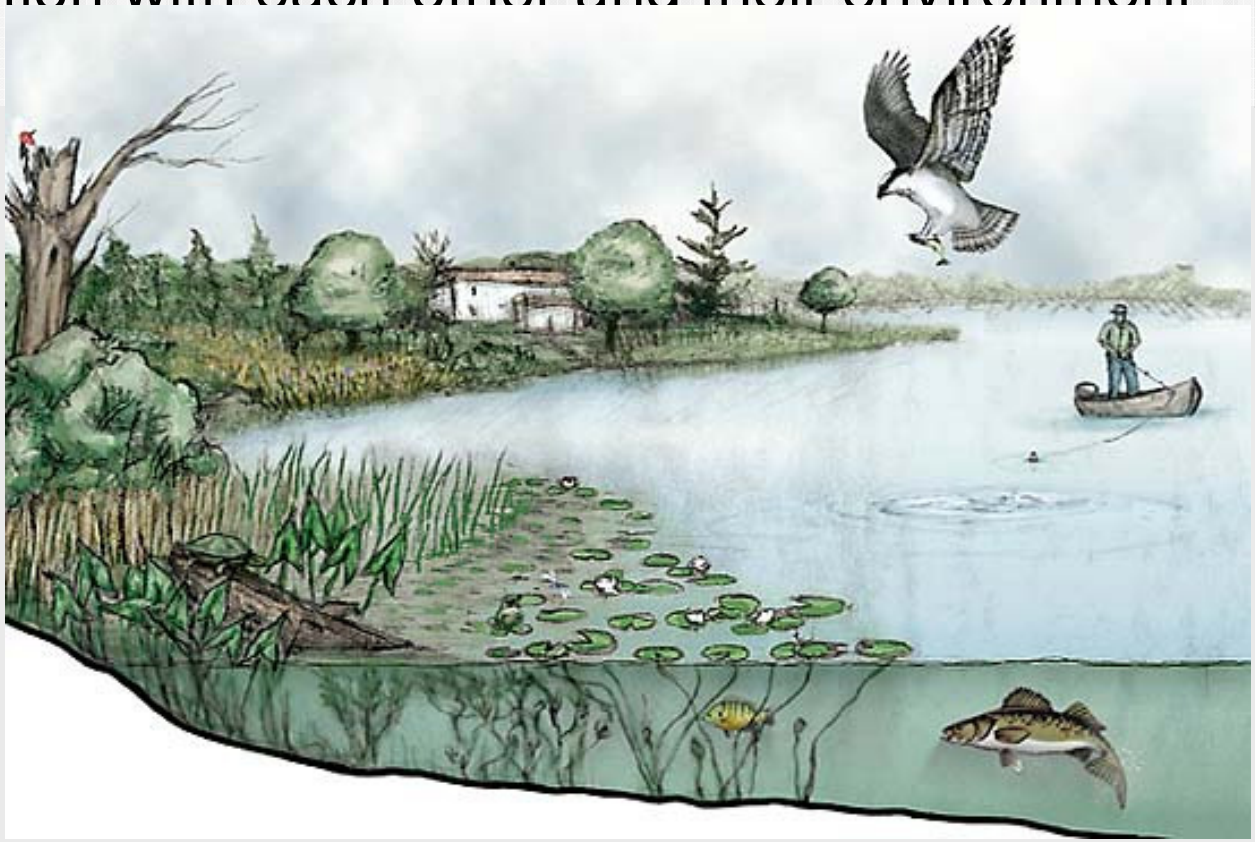


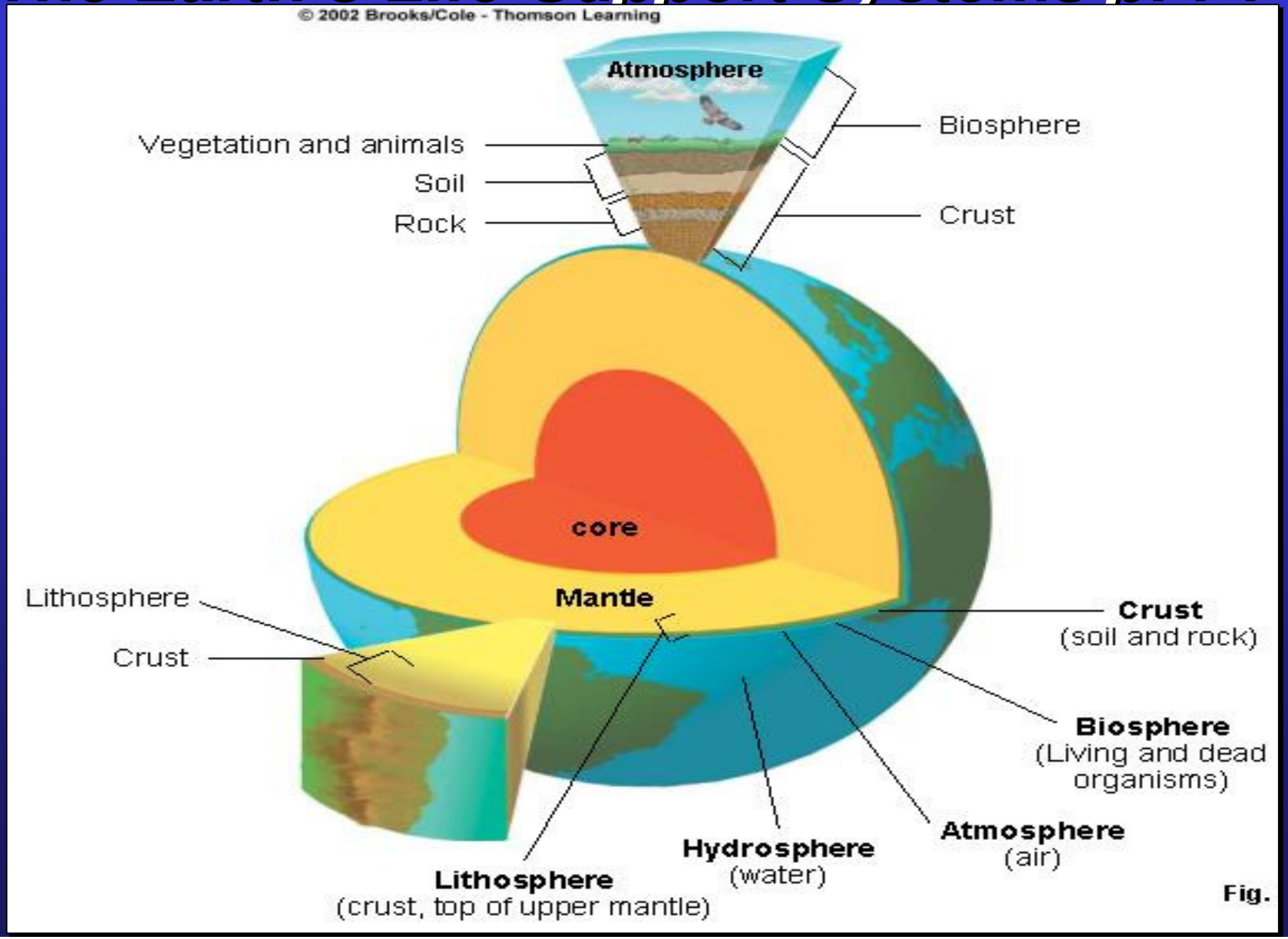
Fig. 4-2 p. 72

Communities, Ecosystems & The Biosphere

- **Habitat**- the place where a population or organism lives
- **Community**- all of the organisms that occupy a specific area; also called biological community
- **Ecosystem**- a community of different species and their interaction with each other and their environment

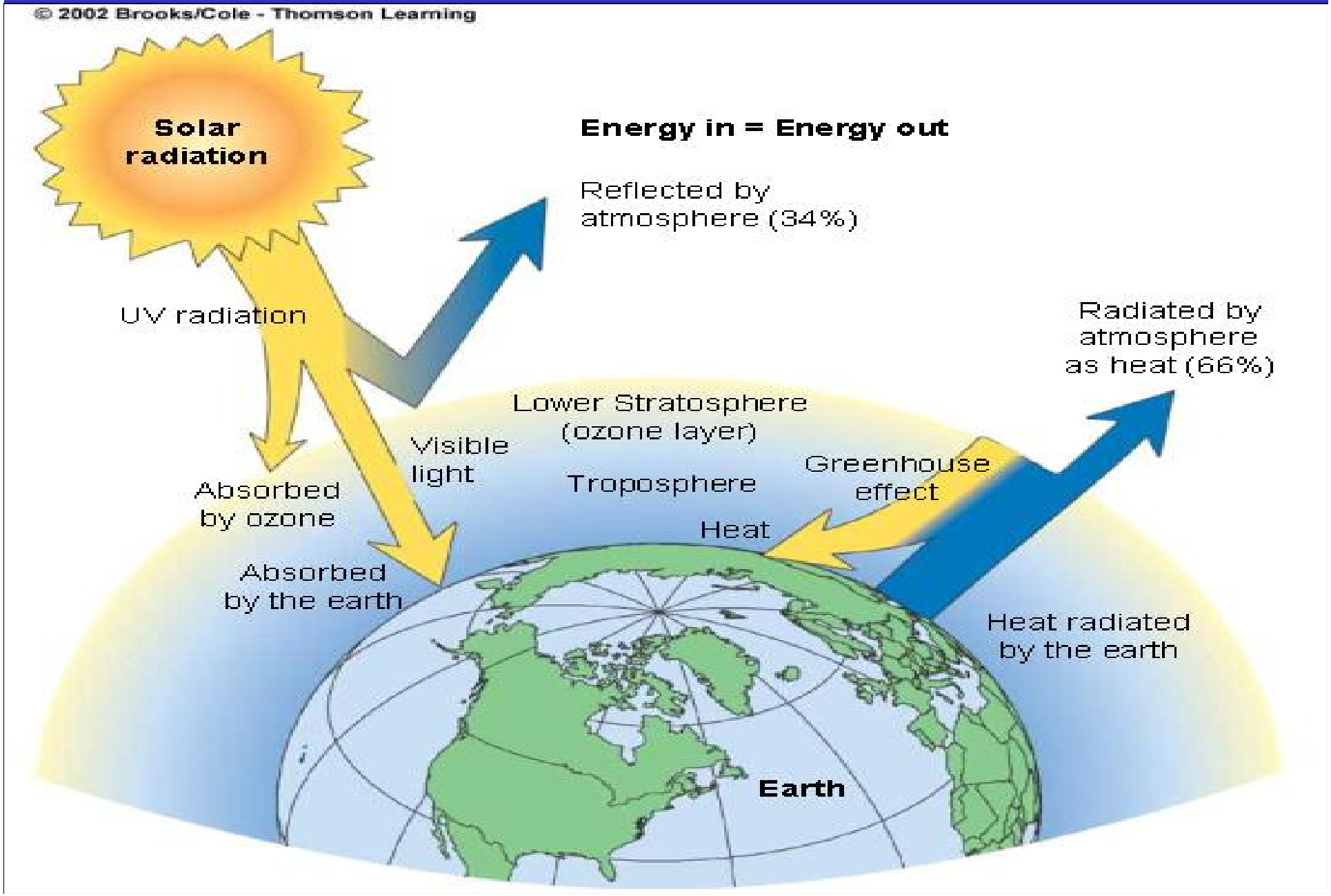


The Earth's Life-Support Systems p. 74

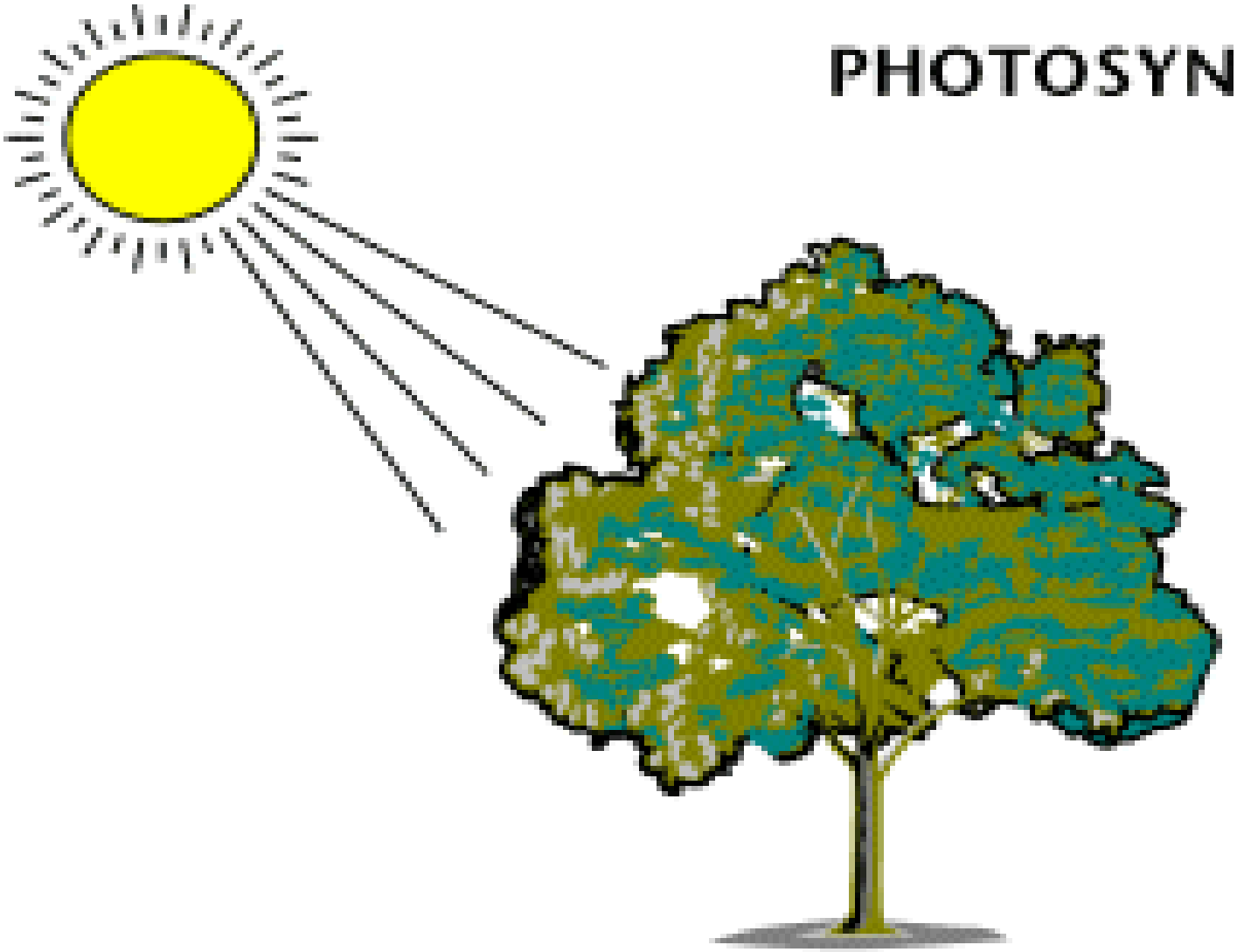


The Source of Energy

Fig. 4-8 p. 75



PHOTOSYNTHESIS



In the process of photosynthesis, plants convert radiant energy from the sun into chemical energy in the form of glucose - or sugar.

water	+	carbon dioxide	+	sunlight	$\longrightarrow$	glucose	+	oxygen
$6\ H_2O$	+	$6\ CO_2$	+	radiant energy	$\longrightarrow$	$C_6H_{12}O_6$	+	$6\ O_2$

Sustaining Life of Earth

- **One-Way Energy Flow**: All energy on earth comes from the sun (as high quality energy)
  - Moves through organisms by feeding interactions
  - Becomes low quality energy and radiates as heat
  - Returns into space as heat
- **Cycling of Matter**: all matter moves via cyclic patterns; all matter on earth is essentially trapped here.

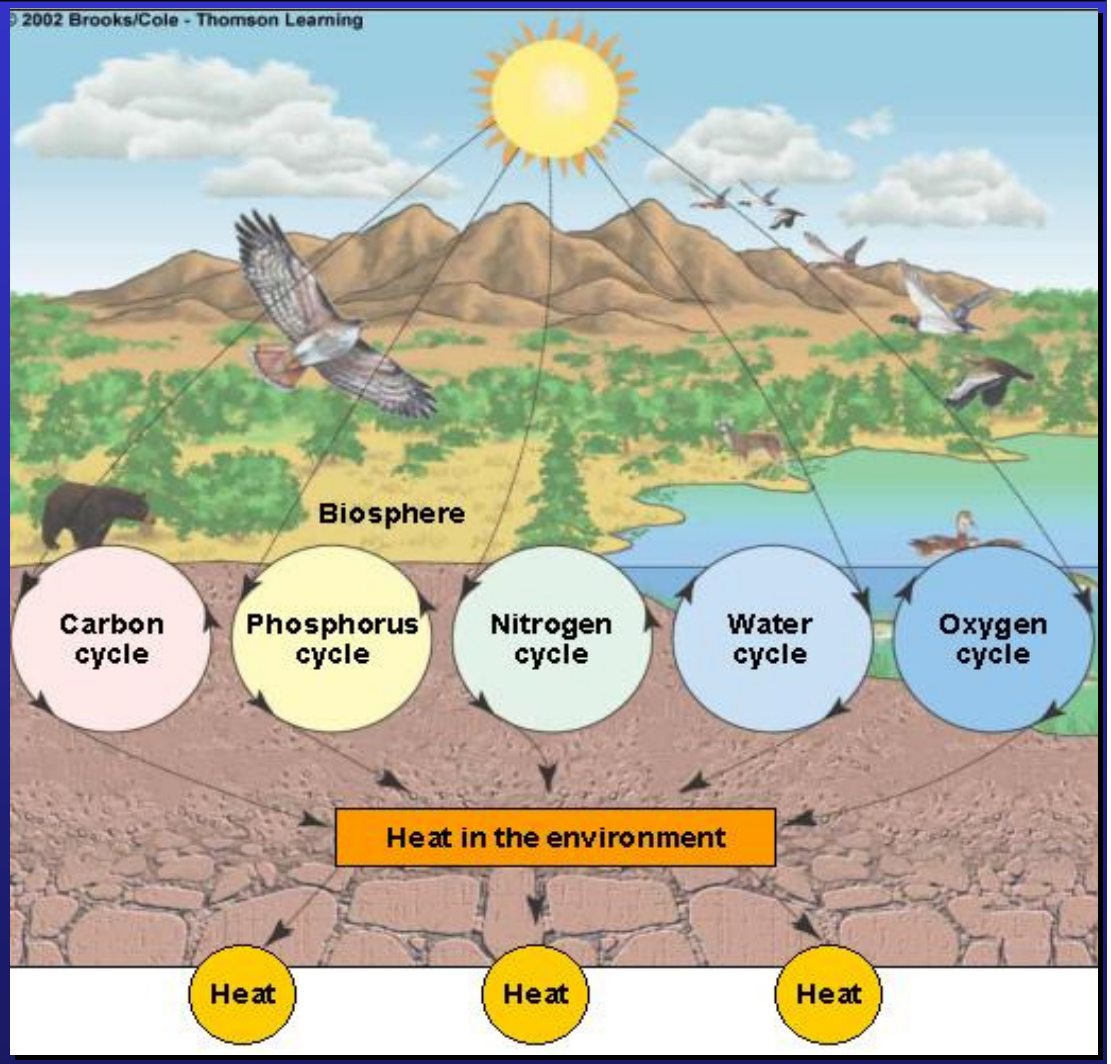


Fig. 4-7 p. 75

Ecosystem Concepts and Components

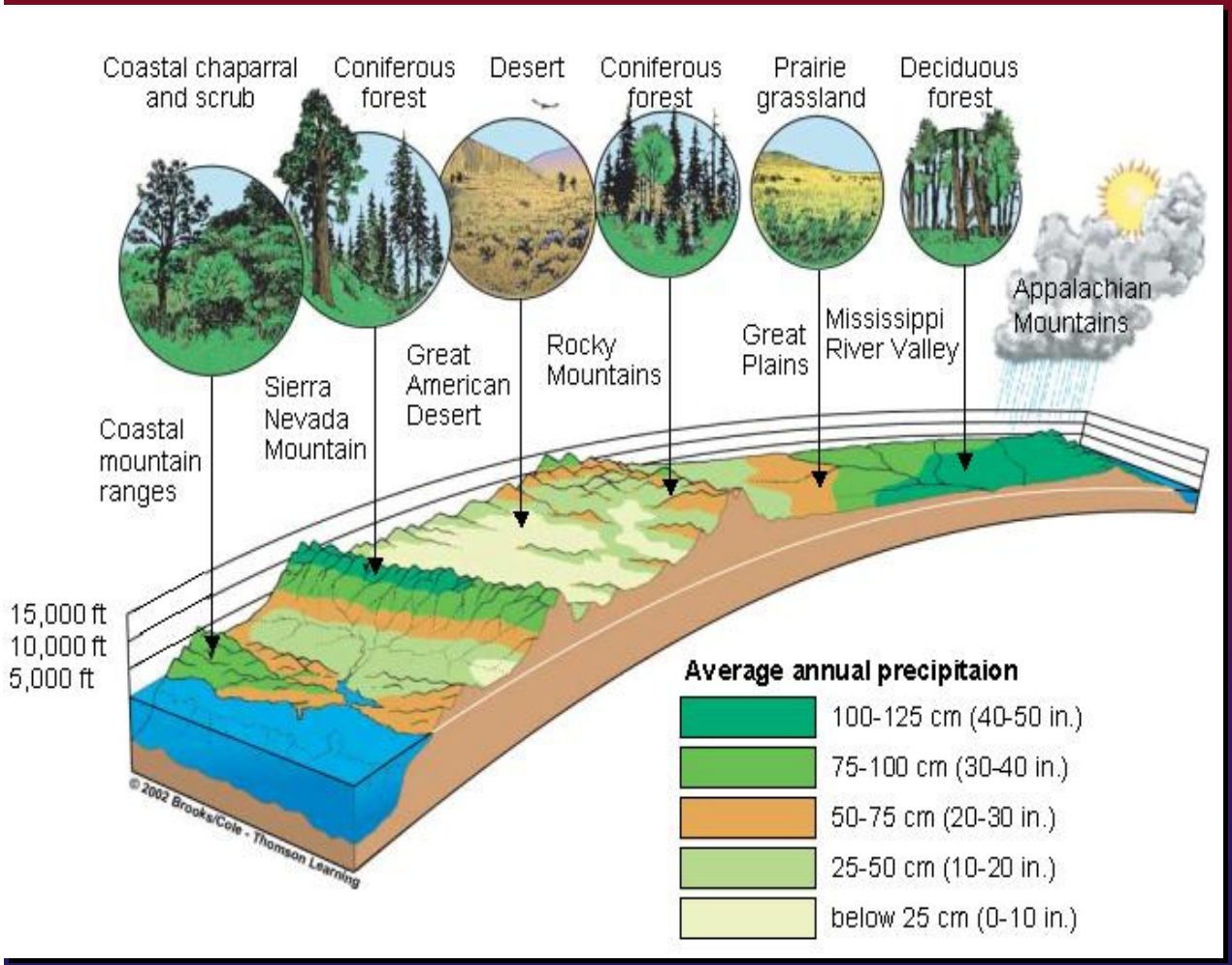
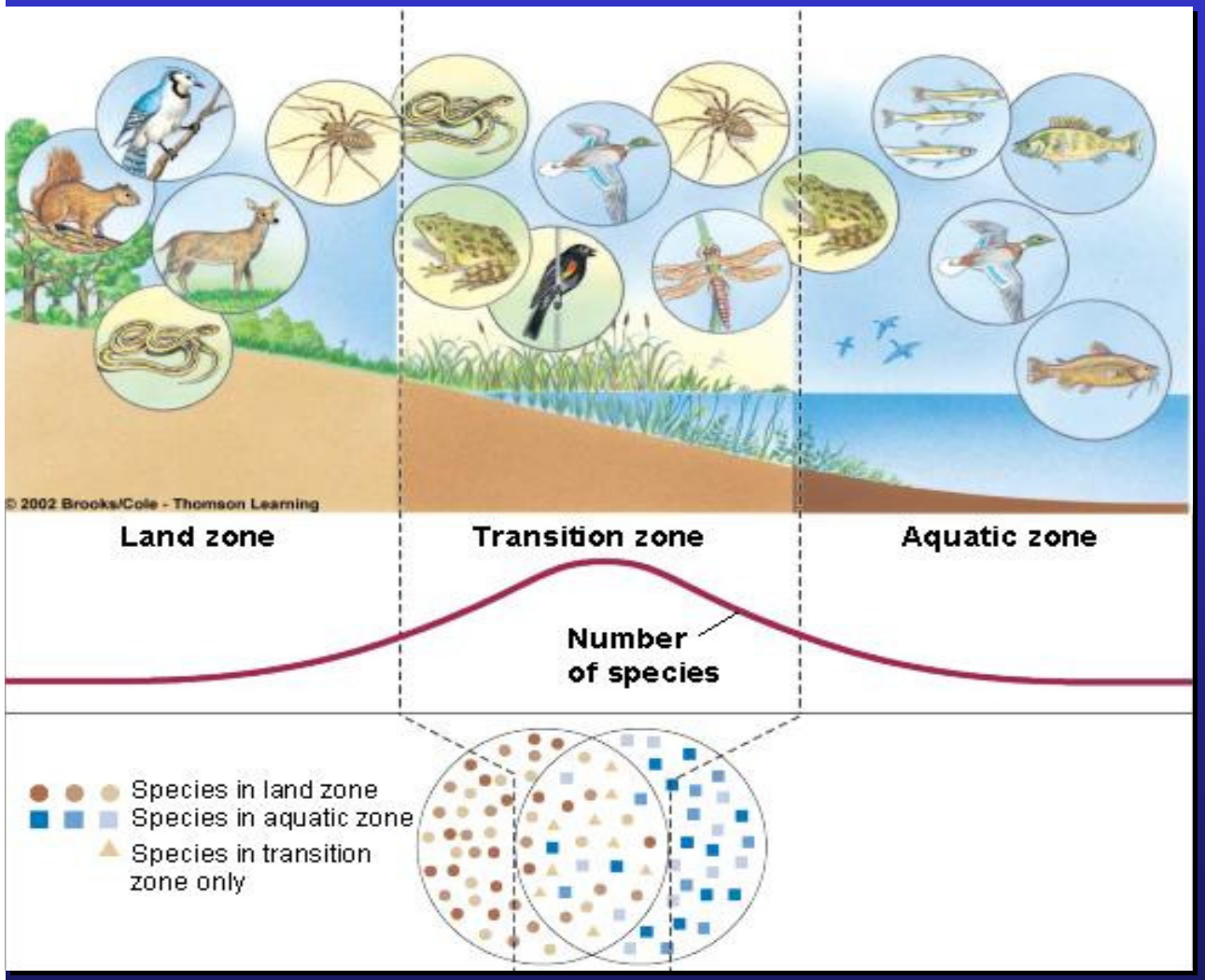


Fig. 4-9 p. 76

- **<u>Biomes</u>**-areas with a consistent climate and with similar organisms
  - ***Climate***- long-term weather patterns in a given area
- **<u>Aquatic life zones</u>**- marine and freshwater portions of the biosphere

Ecosystem Boundaries: Ecotones

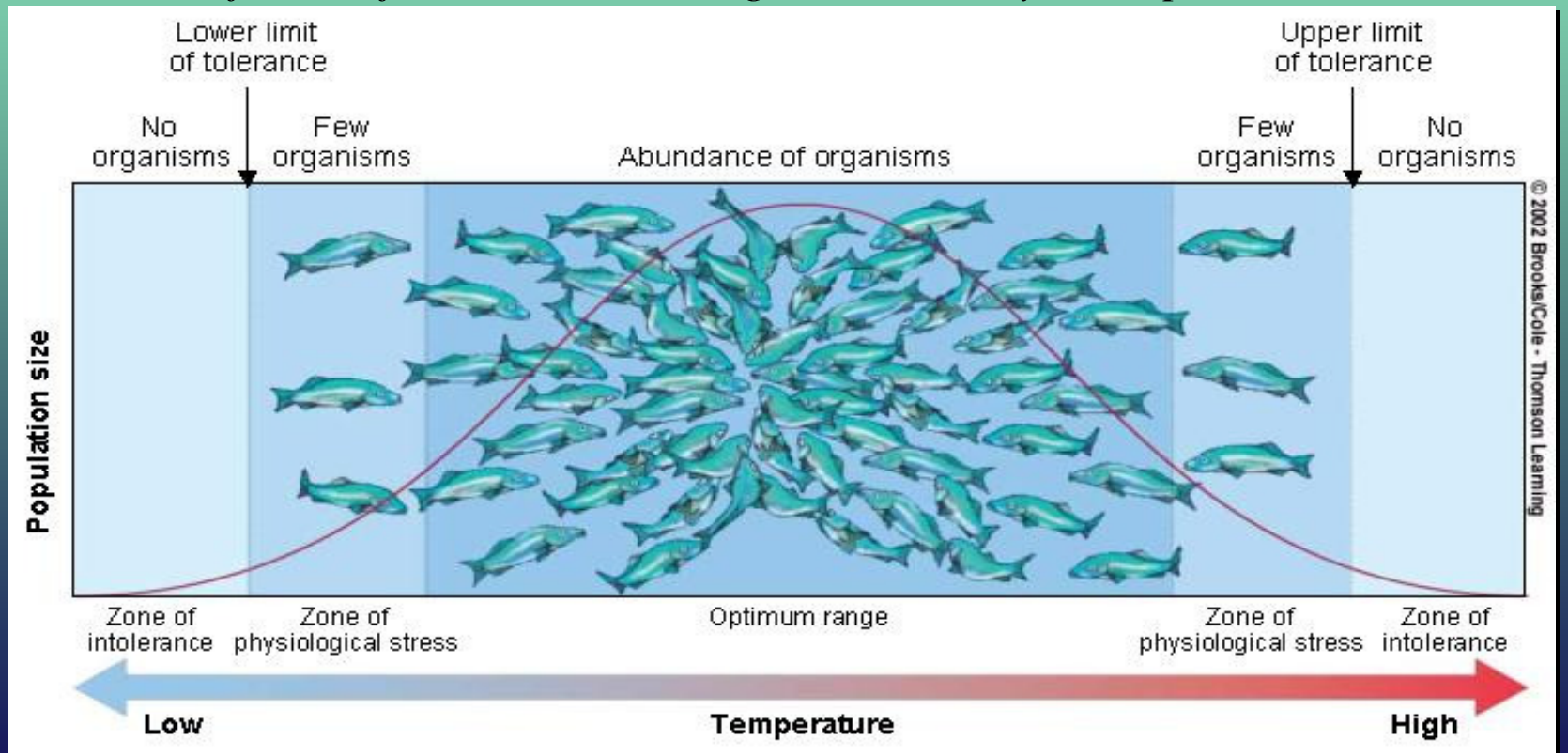


- **Ecotone**- transitional zones between ecosystems where there are a mixture of species not found together in adjacent ecosystems

Fig. 4-10 p. 77

Principles of Ecological Factors p.79

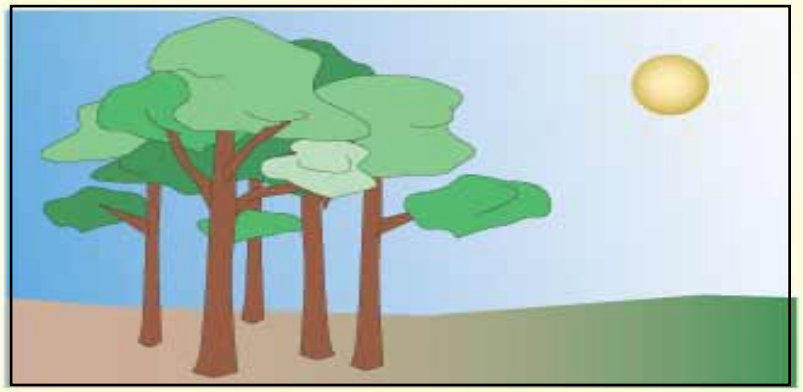
- **Abiotic Factors**- all of the nonliving parts in an ecosystem
- **Biotic Factors**-all of the living factors in an ecosystem
- **Range of Tolerance**- any variation in the physical or chemical environment that an organism can withstand before it is killed/harmed
  - ***Law of tolerance****-the existence, abundance, and distribution of a species in a n ecosystem are determined by whether the levels of one or more physical or chemical factors fall within the range tolerated by that species.*



Regulating Population Growth

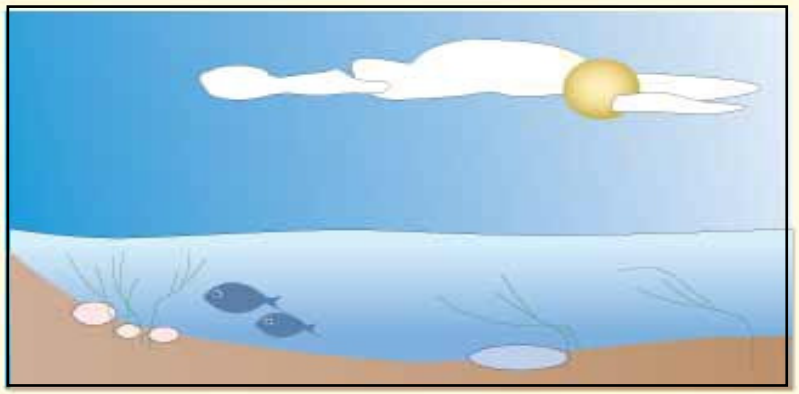
- **Limiting Factors**- a distinguishing chemical or physical factor that regulates the population growth of a species; more specific than any other factor
  - ***Limiting Factor Principle***- *Too much or too little of any abiotic factor can limit or prevent growth of a population, even if all other factors are at or near the optimum range of tolerance.*
- **Niche**- an organisms functional role within an ecosystem; everything that affects the survival and reproduction
  - *Range of tolerance; resources it utilizes (food, space); interaction with other biota and abiotic factors; its role in the food web/matter cycle*

Terrestrial Ecosystems



- Sunlight
- Temperature
- Precipitation
- Wind
- Latitude
- Altitude
- Fire frequency
- Soil

Aquatic Life Zones



- Light penetration
- Water currents
- Dissolved nutrient concentrations (especially N and P)
- Suspended solids
- Salinity

Figure 4-13 Page 79

The Biotic Components of Ecosystems

- Producers (autotrophs)
- Consumers (heterotrophs)
- Decomposers

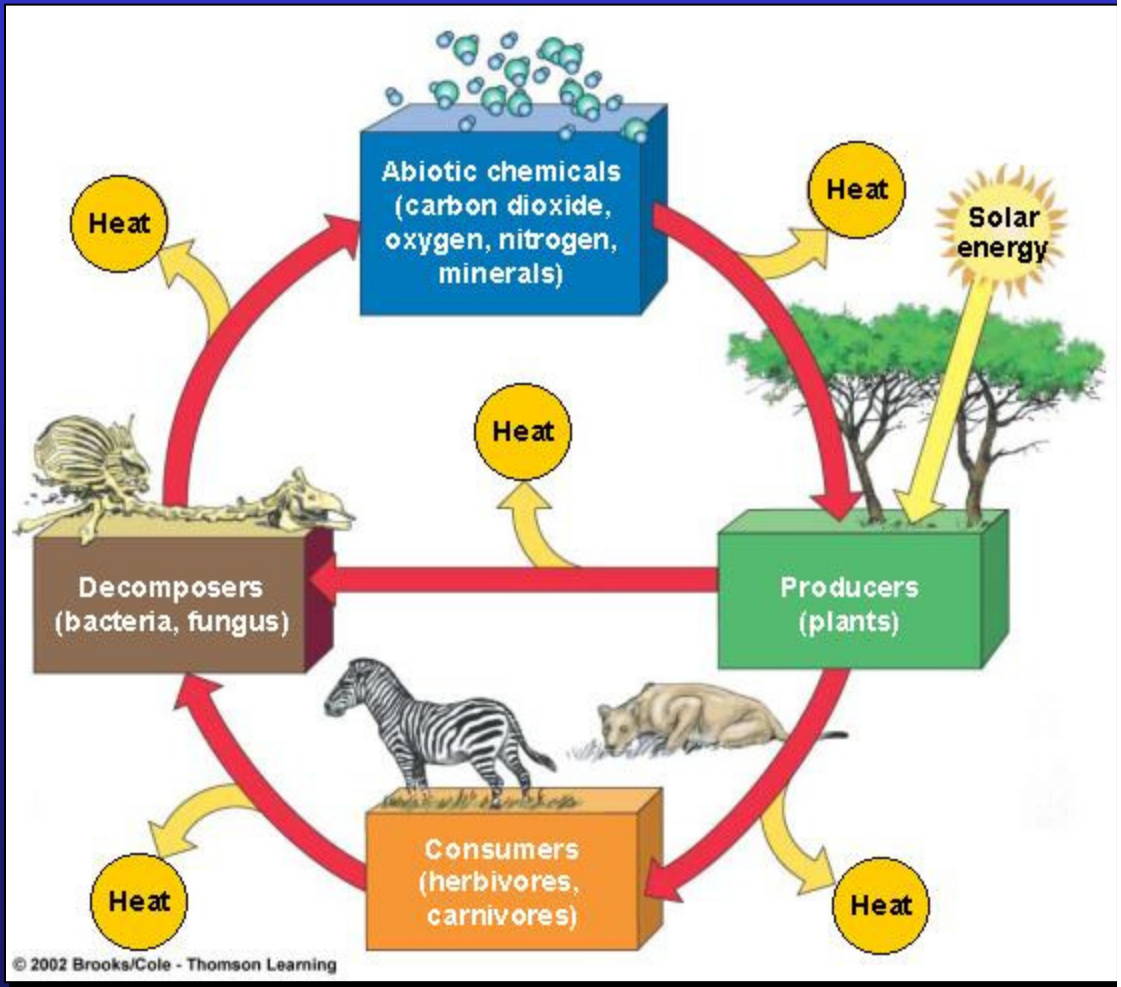


Fig. 4-16 p. 82

Production of Energy

- **<u>Chemosynthesis</u>** (typically bacteria)-The conversion of simple compounds into more complex nutrient compounds without the aide of sunlight
- **<u>Aerobic Respiration</u>**-the use of oxygen to produce energy
  - Glucose + Oxygen --> Carbon Dioxide + Water + Energy
  - $C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O$ + Energy
- **<u>Anaerobic Respiration</u>**- *(a.k.a.* ***fermentation****)* a form of cellular respiration in the absence of oxygen
  - End products: *methane; ethyl alcohol; acetic acid; or hydrogen sulfide*

Biodiversity

- **Species Diversity**- the variety among the species or distinct types of living organisms found in different habitats of the planet
- **Ecological Diversity**- the variety of different biomes around the world; all biological communities
- **Functional Diversity**- biological and chemical processes or functions such as energy flow and matter cycling needed for the survival of species and biological communities

Trophic Levels

- **Primary consumer (herbivore)**
- **Secondary consumer (carnivore)**
- **Tertiary consumer**
- **Omnivore**
- **Detritivores and scavengers**
- **Decomposers**

Connections: Food Webs and Energy Flow in Ecosystems

- Food chains

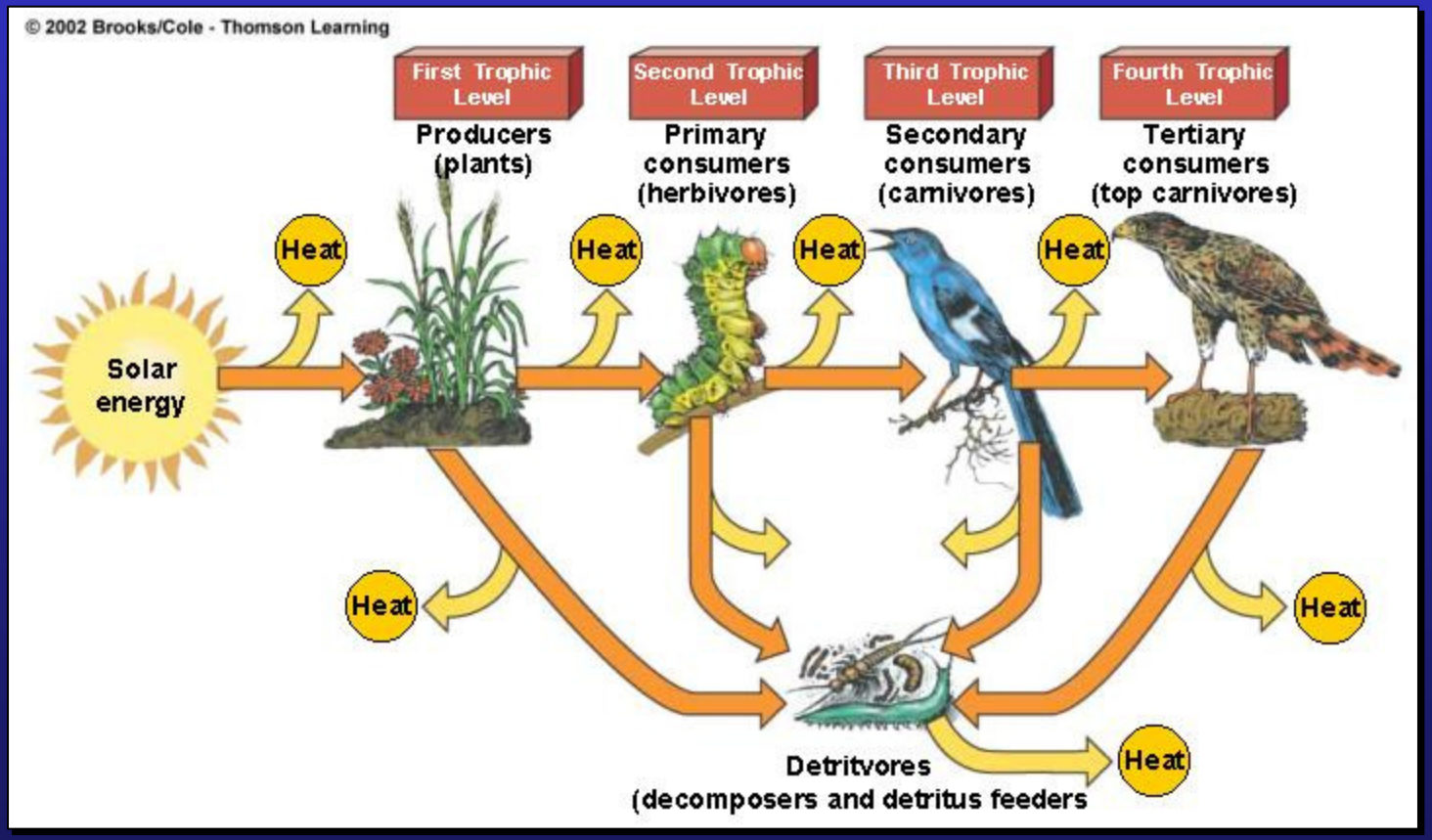
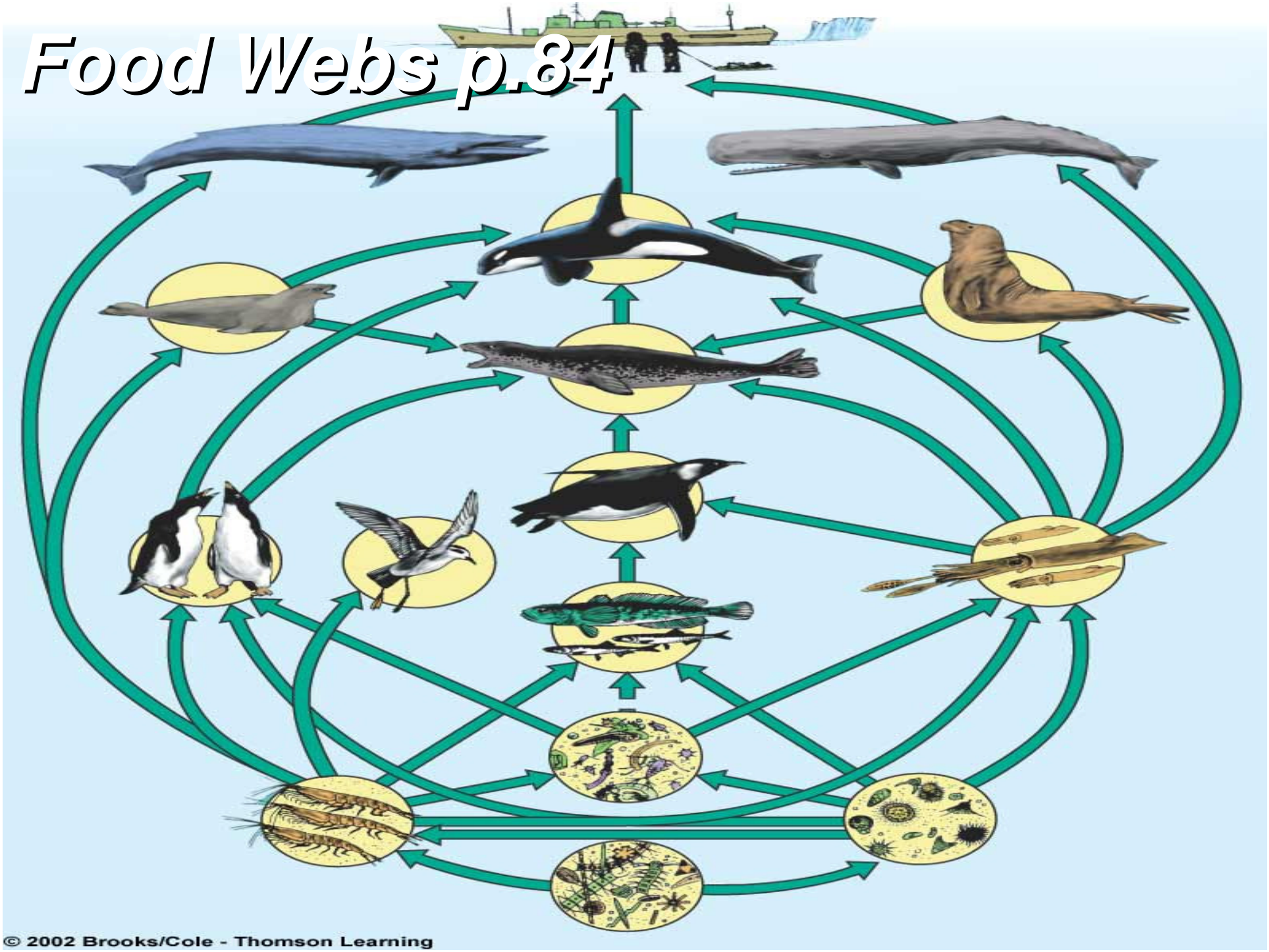


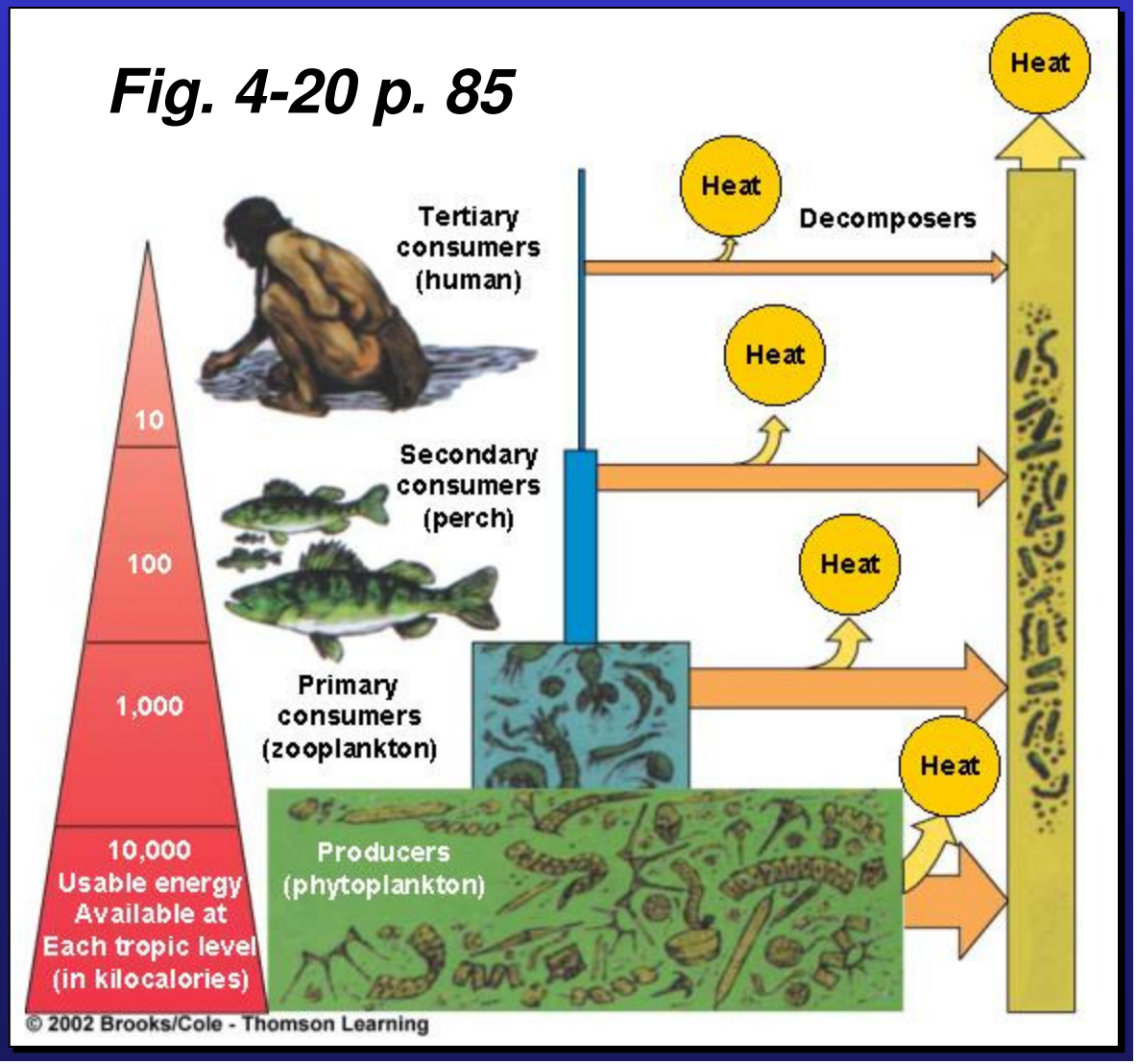
Fig. 4-18 p. 83

Food Webs p.84



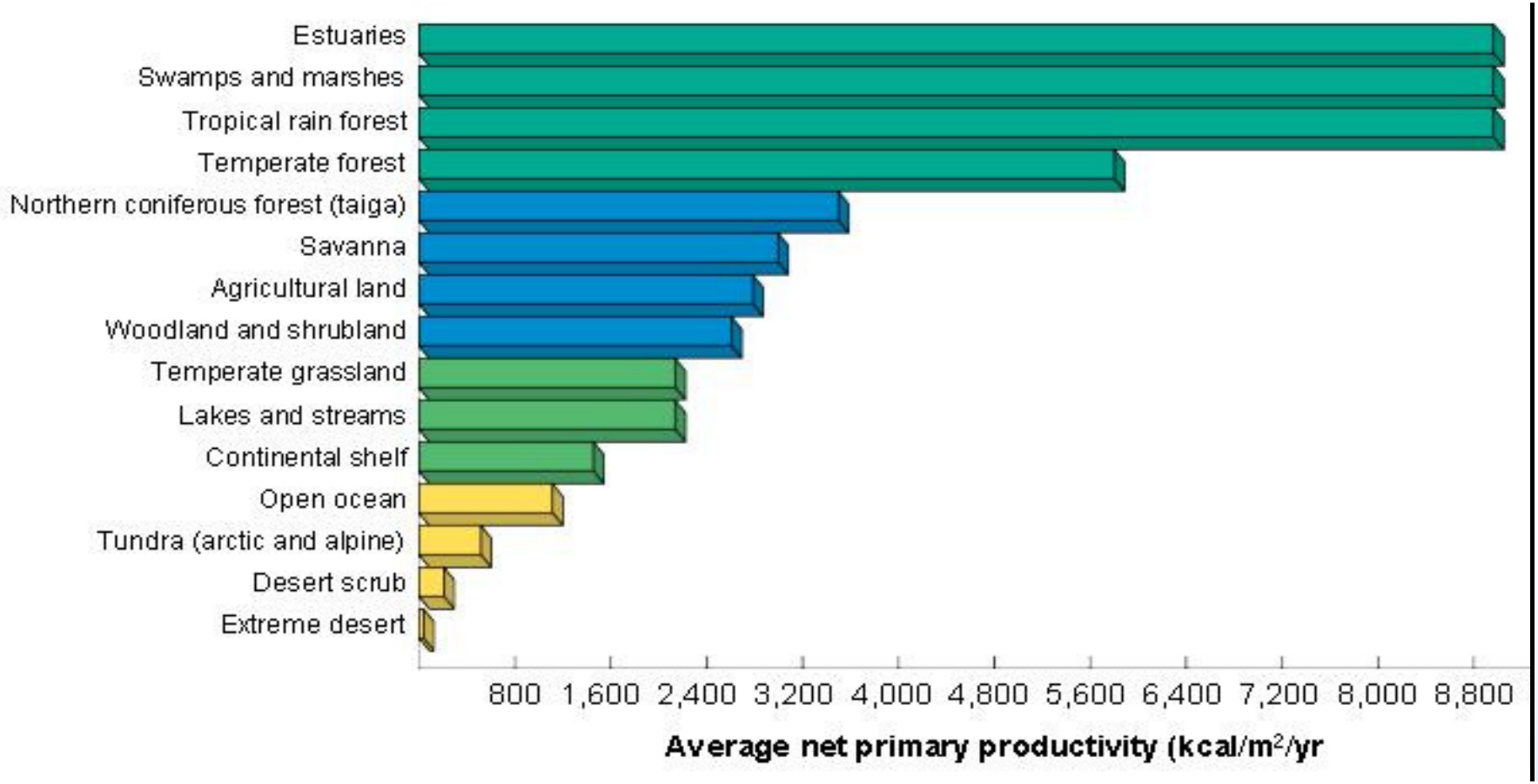
Ecological Pyramids

- Pyramid of energy flow
- Ecological efficiency
- Pyramid of biomass
- Pyramid of numbers



Primary Productivity of Ecosystems p.88

- **<u>Gross Primary Productivity</u>** (GPP)- the rate at which an ecosystem's producers convert sunlight into biomass
- **<u>Net Primary Productivity</u>** (NPP)- the rate at which energy for use by consumers is stored in new biomass



Ecosystem Services and Sustainability

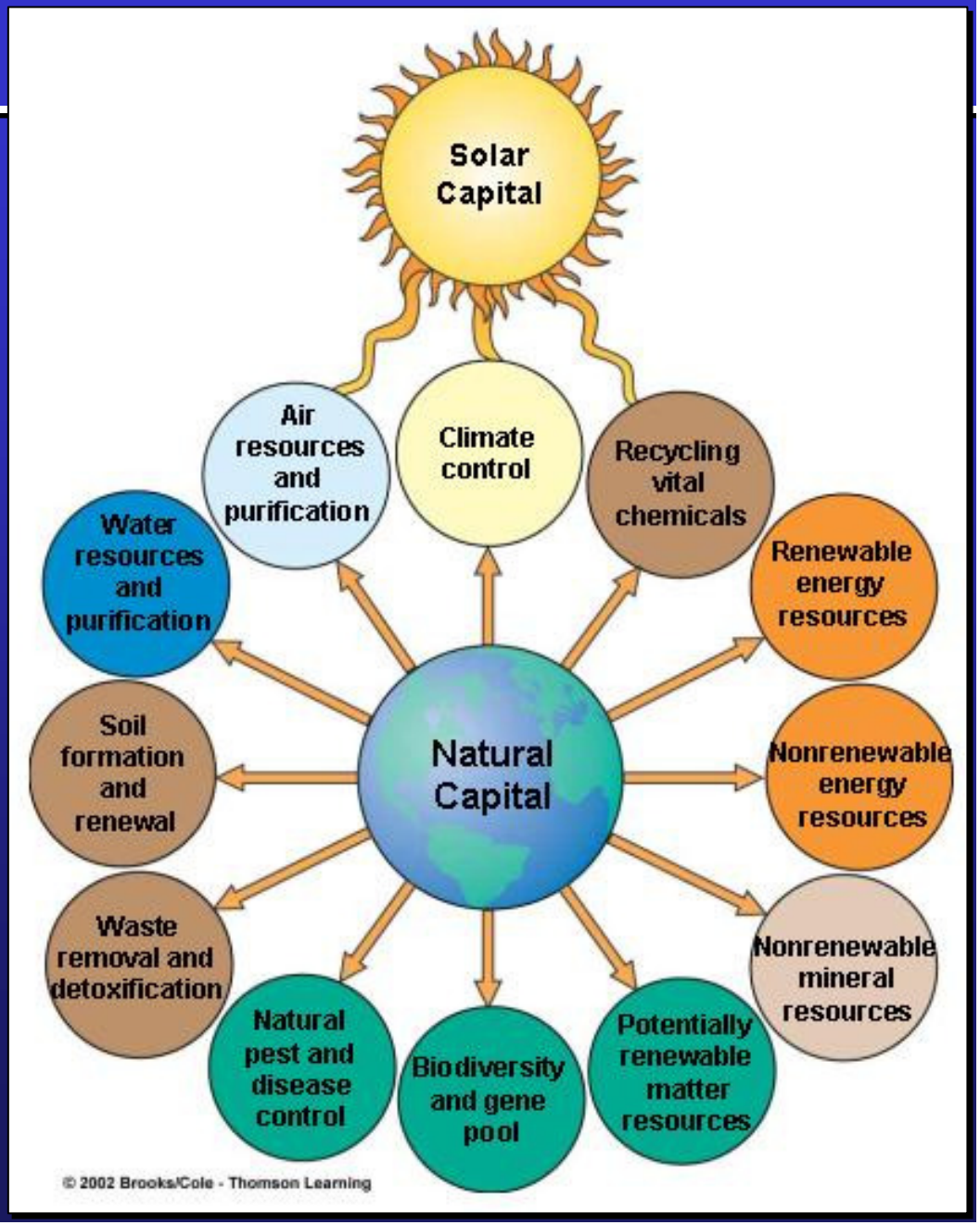


Fig. 4-36 p. 99

Almost all natural ecosystems and the biosphere itself achieve sustainability by:

- Using renewable solar energy as their energy source
- Recycling the chemical nutrients its organisms need for survival, growth, and reproduction

(Two Basic Principles of Ecosystem Sustainability p. 99 and 100)