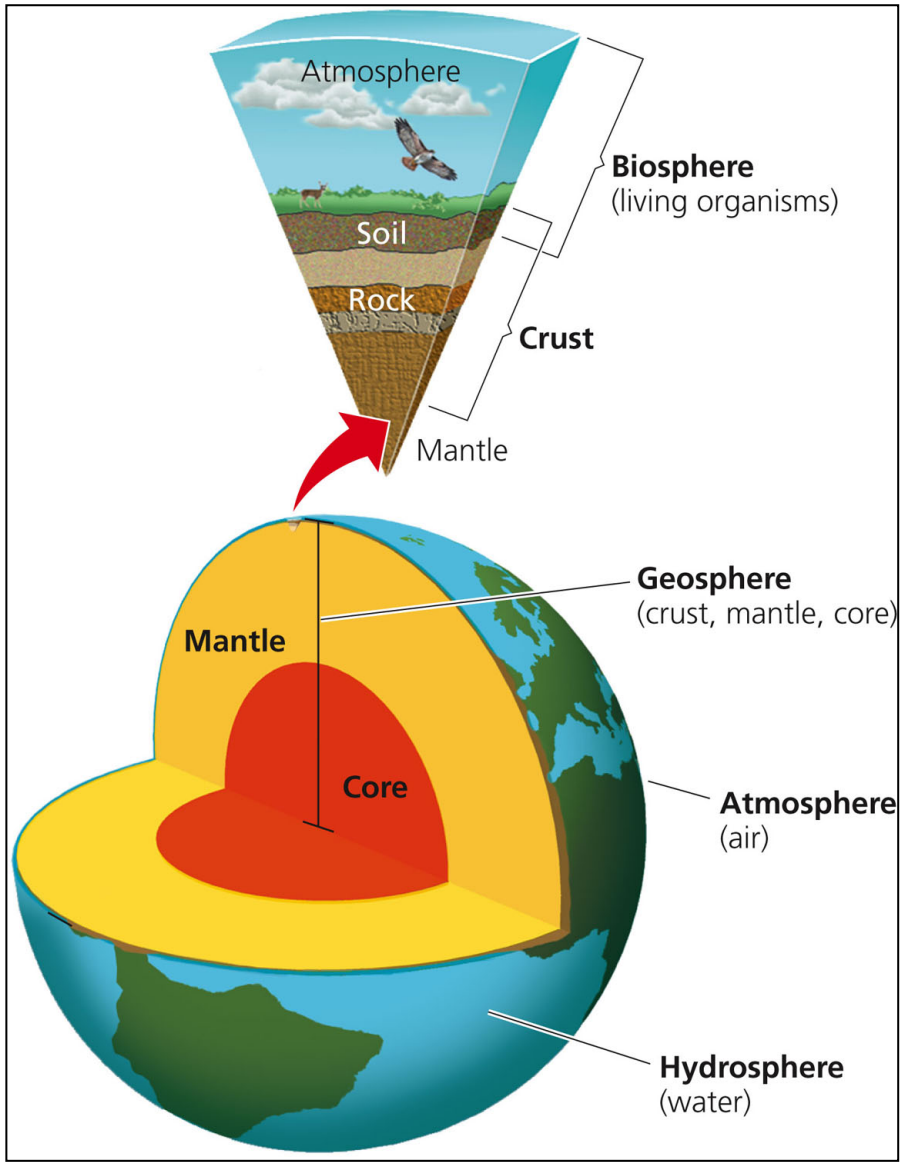
CHAPTER 3

Ecosystems: What Are They and How Do They Work?

The Four Earth Systems

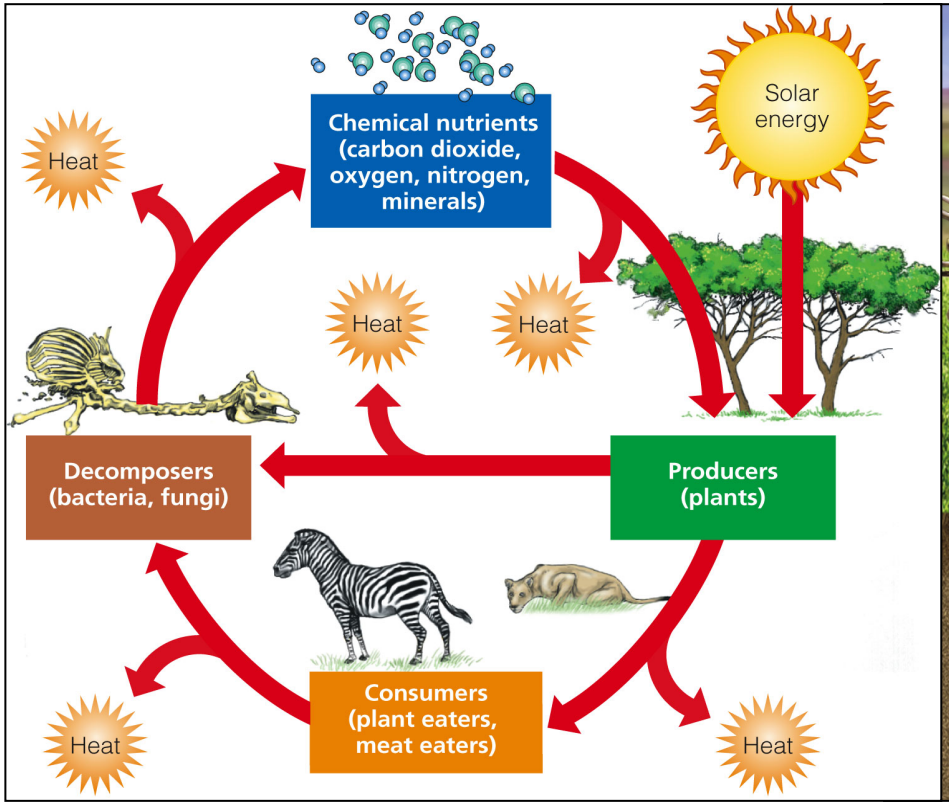
- **Atmosphere**
  - **Troposphere**
    - where weather happens
  - **Stratosphere**
    - contains ozone layer
- **Hydrosphere**
- **Geosphere**
- **Biosphere**

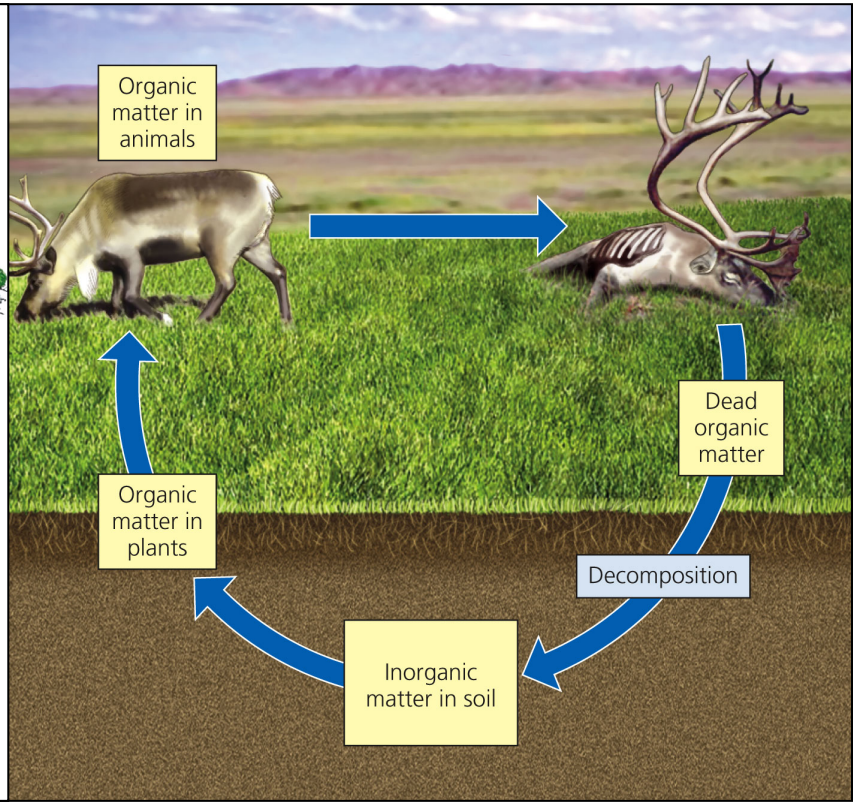


Sun, Earth, Life, and Climate

Factors Sustain Life on Earth

- One-way flow of high-quality energy:
  - Sun → plants → living things → environment as heat → radiation to space
- Cycling of nutrients through parts of the biosphere

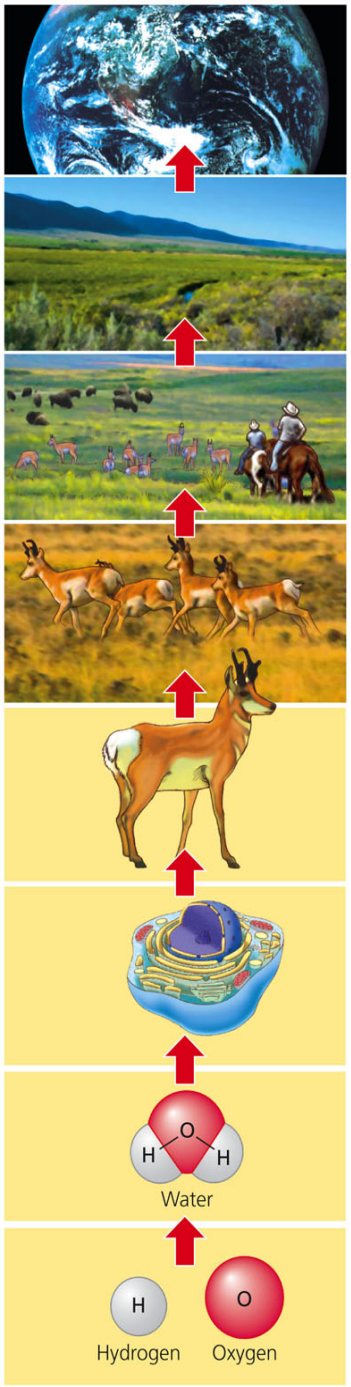




Ecologists Study Interactions in Nature

Ecology: how organisms interact with each other and their nonliving environment.

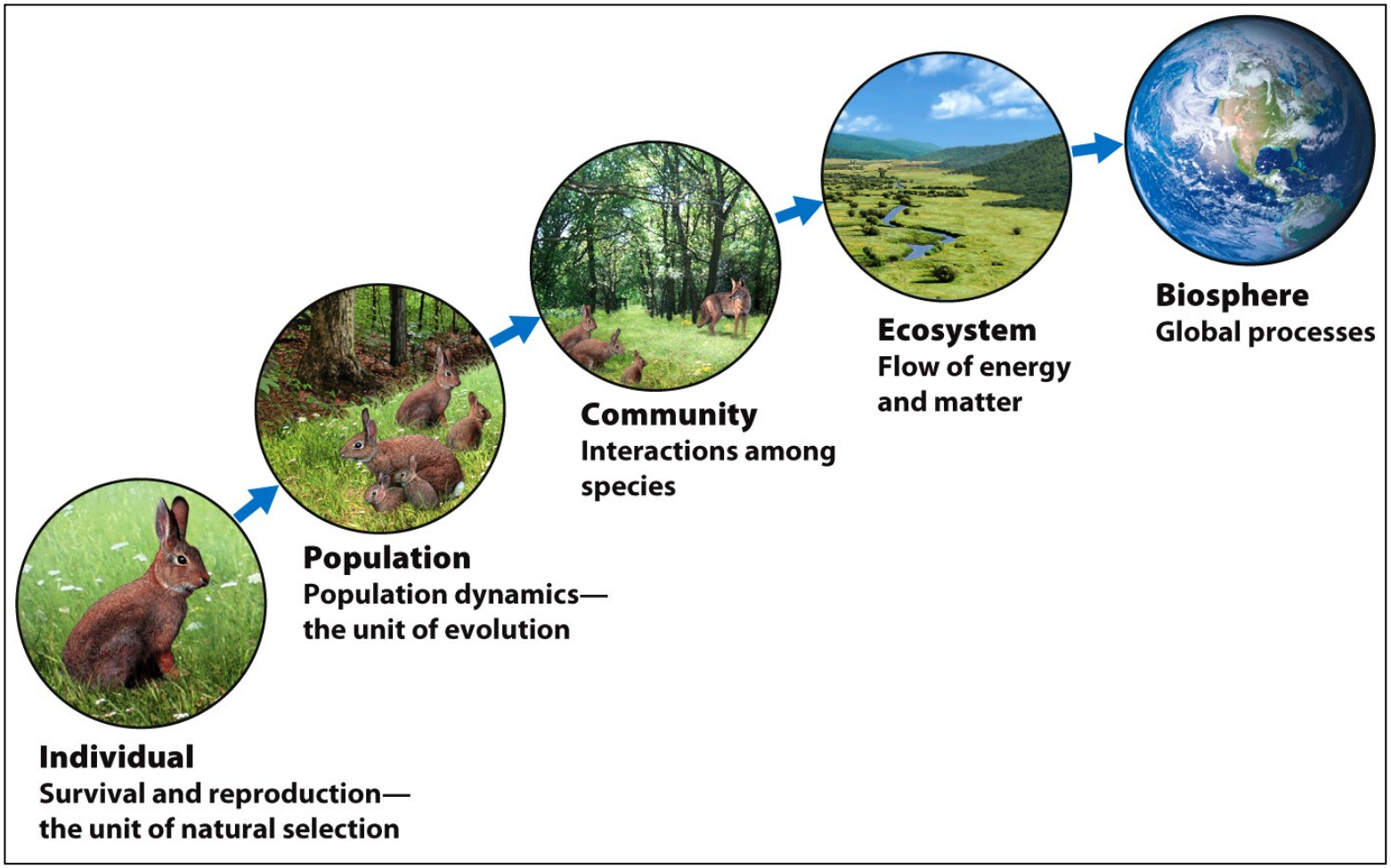
- Organisms
- Populations
- Communities
- Ecosystems
- Biosphere



Biosphere	**Parts of the earth's air, water, and soil where life is found**
Ecosystem	**A community of different species interacting with one another and with their nonliving environment of matter and energy**
Community	**Populations of different species living in a particular place, and potentially interacting with each other**
Population	**A group of individuals of the same species living in a particular place**
Organism	**An individual living being**
Cell	**The fundamental structural and functional unit of life**
Molecule	**Chemical combination of two or more atoms of the same or different elements**
Atom	**Smallest unit of a chemical element that exhibits its chemical properties**

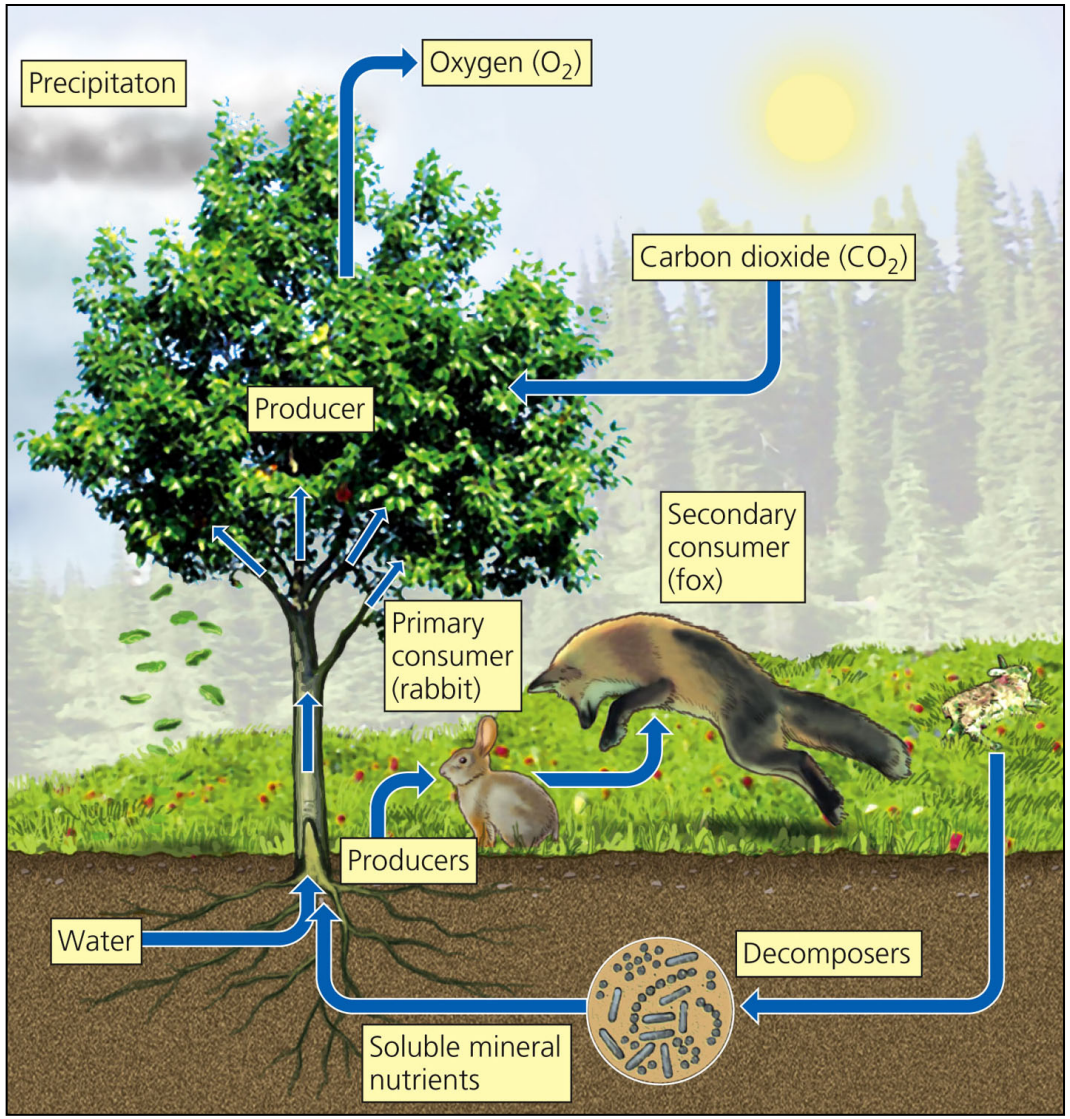
Levels of Organization

Organism→Species→Population→Community→Ecosystem→Biosphere



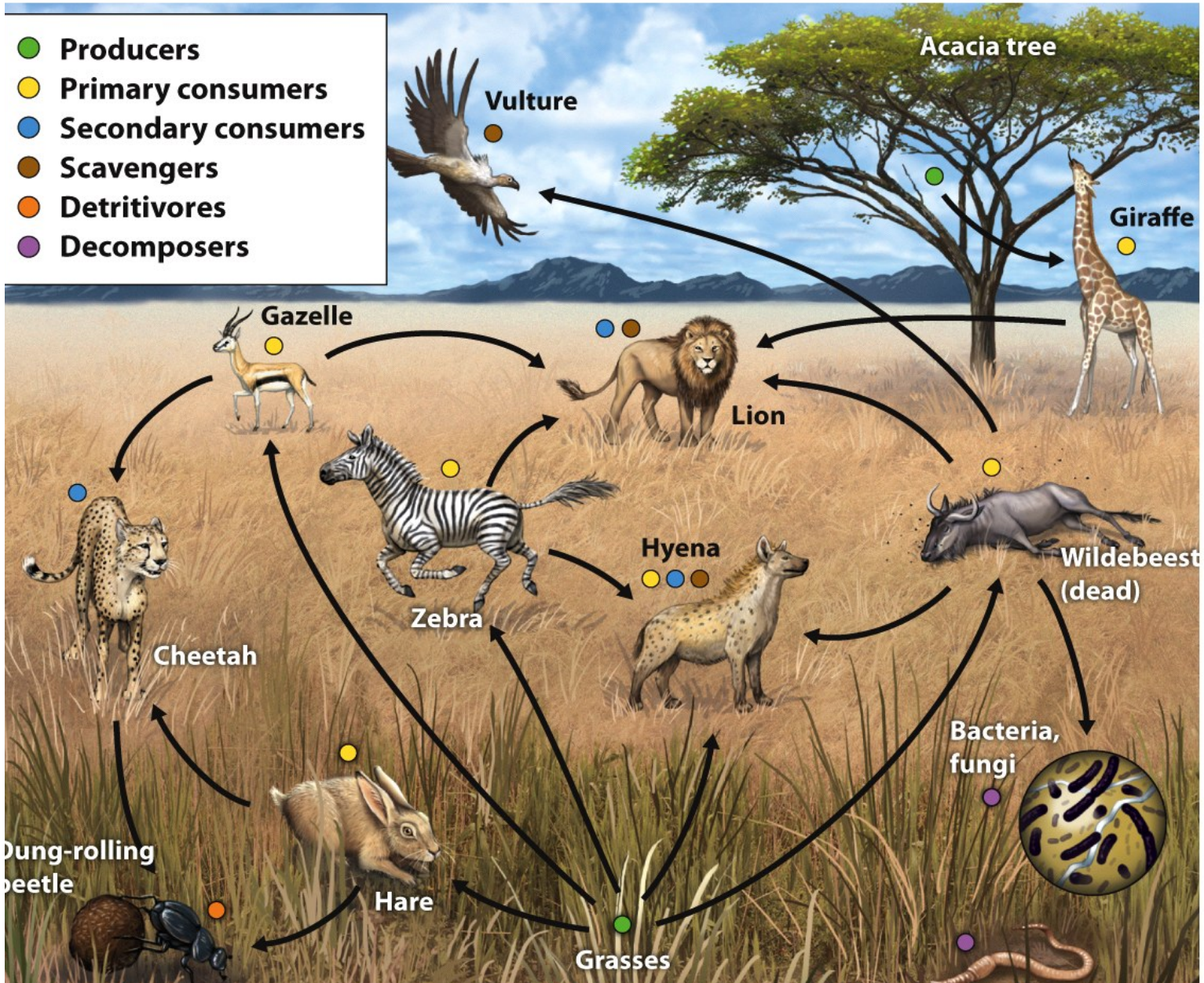
Ecosystems Have Living & Nonliving Components

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



Major Biotic and Abiotic Components of an Ecosystem

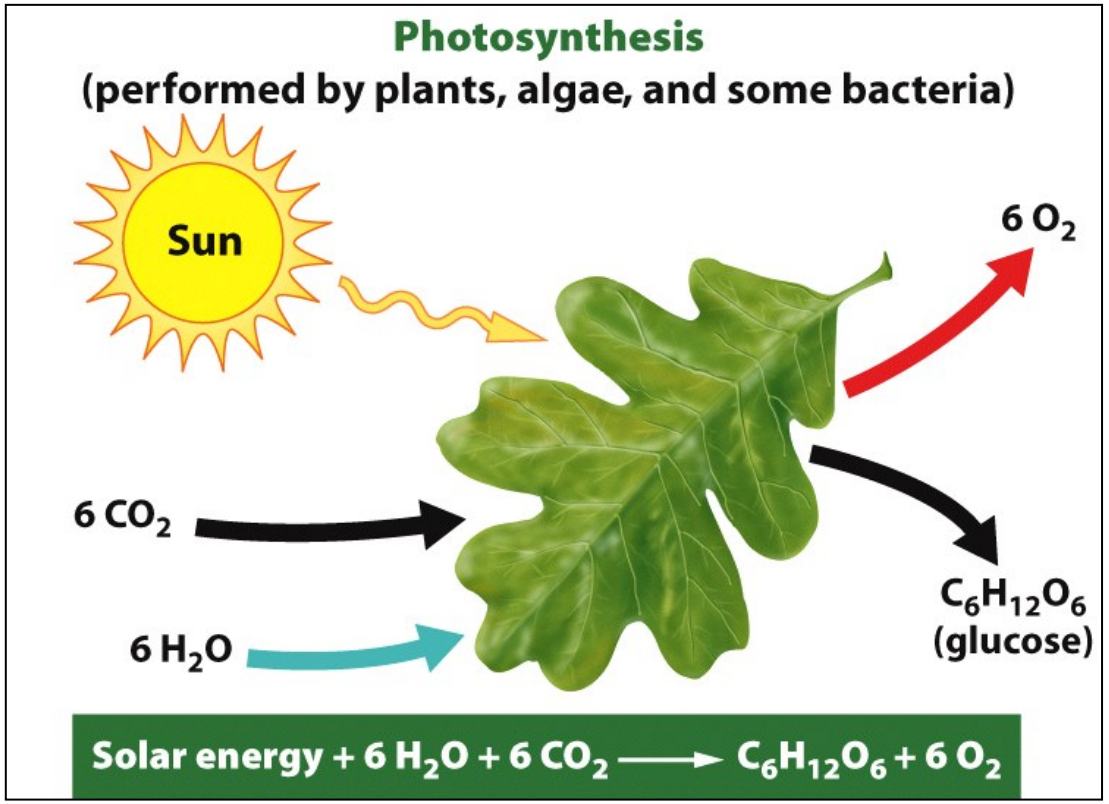
Producers & Consumers: The Living Components of Ecosystems



Producers & Consumers: The Living Components of Ecosystems

Producers, autotrophs

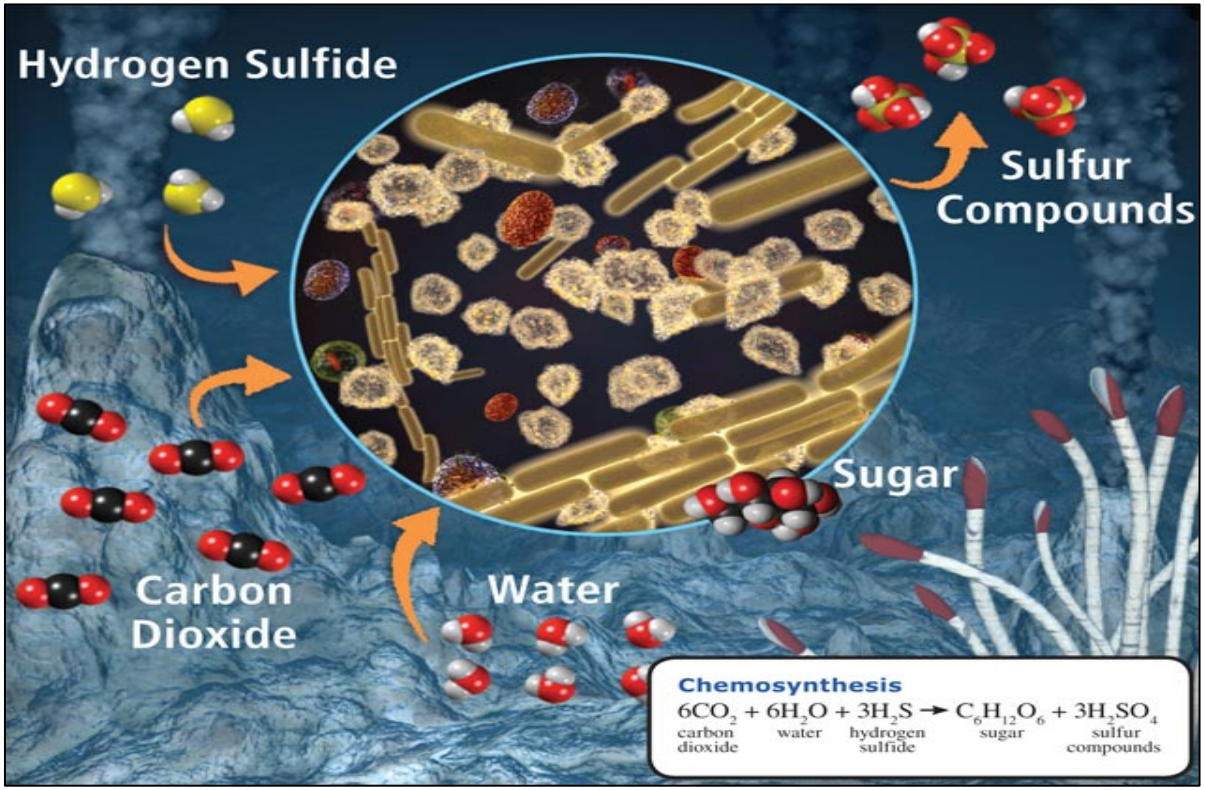
- **Photosynthesis**: $CO_2 + H_2O$ + sunlight → glucose + oxygen



Producers & Consumers: The Living Components of Ecosystems

Producers, autotrophs

- **Chemosynthesis:** chemosynthetic microbes grow on and below the seafloor and even within other animals at the vents
  - The microbes break down sulfide compounds (H_2S)



Producers & Consumers: The Living Components of Ecosystems

- Consumers, heterotrophs
  - Primary consumers = herbivores
  - Secondary consumers
  - Tertiary consumers
  - Carnivores, Omnivores

Producers & Consumers: The Living Components of Ecosystems

Aerobic respiration

- Using oxygen to turn glucose back to carbon dioxide and water

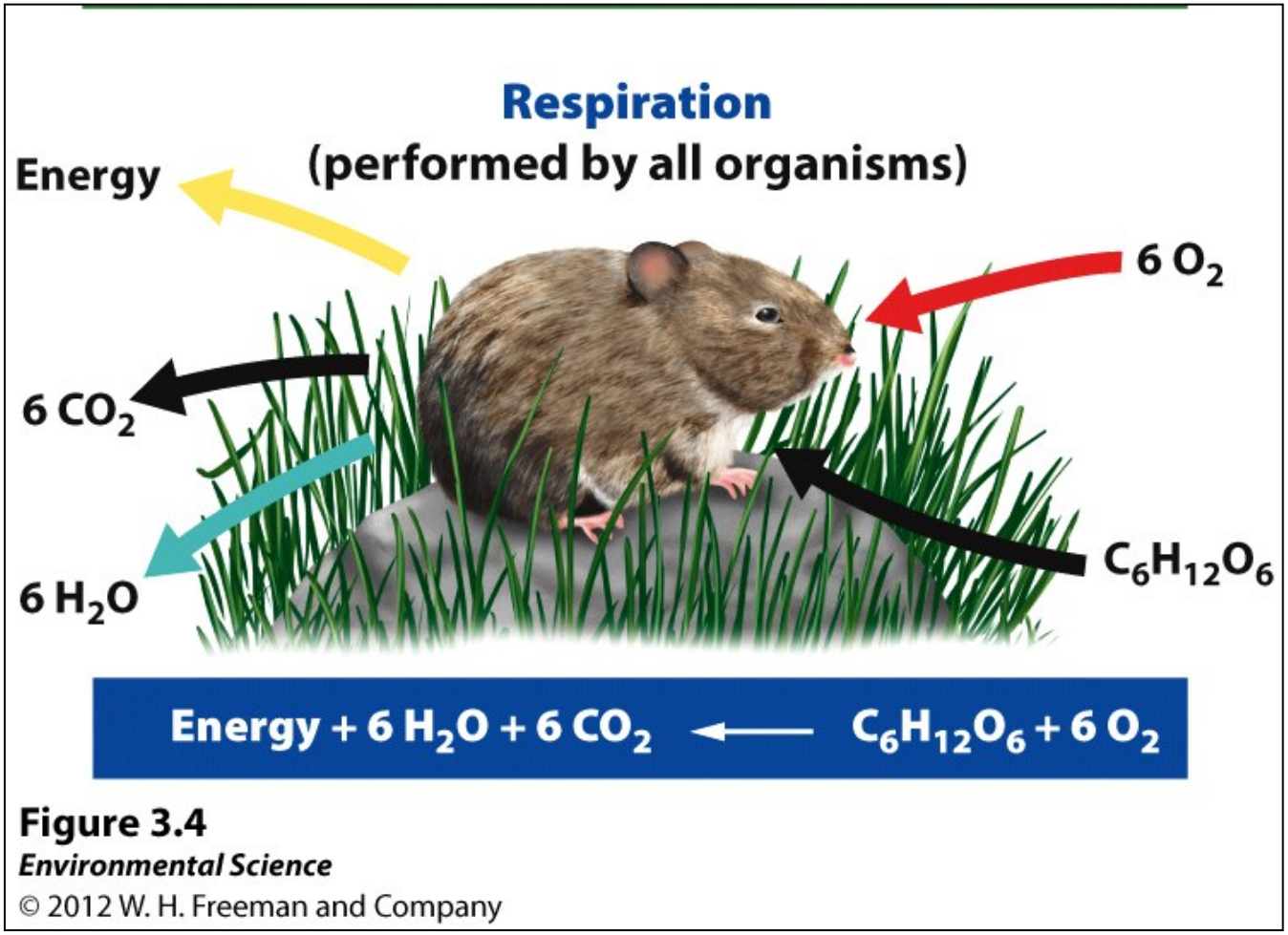
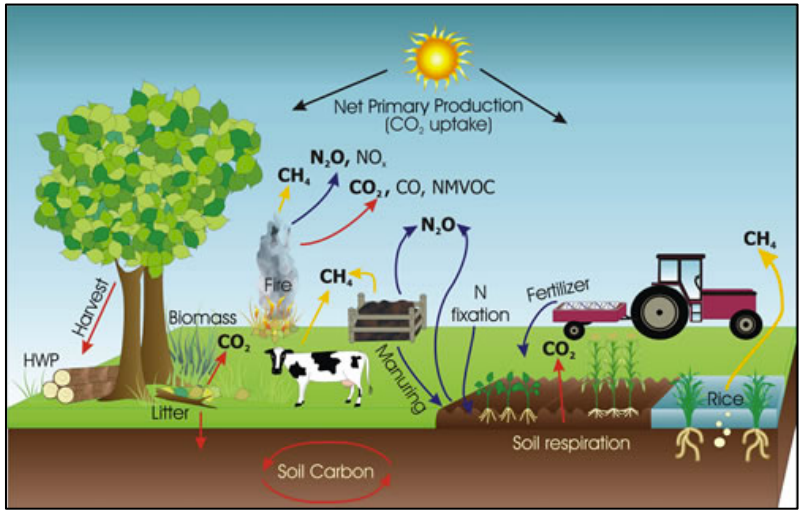
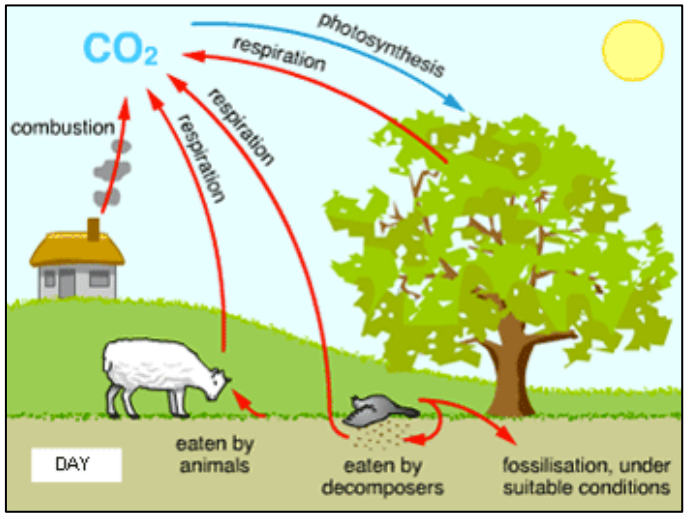


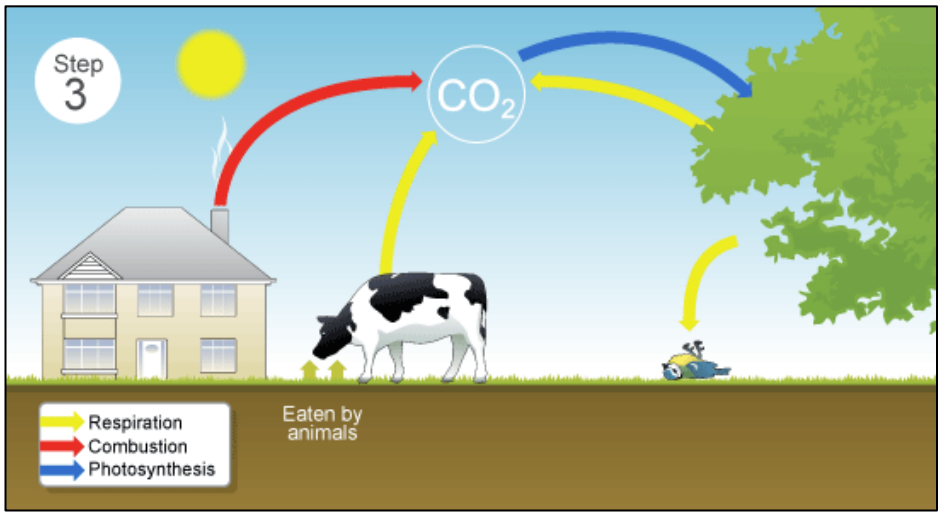
Figure 3.4
Environmental Science

Producers & Consumers: The Living Components of Ecosystems

Aerobic decomposition is the most common decomposition process in nature. Aerobic microorganisms, such as bacteria & fungus, utilize considerable amounts of oxygen in decomposing organic matter.



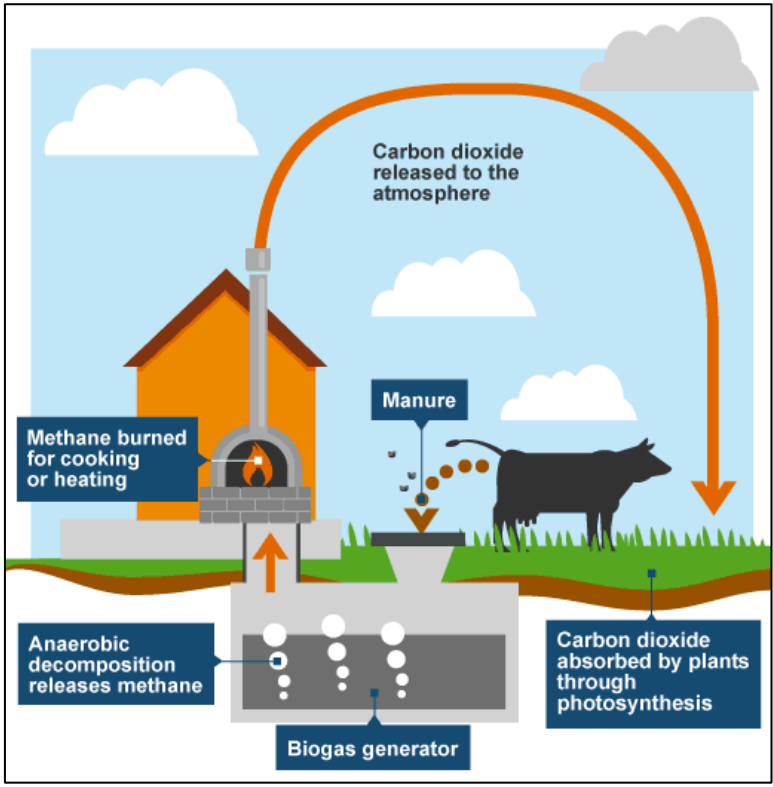




Producers & Consumers: The Living Components of Ecosystems

Anaerobic respiration: fermentation and decomposition

- Breakdown of glucose/cellulose in absence of oxygen often by bacteria and fungus.
- Products are **methane** (CH_4), **ethyl alcohol** (C_2H_6O) & **acetic acid** ($C_2H_4O_2$)



Producers & Consumers: The Living Components of Ecosystems

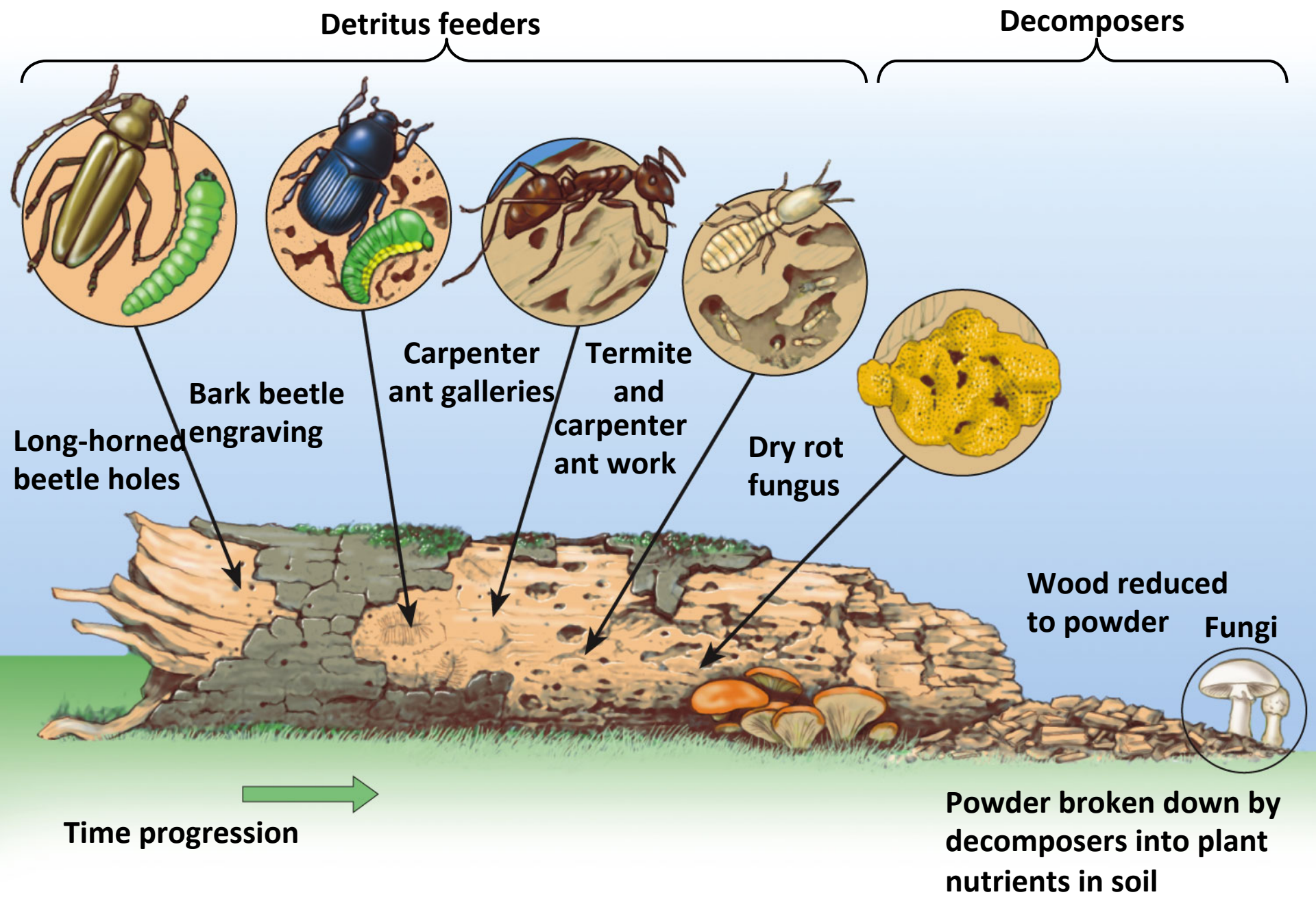
Decomposers

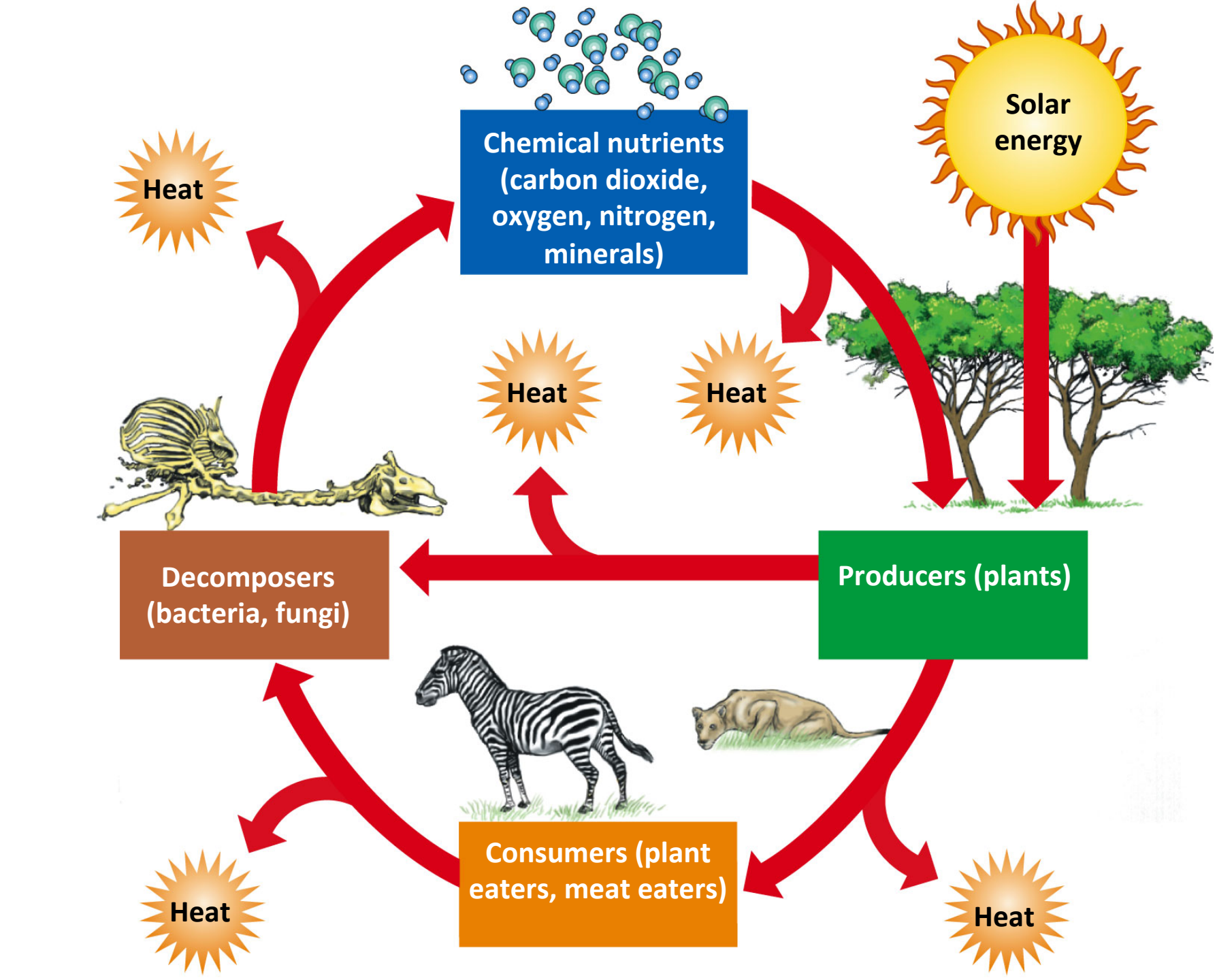
- Consumers that release nutrients
- Bacteria
- Fungi

Detritivores

- Feed on dead bodies of other organisms
- Earthworms
- Vultures

Detritivores & Decomposers

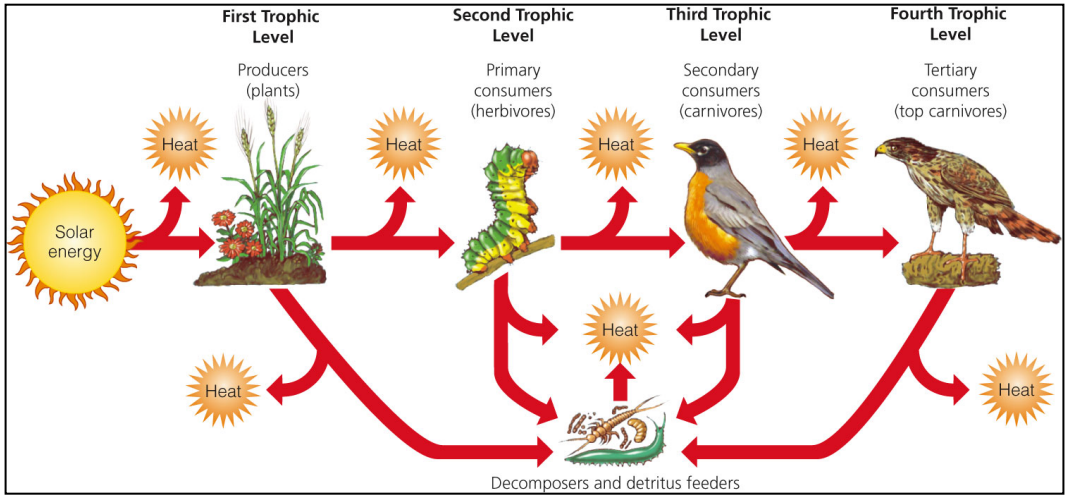



Chemical nutrients (carbon dioxide, oxygen, nitrogen, minerals)
Solar energy
Heat
Heat
Heat
Heat
Decomposers (bacteria, fungi)
Producers (plants)
Consumers (plant eaters, meat eaters)
Heat
Heat

Energy Flows Through Ecosystems in Food Chains and Food Webs

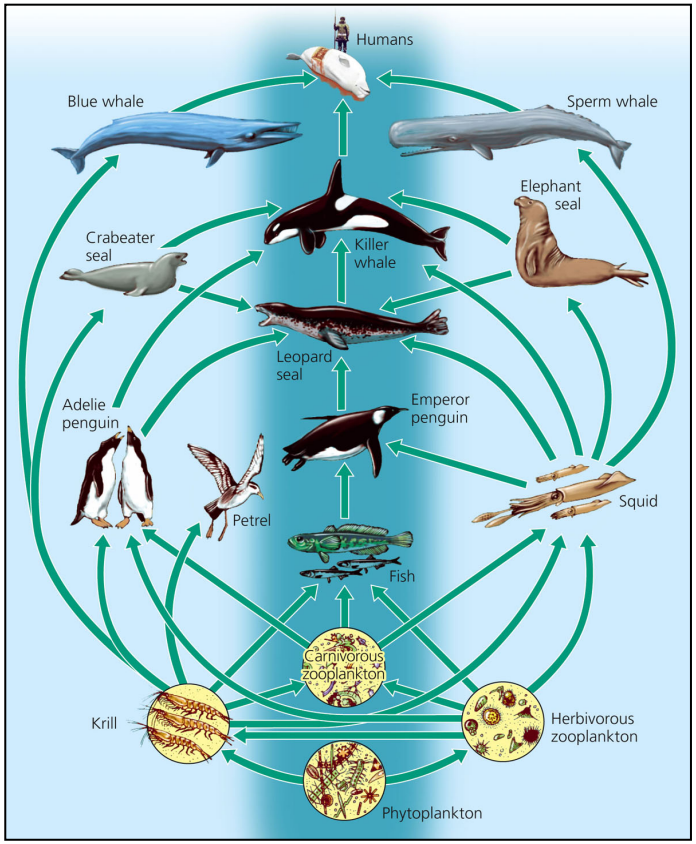
Food chain ⬇

- Movement of energy and nutrients from one **trophic level** to the next
- Photosynthesis → feeding → decomposition



Food web ➔

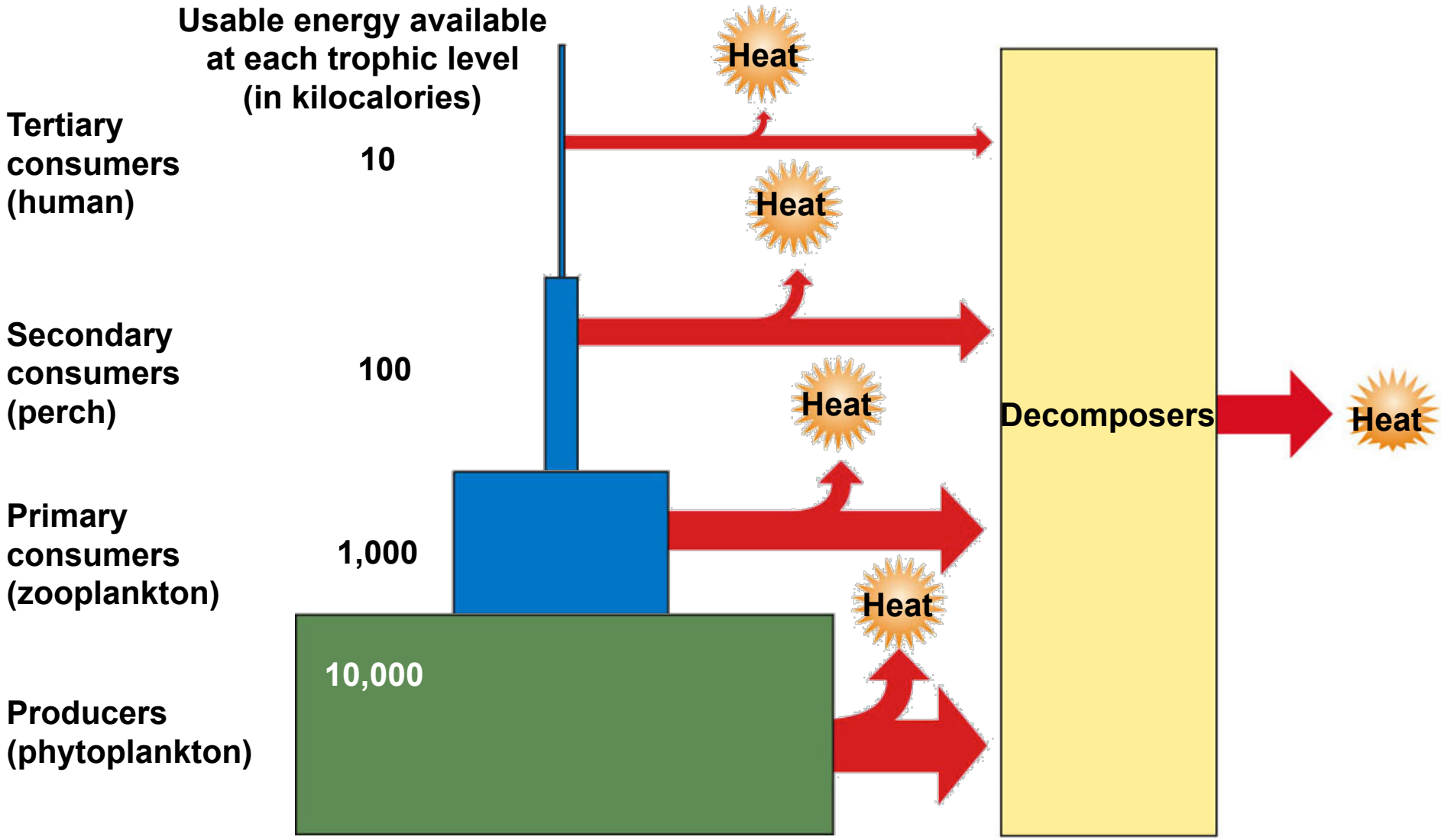
- Network of interconnected food chains



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

Pyramid of energy flow → 90% of energy lost with each transfer

- Less chemical energy for higher trophic levels



Some Ecosystems Produce Plant Matter Faster Than Others Do

Biomass

- Dry weight of all organic matter of a given trophic level in a food chain or food web
- Decreases at each higher trophic level due to heat loss

Gross primary productivity (GPP)

- Rate at which an ecosystem's producers convert solar energy to chemical energy and biomass
- Kcal/m^2/year

Net primary productivity (NPP)

- Rate at which an ecosystem's producers convert solar energy to chemical energy, minus the rate at which producers use energy for aerobic respiration
- Ecosystems and life zones differ in their NPP

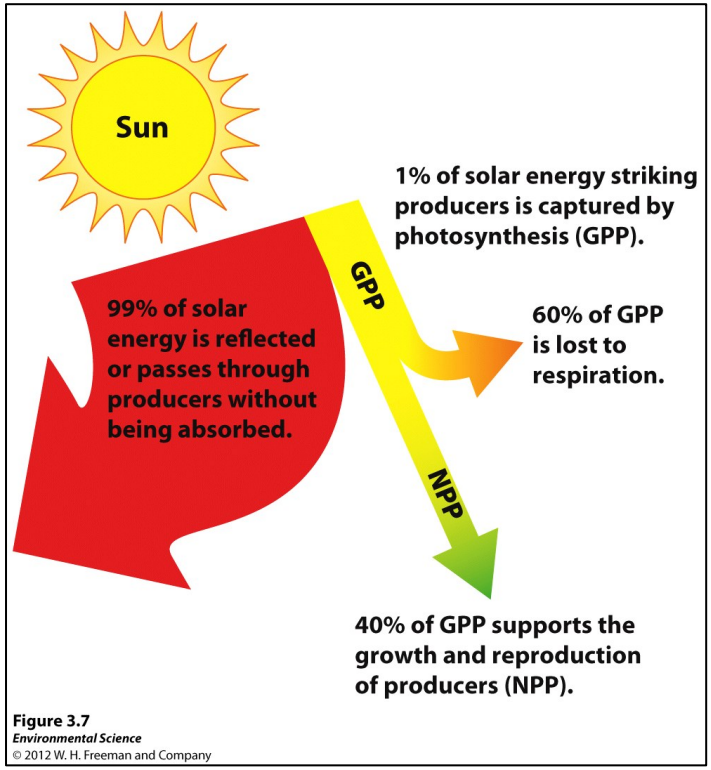
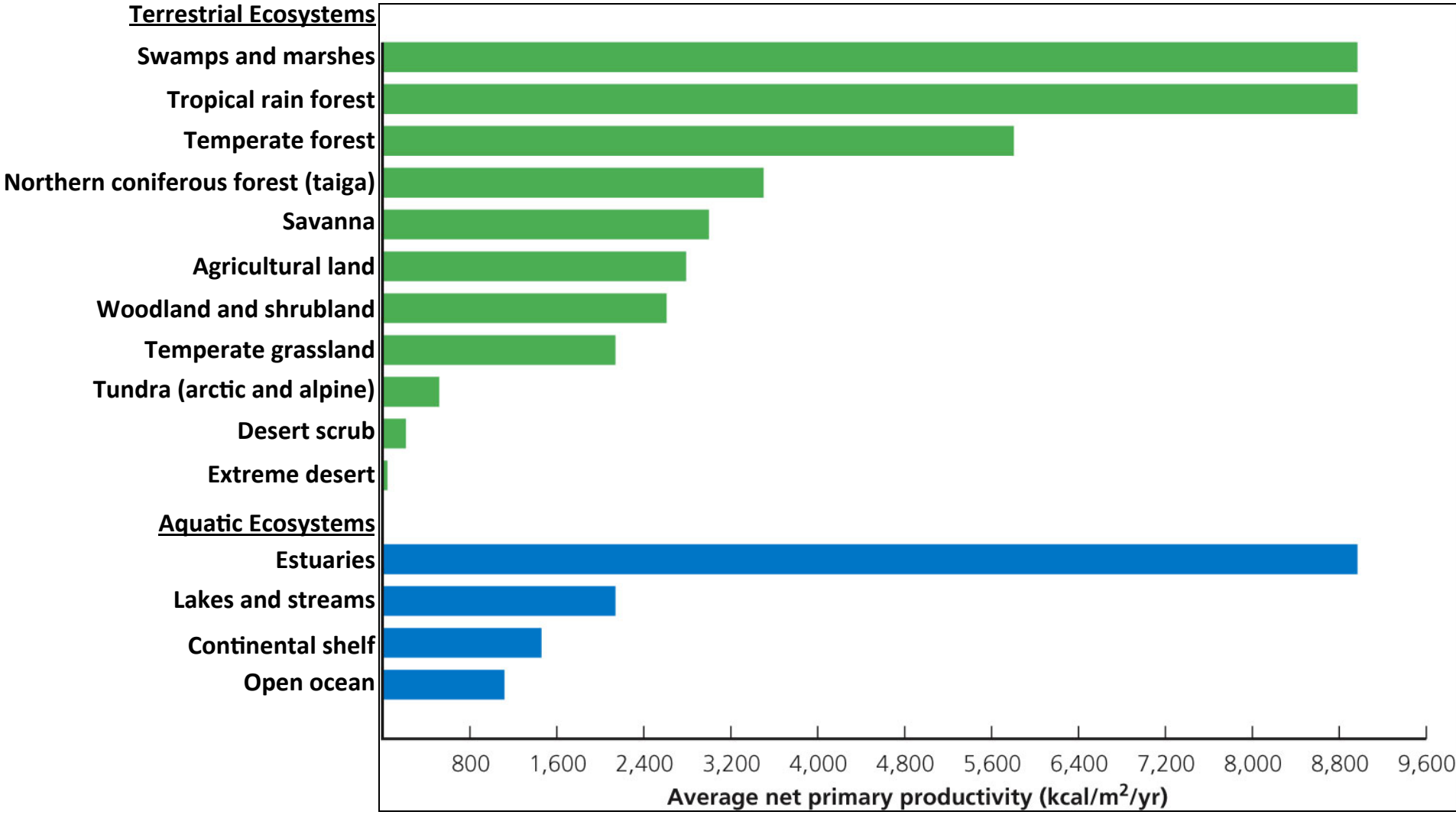


Figure 3.7
Environmental Science

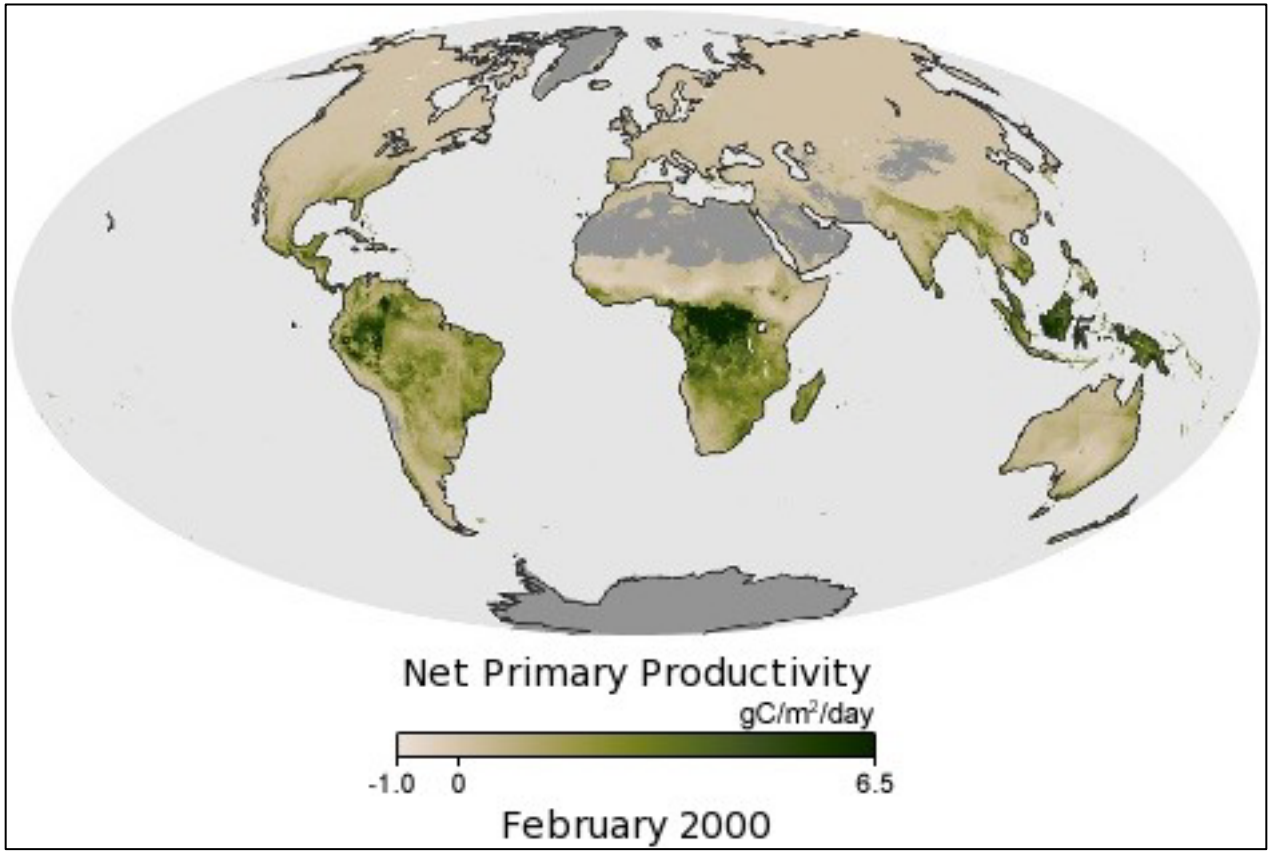
Average Net primary productivity (NPP) of Various Ecosystems



Why Productivity is Important?

The energy in an ecosystem can be measure in terms of ***biomass*** (total mass of all living matter).

NPP establishes the **rate** at which biomass is produced over a given amount of time.



Why Productivity is Important?

Example

The amount of sunlight that reaches a lake determines how much algae (phytoplankton) can live in the marine ecosystem.

Amount of Algae determine the number of zooplankton the marine ecosystem can support.

Size of zooplankton population determines size of fish population.