



# ENERGY FLOW IN ECOSYSTEMS

TOPICS 1.9 TO 1.11

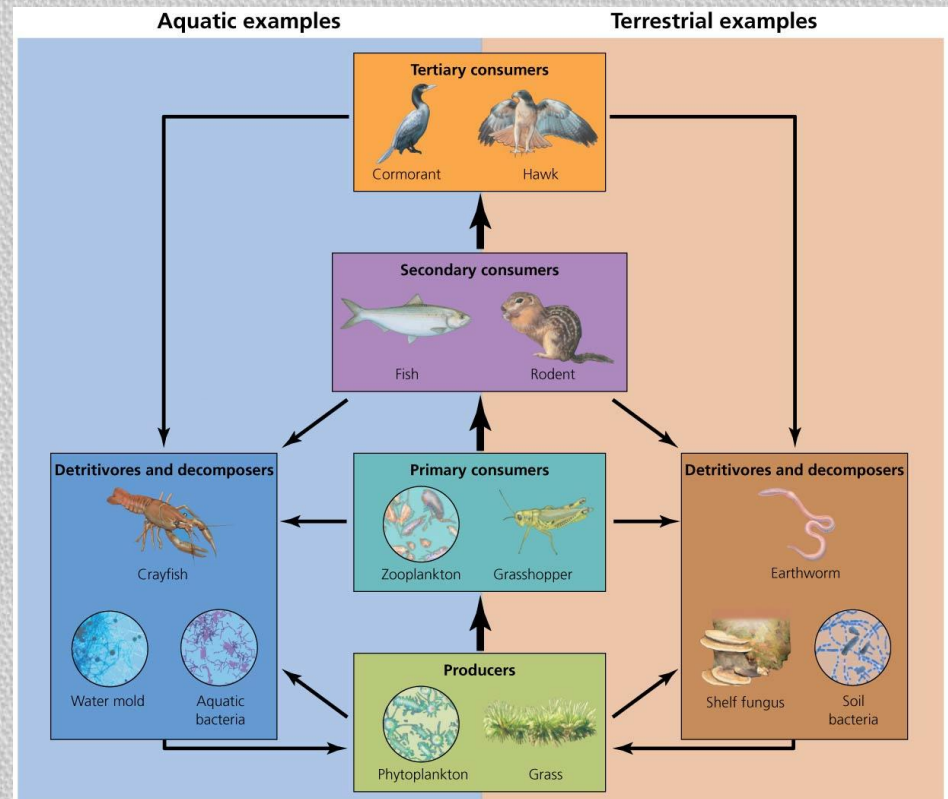
**Enduring Understanding:** Energy can be converted from one form to another.

**Learning Objective:** Explain how matter is recycled within ecosystems and energy decreases as it flows through ecosystems.



# Energy and Matter Pass Through Trophic Levels

- Energy and matter are transferred through ecosystems when community members consume one another.
  - As we saw with the biogeochemical cycles, matter is continuously recycled within ecosystems.
  - As we saw with primary productivity, energy in ecosystems is constantly being absorbed and lost as heat due to cellular respiration needs of cellular metabolism.
- Organisms are assigned to trophic levels based on how they obtain matter and energy.
  - trophic levels are ranks in the feeding hierarchy of an ecosystem
  - Organisms in lower trophic levels supply organisms of higher trophic levels with matter and energy.
  - Producers (autotrophs)
  - Consumers (1°, 2°, 3°; heterotrophs)
  - Detritivores and decomposers

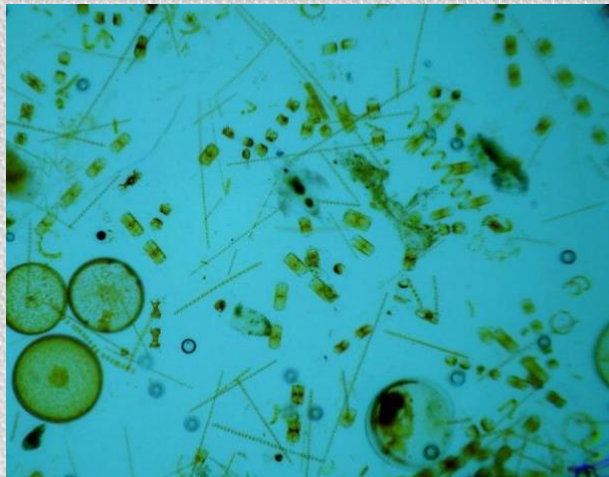




# Producers produce food from inorganic sources of matter and energy

## Producers or autotrophs (“self-feeders”)

- Organisms that produce their own organic compounds from simple inorganic compounds.
  - Photosynthetic producers use  $\text{CO}_2$  and  $\text{H}_2\text{O}$  and the energy from sunlight to make glucose
    - Green plants, Algae and phytoplankton (Protista), Cyanobacteria
  - Chemosynthetic bacteria oxidize simple inorganic compounds (such as  $\text{H}_2\text{S}$ ) to release enough energy to fix Carbon from  $\text{CO}_2$  and synthesize simple sugars
    - Various extremophiles of the domain Archaea





# Consumers

- **Primary consumers**

- second trophic level
- Organisms that consume producers
- Herbivores consume plants
  - Deer, grasshoppers

- **Secondary (and higher) consumers**

- third (or higher) trophic level
- Organisms that are predators
- Carnivores consume meat
- Wolves, raptors, rodents (that eat insects)



**Omnivores** are consumers that eat both producers (plants) and other consumer species (animals). **What trophic level are they?**



# Detritivores and Decomposers

- Organisms that consume nonliving organic matter
- enrich soils and/or recycle nutrients found in dead organisms and waste material
- Usually assigned to the highest trophic level in an ecosystem since they can feed from all other available trophic levels.

- **Detritivores** scavenge waste products or dead bodies
  - “Eat” their way through soil
  - Millipedes, earthworms, soil insects, vultures



- **Decomposers** break down organic material into simpler chemicals
  - Secrete enzymes, dissolve organic matter and absorb nutrients
  - Fungi, bacteria



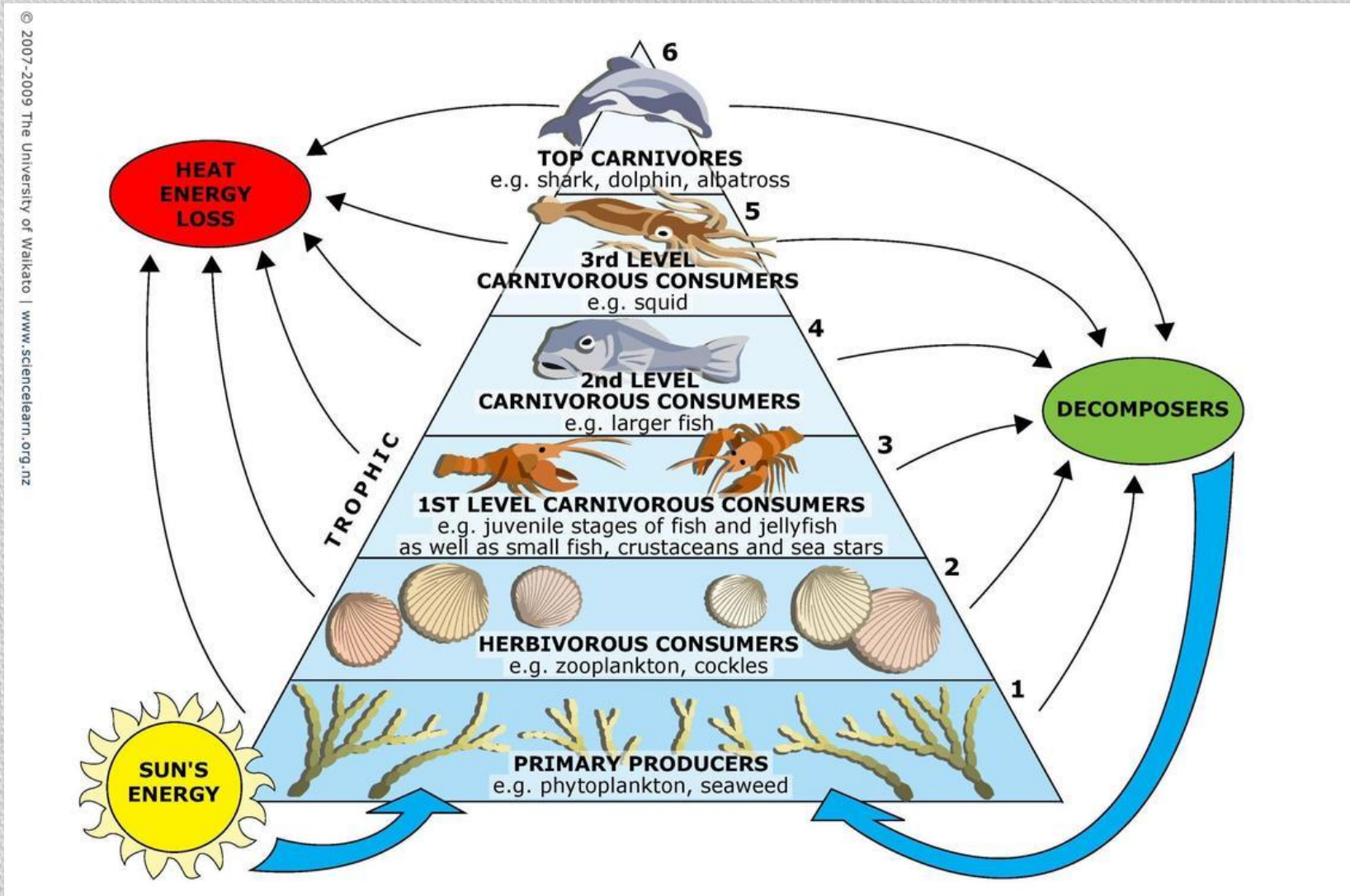


# Energy, biomass, and numbers decrease at higher trophic levels

- Typically, producers obtain energy from inorganic sources
- As organisms do work, chemical energy is converted to heat through cellular respiration
  - Each trophic level contains less energy than the trophic level below it
  - Excess energy, not used for an organisms own metabolism, is stored in the chemical bonds of their cells and tissues
- Since energy is stored in the bonds of biomass, if there is less energy, there is also less biomass at a given trophic level.
- Because most higher trophic level species are predators, they are usually larger than their prey, so the number of organisms also declines with each successive trophic level



# Example trophic levels and the transfer of energy and matter in marine ecosystems





# Trophic Level Efficiency

- The efficiency of energy and biomass transfer from one trophic level to the next higher level is typically estimated as 10%
- In many food webs it is likely less than 10%

**Trophic Efficiency** =  $\frac{\text{energy stored in one trophic level}}{\text{energy stored on the next lower level}}$

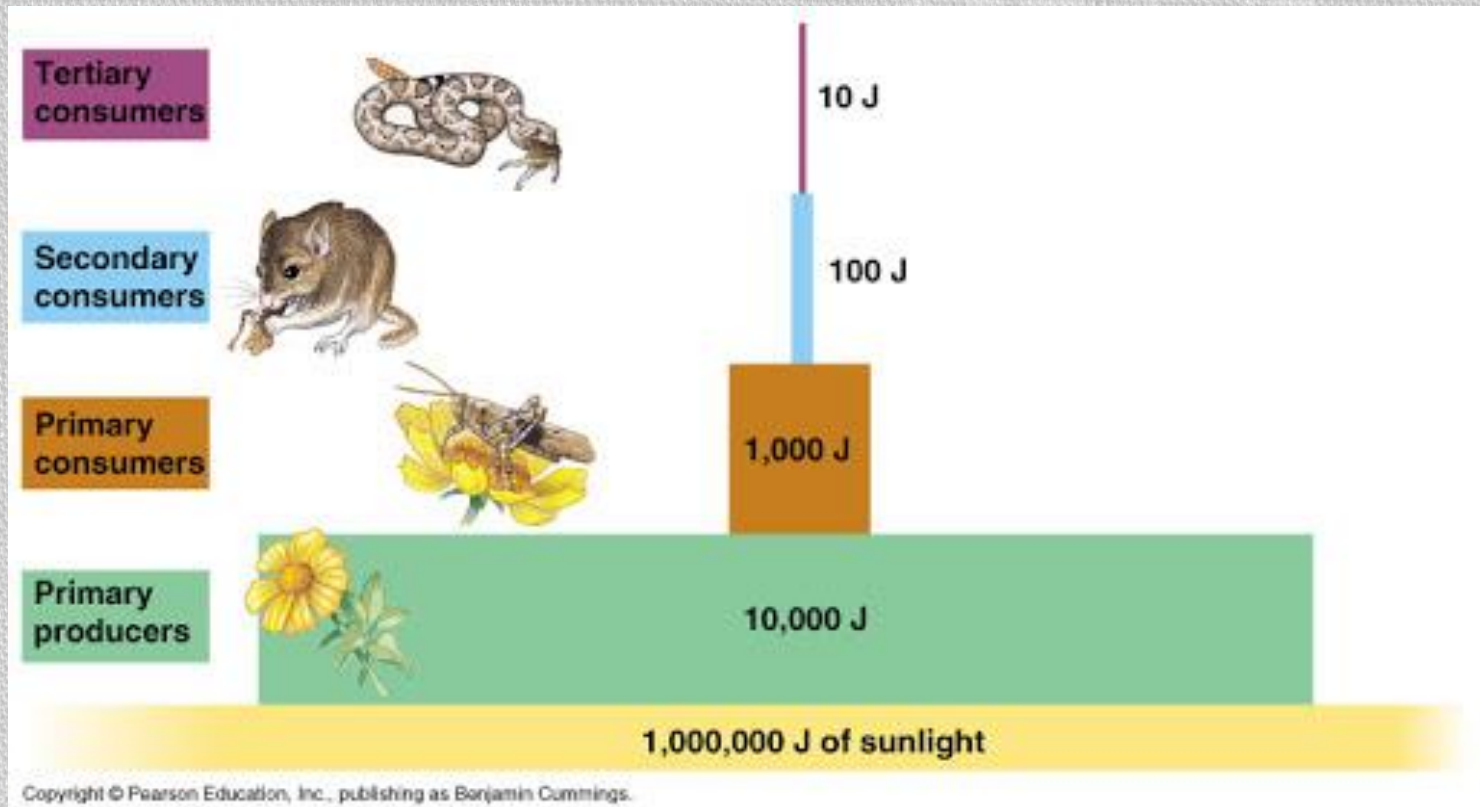
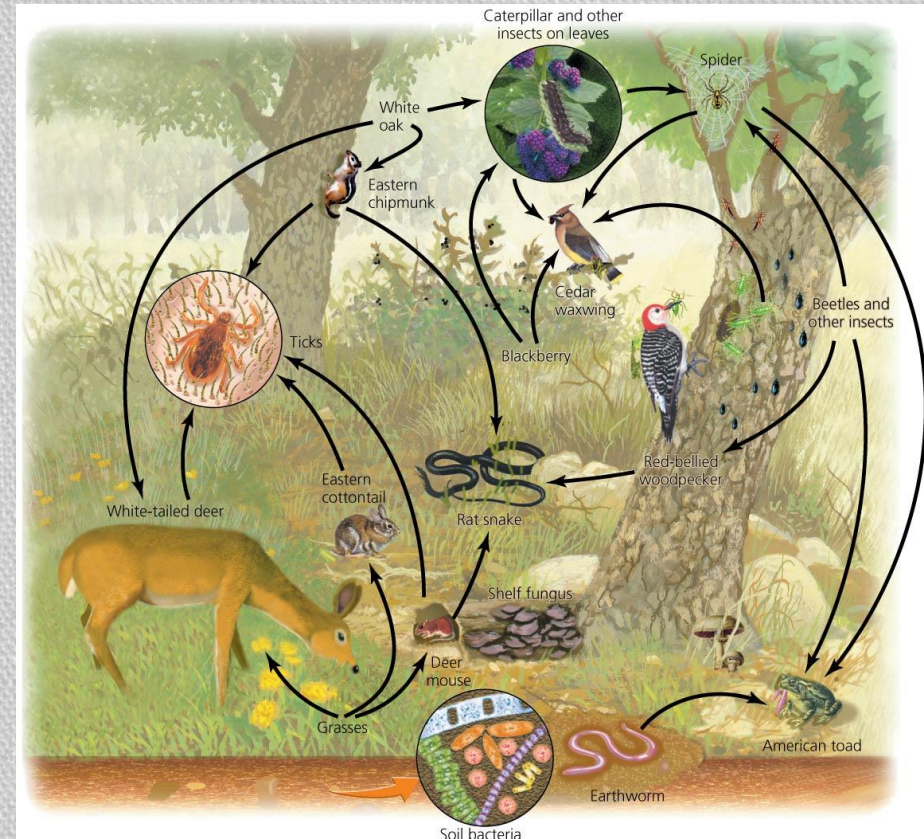


Figure represents energy stored in biomass at each trophic level



# Food webs show feeding relationships and the flow of matter and energy

- **Food chains** are a linear series of feeding relationships
  - Greatly simplified; leaves out most species
- **Food webs** are a visual map of feeding relationships and energy flow
  - Includes many different organisms at all various levels
  - Consists of many food chains



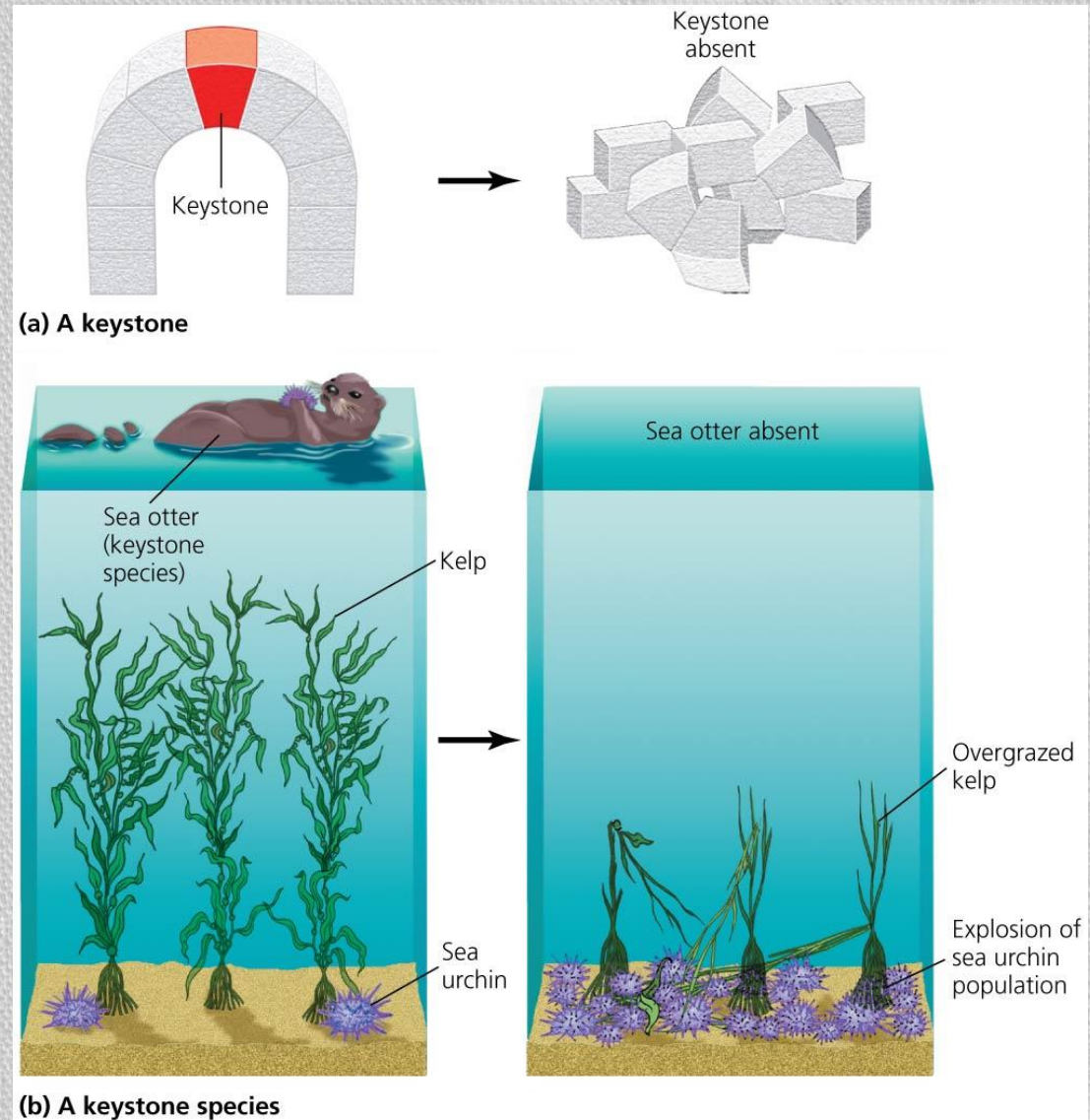
What direction do the arrows point? Why?

- Circumstances that affect the population of one species, are likely to result in a chain reaction that affects of populations of one or more other species in food web



# Some organisms play outsized roles in communities

- Species interactions differ in the strength of their effects
- *Keystone species* have a strong or wide-reaching impact far out of proportion to their abundance
- Removal of a keystone species has substantial ripple effects
  - Removal of otters significantly alter the entire food web





# Some organisms play outsized roles in communities

- **Keystone species may cause a trophic cascade**
  - a phenomenon in which predators at high trophic levels indirectly affect populations at low trophic levels
  - Predators keep species at intermediate trophic levels in check, allowing growth of species at a lower level
  - Extermination of wolves led to increased deer and elk populations, which overgrazed vegetation and changed forest structure
- **Other keystone Species are “Ecosystem Engineers”**
  - They physically modify the environment
  - Beaver dams, prairie dogs, ants, zebra mussels

