Energy Flow in the Biosphere

36.1-36.2
Objectives

• Compare and contrast the pathways of matter and energy in an ecosystem.
• Identify and describe the various feeding relationships in an ecosystem.
• Describe the relationship between an organisms trophic level and available energy.
• Define primary productivity and explain its impact on energy flow in an ecosystem.
Factors Effecting Energy/Matter Flow

- Key Concept: Matter (chemicals) is cycled in the biosphere but energy flows through it.
- Energy is not recycled within an ecosystem, but flows through it and out.
- Energy enters an ecosystem as light, is converted to chemical energy by producers, and exits the ecosystem as heat.
  - 1. Energy enters the biosphere as sunlight
  - 2. Sunlight is converted to chemical energy and stored in organic compounds (biomass) by producers.
  - 3. Biomass is broken down to release energy through respiration by consumers
  - 4. Energy leaves the biosphere as heat
- Producers must continue to receive energy input for the ecosystem to survive.
Factors Effecting Energy/Matter Flow

• Key Concept: Energy / Matter flow through the biosphere is determined by feeding relationships called trophic levels.

• Although energy flows through an ecosystem, while chemicals can be used again and again, the movements of both energy and chemicals are related to patterns of feeding within the ecosystem.
  – Producers:
    • Are the foundation of all other trophic levels in an ecosystem
    • Convert energy into organic compounds that can be used by other organisms
      – Terrestrial Plants use photosynthesis produce simple sugars
      – Aquatic Phytoplankton and Algae use photosynthesis produce simple sugars
      – Hydrothermal Bacteria use chemosynthesis of sulfur compounds produce simple sugars
Feeding Relationships in Ecosystems

• Consumers:
  • Use organic compounds from producers or other consumers to meet their energy requirements.
  • Depend upon the energy flow from the trophic levels below them for survival.
    – Primary Consumer
      » Second trophic level
      » Always eats only producers (plants, seeds, fruit, and nuts).
      » Is a herbivore
    – Secondary Consumer
      » 3rd Trophic level
      » Eats primary consumers (meat and flesh, no plants)
      » Is a carnivore
    – Other Consumers
      » There can be tertiary or quaternary consumers depending on the food chain
Feeding Relationships in Ecosystems

- Consumers:
  - Omnivores
    - Are consumers that can be herbivores or carnivores (eat plants or other animals).
    - Operate on different or multiple trophic levels within a food chain.
    - Examples include Humans, Raccoons, Coyotes and Bears
  - Decomposers
    - Are consumers that feed on and obtain energy from the wastes or dead remains of other organisms.
    - Are members of every food chain.
    - Are important because they recycle chemicals/matter within the biosphere.
    - Examples include bacteria and fungi, vultures, earthworms, and many insects.
Mapping Energy/Matter Flow in the Biosphere

- Primary productivity is the rate at which producers in an ecosystem can make organic molecules or biomass.
  - Most strongly affected by the amount of sunlight that enters an ecosystem.
    - Tropics get most direct sunlight = highest primary productivity.
    - Polar regions get least direct sunlight = lowest primary productivity.
- Key Concept: Primary productivity determines the maximum amount of energy available to all higher trophic levels within an ecosystem.
Mapping Energy/Matter Flow in the Biosphere

- **Food Chains and Food Webs**
  - Food chains show the flow of matter and energy for a limited set of feeding relationships within an ecosystem.
    - They do not represent the amount of matter/energy transferred, only the direction.
    - They attempt to show only one pathway for a given set of organisms.
    - They are linear, beginning with a producer and ending with a higher level consumer.
  - Food webs show the flow of matter and energy between all the producers and consumers in a given ecosystem.
    - They do not represent the amount of matter/energy transferred, only the direction.
    - They attempt to show all possible pathways for all members of an ecosystem.
    - They are web-like showing multiple connections between many organisms.
Mapping Energy/Matter Flow in the Biosphere

- An Energy Pyramid: (AKA food pyramid) shows the amount of energy transferred from one trophic level to the next higher level as organisms feed within an ecosystem.

- Key Concepts of energy flow:
  1. Energy conversion from one level to the next is not 100% efficient.
     - About 10% of the energy consumed converts to biomass for the consumer.
     - 90% of the energy is lost as heat.
  2. The higher the trophic level, the less energy is available to consumers on that level.
  3. The number of trophic levels in an ecosystem depends on the primary productivity (producers) within the ecosystem.
     - Most food chains are limited to 3 or 4 trophic levels because there is not enough energy available to support another trophic level.
Mapping Energy/Matter Flow in the Biosphere

• Biomass pyramid: represents the actual biomass (dry mass of all organisms) in each trophic level in an ecosystem.
• Pyramid of Numbers: depicts the number of individual organisms in each trophic level of an ecosystem.
  – Organized like energy pyramids, with producers found at the foundation and higher trophic levels on each step above them.
  – The foundation is again the widest section, indicating that there are more individual producers than there are primary consumers, and so on.
  – These pyramids emphasize how few top-level consumers an ecosystem can support.
Key Concepts to Remember

• Matter is cycled in the biosphere but energy flows through it.
• Energy / Matter flow through the biosphere is determined by feeding relationships.
• Organisms depend on the energy flow from the trophic levels below them for survival.
• Primary productivity determines the maximum amount of energy available to all higher trophic levels within an ecosystem.
• The number of trophic levels in an ecosystem depends on the primary productivity.