**Chapter 3**

**Ecosystems and Energy**

**Lecture Outline:**

I. What is Ecology?

A. Ernst Haeckel developed the concept of *ecology* in the 19th century

i. Ecology literally means “the study of one’s house”; it is the broadest field within the biological sciences , and is linked to many other disciplines (i.e., geology, earth science, chemistry, physics)

ii. It examines the systems that include interactions among organisms and between organisms and their abiotic environment

1. The *biotic* environment includes all living organisms

2. The *abiotic* environment includes living space, temperature, sunlight, soil, wind and precipitation

B. Ecologists are most interested in the levels of biological organization that include or are above the level of the individual organism

i. A group of similar organisms whose members freely interbreed with one another in the wild to produce fertile offspring is termed a *species*

ii. A *population* is a group of organisms of the same species that live in the same area at the same time

iii. A natural association that consists of all the populations of different species that live and interact within an area at the same time is called a *community*

iv. A community and its physical environment comprise an *ecosystem*

1. An ecosystem is a system in which all of the biological, physical, and chemical components of an area form a complex, interacting network of energy flow and materials cycling

2. Ecosystem processes collectively regulate global cycles of water, carbon, nitrogen, phosphorus, and sulfur essential to the survival of humans and all other organisms

C. *Landscape ecology* is a subdiscipline of ecology

i. It studies ecological processes that operate over large areas

ii. A *landscape* is a region that includes several interacting ecosystems

D. Ecologists who study the biosphere examine global interrelationships among Earth’s atmosphere, land, water, and organisms

i. The parts of Earth’s atmosphere, ocean, land surface, and soil that contain all living organisms is termed the *biosphere*

ii. The *atmosphere* is a gaseous envelope surrounding Earth

iii. The *hydrosphere* is Earth’s supply of water

iv. The *lithosphere* is the soil and rock of Earth’s crust

II. The Energy of Life

A. Energy is the capacity or ability to do work

i. *Energy* exists in several forms: chemical radiant, thermal, mechanical, nuclear, and electrical

ii. Energy can exist as stored energy (*potential*) or as the energy of motion (*kinetic*)

B. The study of energy and its transformations is called *thermodynamics*

i. In thermodynamics, the word *system* is used to refer to a group of atoms, molecules, or objects being studied

1. A *closed system* is self-contained and isolated; it does not exchange energy with its surroundings

2. An *open system* exhibits an exchange of energy with its surroundings

ii. The *first law of thermodynamics* holds that energy cannot be created or destroyed, although it can change from one form to another

iii. The *second law of thermodynamics* holds that when energy is converted from one form to another, some of it is degraded into heat, a less usable form that disperses into the environment

1. The less usable energy is more diffuse, or disorganized; *entropy* is a measure of this disorder or randomness

2. No process requiring an energy conversion is ever 100% efficient because much of the energy is dispersed as heat, resulting in an increase in entropy

C. Photosynthesis and cellular respiration

i. *Photosynthesis* is the biological process in which light energy from the sun is captured and transformed into the chemical energy of carbohydrate (glucose) molecules

1. 6CO2 + 12H2O + radiant energy --> C6H12O6 + 6H2O +6O2

2. Plants, some bacteria, and algae perform photosynthesis

ii. The chemical energy that plants store in carbohydrates and other molecules is released within cells of plants, animals, or other organisms through *cellular respiration*

1. In aerobic cellular respiration, molecules such as glucose are broken down in the presence of oxygen and water

a. C6H12O6 +6O2 + 6H2O --> 6CO2 + 12H2O + energy

2. Anaerobic bacteria that live in waterlogged soil, stagnant ponds, or animal intestines respire in the absence of oxygen

D. *Chemosynthesis* is the process by which energy produced from inorganic raw materials such as enzymes, hydrogen sulfide and oxygen; water and sulfur/sulfate are additional byproducts

III. The Flow of Energy Through Ecosystems

A. *Energy flow* is the passage of energy in a one-way direction through an ecosystem

B. Producers, consumers, and decomposers

i. *Producers* (aka autotrophs)

1. In photosynthesis, producers use the energy from sunlight to make organic molecules from carbon dioxide and water

2. Plants, algae and certain types of bacteria are important producers

ii. *Consumers* (aka heterotrophs)

1. Consumers obtain energy when they eat producers or other consumers

a. Consumers that eat producers are primary consumers (herbivores)

b. Secondary consumers (carnivore) eat primary consumers

c. Tertiary consumers (top carnivores) eat secondary consumers

2. Omnivores eat a variety of organisms

3. Detritus feeders (detritivores) consume organic matter that includes animal carcasses, leaf litter, and feces

iii. *Decomposers* (aka saprotrophs)

1. Wastes and dead organic material from producers and consumers supply decomposers (i.e., bacteria, fungi) with energy

2. Bacteria and fungi are important decomposers

C. The path of energy flow: who eats whom in ecosystems

i. In an ecosystem, energy flow occurs in *food chains*, in which energy from food passes from one organism to the next in a sequence

1. Energy enters ecosystems from an external source (the sun), flows linearly, and exits as heat loss

2. Each level in a food chain is termed a *trophic level*

a. Producers (photosynthetic organisms) form the first trophic level

b. Primary consumers (herbivores) form the second trophic level

c. Secondary consumers (carnivores) form the third trophic level

d. Decomposers occur at every step in a food chain

ii. Simple food chains rarely occur in nature, a *food web* is a more realistic model

D. Ecological pyramids

i. *Ecological pyramids* graphically represent the relative energy values of each trophic level

1. A *pyramid of numbers* show the number of organisms at each trophic level in a given ecosystem

2. A *pyramid of biomass* illustrates the total biomass at each successive trophic level

a. *Biomass* is a quantitative estimate of the total mass of living material

b. Biomass indicates the amount of fixed energy at a particular time

3. A *pyramid of energy* illustrates the energy content, often expressed as kilocalories per square meter per year, of the biomass at each trophic level

E. Ecosystem productivity

i. The *gross primary productivity* (GPP) of an ecosystem is the rate at which energy is captured during photosynthesis

ii. *Net primary productivity* (NPP) is the energy in plant tissues after cellular respiration has occurred

1. Only the energy represented by NPP is available as food for an ecosystem’s consumers

2. Ecosystems differ strikingly in their productivities (NPP)

iii. Human impact on NPP

1. Humans consume far more of Earth’s resources than any other of the millions of animal species (approximately 32% of the annual NPP of land-based ecosystems)

2. Humans only represent 0.5% of the total biomass of all consumers on Earth