Ecology, the Environment, and Us
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OUTLINE:

- Earth as an Ecosystem
- Biosphere
- Ecological Succession
- Energy Flow
- Chemical Cycles
- Biodiversity
Earth as an Ecosystem

- Ecology
  - The study of interactions between organisms and between organisms and the environment

- Earth as an ecosystem
  - No source of new materials
    - Many materials cycle between organisms and between living and nonliving components
  - Energy comes from the sun
    - Captured by green plants and transferred from organism to organism
Figure 23.1 A view of Earth from space.
Biosphere

- Biosphere
  - Part of Earth where life exists, consists of many ecosystems

- Ecosystem
  - Organisms in a specific geographic area and their physical environment

- Community
  - All of the living species in an ecosystem that can potentially interact
Biosphere

- Population
  - All the individuals of the same species that can potentially interact

- Niche
  - An organism’s role in the ecosystem
    - All the physical, chemical, and biological factors that keep the organism healthy and allow it to reproduce

- Habitat
  - The place where an organism lives
  - Part of its niche
Ecological Succession

- Sequence of changes in the species composition of a community over time
  - Two types
    - Primary
    - Secondary
Ecological Succession

- **Primary succession**
  - Occurs where no previous community existed
    - At the start, no soil present
  - Pioneer species
    - First living things to invade such an area
    - Example: lichens
  - Eventually, a climax community forms
    - Important factors include temperature, rainfall, nutrient availability, and exposure to sun and wind
Figure 23.2 Primary succession.

This thin mat of lichen is helping break down the bare rock, beginning soil formation.

After soil has begun to accumulate, plant species appear that often include shrubs and dwarf trees.

Trees often later become the dominant plant form, depending on elevation, annual rainfall, and average temperature.
Ecological Succession

- Secondary succession
  - Occurs when an existing community is cleared and undergoes a series of events leading once again to a climax community
  - Soil is present at the start
  - Initial invaders usually include grasses, weeds, shrubs
Figure 23.3 Selected climax communities of Earth.

**Temperate deciduous forest.** These forests receive 75 to 125 cm (30 to 50 in.) of rainfall per year. Summers are hot, and winters are cold. Trees lose their leaves in the winter to avoid water loss when it is too cold to photosynthesize. Insects, mice, squirrels, and many species of birds are common in these forests.

**Temperate grasslands.** These grasslands receive 25 to 75 cm (10 to 30 in.) of rainfall per year. Long dry periods and fire are important factors in maintaining grasslands. Grazing animals, such as antelope, and burrowing animals, such as prairie dogs, are common.

**Desert.** Lack of water defines the desert community. Deserts receive less than 25 cm (10 in.) of rain each year. Most deserts are hot, but some are cold. Both plants and animals must be able to conserve water. Many desert plants are succulents with leaves that retain and store water. Animals may tend to avoid the sun by foraging at night.

**Taiga.** The taiga is composed of evergreen forests with variable rainfall of 50 to 100 cm (20 to 40 in.) per year. Winters are long and cold, and summers are short. The needles on evergreen trees help save water by providing little surface through which water can leave. Animals such as the grizzly bear, moose, wolf, and snowshoe hare are common.

**Tropical rain forest.** Tropical rain forests may receive 200 to 1000 cm (80 to 400 in.) of rain each year. It is hot throughout the year. Tropical rain forests have a tremendous diversity of life.
Figure 23.4 Secondary succession.

Immediately after a fire there are no visible signs of life. Dead trees stand as ghostly reminders of the forest that had existed, and gray ash covers the forest floor.

The following spring young plants appear and begin the stages of secondary succession.
Energy Flow

- Energy
  - Supplied by the sun
  - Enters the living world as photosynthetic organisms trap the sun’s energy and transform it into glucose during photosynthesis

- Trophic level = feeding level
Energy Flow

- Producers
  - Photosynthesizers
  - Form lowest trophic level
- Consumers
  - Use energy stored by producers
  - Form higher trophic levels
Food Chains and Food Webs

- Consumers grouped by food source
  - Herbivores: primary consumers
    - Eat plants
  - Carnivores: secondary and tertiary consumers
    - Feed on herbivores (secondary consumers)
    - Feed on other carnivores (tertiary consumers)
Food Chains and Food Webs

- Consumers grouped by food source (cont’d)
  - Omnivores
    - Eat both plants and animals
  - Decomposers
    - Consume dead organic material for energy
    - Release inorganic material that can be used by producers
Figure 23.5 Trophic levels.

Tertiary consumers are carnivores that feed on secondary consumers.

Secondary consumers are carnivores that feed on herbivores.

Primary consumers (herbivores) consume producers.

Producers use the energy of the sun to produce organic molecules.
Food Chains and Food Webs

- Depict feeding relationships
  - Food chain
    - Linear sequence
    - Simplistic
  - Food web
    - Many organisms eat at several trophic levels
    - More realistic
Figure 23.6 Humans eat at several trophic levels.
Figure 23.7 Simplified food web.
Energy Transfer through Tropic Levels

- Energy is lost when it is transferred from one trophic level to the next
  - About 10% of energy available at one trophic level is transferred to the next
    - This is why ecosystems rarely have more than four or five trophic levels
- Only the energy converted to biomass is available to the next higher trophic level
  - Biomass = dry weight of an organism
Figure 23.8 *Energy flow through a food web.*
Ecological Pyramids

- Diagrams that compare certain properties in a series of related trophic levels
  - Pyramid of energy
    - Depicts energy available at each trophic level
  - Pyramid of biomass
    - Describes number of individuals at each trophic level multiplied by their biomass
Health and Environmental Consequences of Ecological Pyramids

- Two lessons from ecological pyramids

1. Nondegradable substances accumulate to higher concentrations in organisms at higher trophic levels

2. More humans could be nourished on a vegetarian diet than on a diet containing meat
Figure 23.9 *Ecological pyramids.*

Only 10% of the energy available at the trophic level becomes biomass that is available to the next higher trophic level.

Most of the energy in a grassland is in green plants.
Biological Magnification

- The tendency of nondegradable chemicals to become more concentrated in organisms in each successive trophic level
Figure 23.10 Example of biological magnification.
World Hunger

- Only about 10% of the energy captured by one trophic level is available to the next
- More people could be fed and less land cultivated if we adopt a largely, or exclusively, vegetarian diet
World Hunger

Energy Flow and Food Webs

Energy flows into the living world through photosynthetic organisms, which capture light energy and convert it into the chemical energy of sugars. These sugars can then be consumed by other organisms in the food chain. Natural communities are more accurately described as food webs, which show the many interconnecting food chains in a community. This tutorial explores energy flow and feeding relationships within a community.

Press "PLAY" to begin Animation.
Figure 23.11 *Energy pyramids may hold an important lesson for humans.*

- **Producers (grains):** (20,000 calories)
  - **Herbivore:** (2000 calories) feeds one human (200 calories)
  - **Carnivore:** feeds 10 humans (200 calories each)
Chemical Cycles

- Earth’s resources are limited
- Many of Earth’s reserves would be depleted without nature’s cycling of materials
- Materials move through a series of transfers from living to nonliving systems and back again in recurring pathways
  - Biogeochemical cycles
Figure 23.12 Example of biogeochemical cycles.
The Water Cycle

- Moves from the atmosphere to land as precipitation, and back to the atmosphere as it evaporates and from transpiration in plants
- Large amounts of water are temporarily stored in living things
- Water forms part of the oxygen cycle (photosynthesis)
- Human activities disrupt the water cycle: deforestation reduces transpiration, runoff patterns altered in cities, use more freshwater than is replenished
The Water Cycle

The hydrologic cycle involves the circulation of water around the Earth. This tutorial describes the processes by which water circulates from the land to the atmosphere and back again. Press "PLAY" to begin Animation.
Figure 23.13 The water cycle.
The Carbon Cycle

- Moves from the environment, into living things, and back to the environment

- Living organisms need carbon to build the molecules of life
  - Proteins
  - Carbohydrates
  - Fats
  - Nucleic acids
The Carbon Cycle

- Carbon dioxide (CO$_2$) is removed from the environment
  - Producers use it during photosynthesis
  - Carbon in organic molecules then moves through the food web
- Carbon is returned to the atmosphere as CO$_2$ during cellular respiration
The Carbon Cycle

- Some carbon is delayed before being returned to the environment
  - Wood of trees
  - Limestone
  - Fossil fuels
The Carbon Cycle

- Three processes release carbon from these long-term storage sites
  - Decomposition
  - Erosion
  - Combustion
The Carbon Cycle

- Human activities increase levels of CO$_2$ in the atmosphere
  - Burning fossil fuels
  - Deforestation
- Results of increased atmospheric CO$_2$
  - Global warming
  - Increased acidity of oceans
The Carbon Cycle

The global carbon cycle is the circulation of carbon among the land, the oceans, and the atmosphere. In recent years, humans have released large amounts of carbon into the atmosphere—a change that many scientists believe is causing global warming. This tutorial explores the natural carbon cycle; the changes produced by human activities; and how CO2 acts as a greenhouse gas, trapping heat in the atmosphere.

Press "PLAY" to begin Animation.
Figure 23.14 The carbon cycle.
The Nitrogen Cycle

- Principal constituent of several molecules needed for life, including proteins and nucleic acids
  - Often in short supply to living systems
  - Largest reservoir is the atmosphere, which is 79% nitrogen gas ($N_2$)
The Nitrogen Cycle

- Atmospheric nitrogen cannot interact with life directly
  - Nitrogen fixation: nitrogen-fixing bacteria in roots of legumes convert nitrogen gas ($N_2$) to ammonium ($NH_4^+$)
  - Nitrification: nitrifying bacteria in the soil convert ammonium to nitrite ($NO_2^-$) and then nitrate ($NO_3^-$), the main form of nitrogen absorbed by plants
The Nitrogen Cycle

- Plants use nitrate to produce proteins and nucleic acids
- Animals eat the plants and use the plants’ nitrogen-containing chemicals to produce their own proteins and nucleic acids
The Nitrogen Cycle

- When plants and animals die, their nitrogen-containing molecules are converted to ammonium (NH$_4^+$) by decomposers such as bacteria
  - Nitrifying bacteria convert ammonium to nitrate (NO$_3^-$)
- Denitrification
  - Certain bacteria convert nitrates (NO$_3^-$) into nitrogen gas, thereby returning nitrogen to the atmosphere
Figure 23.15 *The nitrogen cycle.*
The Nitrogen Cycle

- Human activities and the nitrogen cycle
  - Burning of fossil fuels adds nitrogen dioxide (NO$_2$) gas to the atmosphere, which reacts with water vapor to form acid
    - Falls as acid rain
  - Sunlight can cause hydrocarbons and nitrogen dioxide to form photochemical smog
The Nitrogen Cycle

Nitrogen is abundant in the atmosphere but most organisms cannot use it in its gaseous form. During the nitrogen cycle, atmospheric nitrogen is converted to a form that can be used by living organisms. This tutorial describes the steps involved in that process and also describes how nitrogen gas is returned to the atmosphere.

Press "PLAY" to begin Animation.
The Phosphorus Cycle

- Cycles between rocks and living organisms
  - No atmospheric component
- An important component of many biological molecules, including
  - Genetic material DNA
  - Energy-transfer molecules such as adenosine triphosphate (ATP)
  - Phospholipids found in membranes
  - Vertebrate bones and teeth
The Phosphorus Cycle

- Sedimentary rock is the reservoir of phosphorus
  - Found in the form of phosphate ions
- Rainwater dissolves phosphates from rocks
- Producers absorb phosphates
- Phosphates are passed to other organisms in food webs
- Decomposers return phosphates to soil
Figure 23.16 The phosphorus cycle.
Eutrophication

- Disruptions to the nitrogen and phosphorus cycles can cause eutrophication
  - Enrichment of water in lakes or ponds by nutrients
  - Can be caused by fertilizer runoff
  - Leads to dramatic increases in photosynthetic organisms
  - Eventually may kill fish through depletion of oxygen
Biodiversity

- Includes the number of species living in a given area and the abundance of each
- Decreasing globally, especially in certain critical areas
  - Habitat destruction is largely responsible
Biodiversity

- Mass extinctions
  - Loss of many species
  - Have occurred in the past, but never before because of humans
  - Scientists estimate that we are losing species at the rate of 1000 to 10,000 times the average rate for the last 65 million years
Biodiversity

- Why should we care about the loss of biodiversity?
  - Genetic diversity is useful to crossbreeding and genetic engineering
  - Plants may provide new drugs useful in developing new medications
  - Organisms are critical to properly functioning biogeochemical cycles
You Should Now Be Able To:

- Describe Earth as an ecosystem
- Describe the biosphere
- Describe what is ecological succession
- Understand energy flow
- Understand the main chemical cycles
- Understand biodiversity