Unit 6: Ecological Interactions

Trophic Levels

1. Food Chain and Food Web

- **Food Chain:** A food chain represents a linear sequence of energy transfer through different organisms in an ecosystem, starting from producers and moving up to various levels of consumers. For example, grass → rabbit → fox. Each step in this chain is called a trophic level.
- **Food Web:** In contrast to the simple, linear food chain, a food web shows the complex network of multiple food chains interconnecting in an ecosystem. It depicts how different organisms are interconnected through various feeding relationships, illustrating the multidirectional flow of energy.

Characteristics:

- **Producers (Autotrophs):** Plants are the foundation, capturing solar energy and converting it into chemical energy through photosynthesis. They are at the base of both food chains and food webs.
- **Consumers (Heterotrophs):** Organisms that eat other organisms to obtain energy. They can be herbivores (plant-eaters), carnivores (animal-eaters), or omnivores (both plant and animal eaters). Omnivores can occupy multiple positions in the food chain.

Trophic Levels:

- **First Trophic Level:** Producers (plants) that synthesize their own food.
- **Second Trophic Level:** Herbivores that consume plants.
- **Third Trophic Level:** Carnivores that feed on herbivores.

2. Flow of Energy and Matter Through Ecosystems

- **Energy Flow:** Solar energy is converted by producers into chemical energy, which flows through the ecosystem via food chains or webs. Energy is transferred from one trophic level to the next but is never recycled back to the sun. Energy flow is unidirectional and diminishes as it moves through the levels.
- **Nutrient Recycling:** Unlike energy, nutrients are recycled within ecosystems. Decomposers break down dead organic matter, returning essential nutrients like nitrogen to the soil, which plants then use.

Energy Transfer Efficiency:

- Typically, only about 10% of the energy at one trophic level is transferred to the next level. For example, only about 10% of the energy in grass is converted into biomass in a cow. The rest is lost as heat or used in metabolic processes.

Ecological Pyramids:

- **Pyramid of Energy:** Represents the flow of energy through different trophic levels. It is always upright, with the energy decreasing sharply as you move from the base to the top level.
- **Pyramid of Biomass:** Shows the total mass of organisms at each trophic level. This can be upright or inverted depending on the ecosystem.
- **Pyramid of Numbers:** Represents the number of organisms at each trophic level. Like the pyramid of biomass, it can be upright or inverted.

6.2 Cycling of Materials in an Ecosystem

An **ecosystem** is a dynamic system consisting of living organisms (biotic components) and their non-living environment (abiotic components). The interaction between these components ensures the recycling of materials essential for sustaining life. Key elements such as water, carbon, nitrogen, and phosphorus continually cycle through ecosystems, moving between biotic and abiotic components. Here's an overview of the major cycles involved:

6.2.1 Water Cycle

Water on Earth is constantly moving through the environment. The cycle starts with **evaporation**, where water from oceans, lakes, and other surfaces changes into water vapor due to solar heating. Plants also contribute to this process through **transpiration**, where water evaporates from their leaves.

In the atmosphere, water vapor cools and **condenses** to form clouds. This condensed water then falls back to Earth as **precipitation** (rain or snow). The water that falls on the ground may **run off** into rivers, lakes, and oceans, or it may infiltrate the soil and become **groundwater**. This groundwater can return to the surface through springs or be used for drinking and irrigation.

The cycle restarts with evaporation from these bodies of water. This process ensures the continuous movement and availability of water in the environment.

6.2.2 Carbon Cycle

Carbon is crucial for life and cycles through ecosystems in several ways:

- **Photosynthesis**: Plants absorb carbon dioxide (CO_2) from the atmosphere and convert it into organic compounds.
- **Respiration**: Plants and animals release CO_2 back into the atmosphere through respiration.
- **Decomposition**: When organisms die, decomposers break down their bodies, releasing CO_2 back into the atmosphere.
- **Fossil Fuels**: Over time, dead organisms form fossil fuels. Burning these fuels releases additional CO_2 into the atmosphere.

Increased CO_2 levels due to human activities, like burning fossil fuels, contribute to global warming and climate change by enhancing the greenhouse effect.

6.2.3 Nitrogen Cycle

Nitrogen is essential for the synthesis of proteins and nucleic acids. The nitrogen cycle involves several key processes:

- **Nitrogen Fixation**: Atmospheric nitrogen (N_2) is converted into ammonia (NH_3) by bacteria (e.g., rhizobia in legumes) or through industrial methods.
- **Nitrification**: Ammonia is converted into nitrites (NO_2^-) and then into nitrates (NO_3^-) by nitrifying bacteria.
- **Assimilation**: Plants absorb nitrates or ammonium and use them to form proteins and nucleic acids.
- **Ammonification**: Organic nitrogen from dead organisms is converted back into ammonia.
- **Denitrification**: Nitrates are converted back into nitrogen gas (N_2) and released into the atmosphere by denitrifying bacteria.

6.2.4 Phosphorus Cycle

Phosphorus is crucial for energy transfer in cells and the formation of DNA. The phosphorus cycle includes:

- **Uptake**: Plants absorb phosphate ions from soil and water.
- **Consumption**: These phosphates are transferred through food chains as animals consume plants.
- **Decomposition**: Dead organisms release phosphorus back into the soil and water.
- **Fertilizers**: Phosphates are added to soil through fertilizers, but excess can cause eutrophication in water bodies.

The phosphorus cycle is slower compared to other cycles because phosphorus does not enter the atmosphere.

Summary

In an ecosystem, materials like water, carbon, nitrogen, and phosphorus continuously cycle through biotic and abiotic components. These cycles are essential for maintaining ecosystem health and supporting life. Understanding these cycles helps in managing natural resources and addressing environmental issues like pollution and climate change.