

CUET (UG) Biology Notes: Ecosystem

1. Ecosystem: Structure and Function

An ecosystem is a functional unit of nature, where living organisms interact among themselves and also with the surrounding physical environment.

- Stratification: The vertical distribution of different species occupying different levels in an ecosystem.
 1. Example in a forest: Trees occupy the top vertical strata or layer, shrubs the second, and herbs and grasses occupy the bottom layers.
- Components of Function: To understand the ethos of an aquatic or terrestrial ecosystem, we study it through four basic functional aspects:
 1. Productivity
 2. Decomposition
 3. Energy flow
 4. Nutrient cycling

2. Productivity

A constant input of solar energy is the basic requirement for any ecosystem to function and sustain.

- Primary Production: The amount of biomass or organic matter produced per unit area over a time period by plants during photosynthesis. Expressed in terms of weight (g/m^2) or energy (kcal/m^2).
- Gross Primary Productivity (GPP): The total rate of production of organic matter during photosynthesis. A considerable amount of GPP is utilized by plants in respiration.
- Net Primary Productivity (NPP): The gross primary productivity minus respiration losses (R). This is the available biomass for the consumption of heterotrophs (herbivores and decomposers).
 - Equation: $\text{NPP} = \text{GPP} - \text{R}$
- Secondary Productivity: Defined as the rate of formation of new organic matter by consumers (heterotrophs).

3. Decomposition

Decomposers break down complex organic matter into inorganic substances like carbon dioxide, water, and nutrients.

- Detritus: Dead plant remains (leaves, bark, flowers) and dead remains of animals, including fecal matter. This is the raw material for decomposition.
- Steps of Decomposition:
 - Fragmentation: Detritivores (e.g., earthworms) break down detritus into smaller particles.
 - Leaching: Water-soluble inorganic nutrients go down into the soil horizon and get precipitated as unavailable salts.
 - Catabolism: Bacterial and fungal enzymes degrade detritus into simpler inorganic substances.
 - Humification: Accumulation of a dark-colored amorphous substance called humus that is highly resistant to microbial action and undergoes decomposition at an extremely slow rate. It serves as a reservoir of nutrients.
 - Mineralization: The humus is further degraded by some microbes, releasing inorganic nutrients into the soil.
- Factors Affecting Decomposition: It is largely an oxygen-requiring process.
 - Slower if detritus is rich in lignin and chitin.
 - Quicker if detritus is rich in nitrogen and water-soluble substances like sugars. Warm and moist environments favor decomposition.

4. Energy Flow, Food Chains, and Food Web

Except for the deep sea hydro-thermal ecosystem, the sun is the only source of energy for all ecosystems on Earth.

- Photosynthetically Active Radiation (PAR): Plants capture only 2-10% of the PAR. This small amount of energy sustains the entire living world.

- Unidirectional Flow: Energy flows from the sun to producers and then to consumers. It never flows backward.
- The 10% Law: Formulated by Lindeman. Only 10% of the energy is transferred to each trophic level from the lower trophic level. The rest is lost as heat (respiration).

- Third Trophic Level (T3): Secondary Consumers (Carnivores)
- Fourth Trophic Level (T4): Tertiary Consumers (Top Carnivores)
- Standing Crop: Each trophic level has a certain mass of living material at a particular time. It is measured as the biomass of living organisms or their number in a unit area.




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5. Ecological Pyramids

The graphical representation of ecological parameters (number, biomass, energy) at different trophic levels. The base represents the producers, and the apex represents the top-level consumers.

Type of Pyramid	Shape & NCERT Examples
Pyramid of Number	<p>Usually Upright: (e.g., Grassland ecosystem, where the number of grasses is far greater than the number of top carnivores).</p> <p>Inverted: Tree ecosystem (One single tree supports many birds, which in turn support even more parasites).</p>
Pyramid of Biomass	<p>Usually Upright: (e.g., Forest ecosystem, where the biomass of trees is huge compared to the animals).</p> <p>Inverted: Aquatic ecosystems (e.g., Sea/Pond). The biomass of fishes far exceeds that of phytoplankton, as phytoplankton have a very rapid turnover rate.</p>
Pyramid of Energy	<p>ALWAYS Upright: It can never be inverted. Because when energy flows from a particular trophic level to the next, some energy is always lost as heat at each step (the 10% Law).</p>

Food Chains

- Grazing Food Chain (GFC): Starts with producers (plants). In an aquatic ecosystem, GFC is the major conduit for energy flow.
 - Example: Grass -> Goat -> Man
- Detritus Food Chain (DFC): Starts with dead organic matter. It is made up of decomposers (saprotrophs, mostly fungi and bacteria). In a terrestrial ecosystem, a much larger fraction of energy flows through the DFC than the GFC.

Food Web & Trophic Levels

- Food Web: Natural interconnections of food chains form a food web, providing stability to the ecosystem.
- Trophic Level: Organisms occupy a specific place in the food chain based on their source of food.
 - First Trophic Level (T1): Producers (Plants, Phytoplankton)
 - Second Trophic Level (T2): Primary Consumers (Herbivores, Zooplankton)

Limitations of Ecological Pyramids

1. They assume a simple, straight food chain, which almost never exists in nature.
2. They do not accommodate a food web.

3. Saprophytes (decomposers) are not given any place in ecological pyramids, even though they play a vital role in the ecosystem.
4. They do not take into account the same species belonging to two or more trophic levels (e.g., a bird eating seeds is a primary consumer, but eating insects makes it a secondary consumer).



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