Q2. Discuss energy flow and nutrient cycling in a cybernetic ecosystem

---

a) Explain energy flow using a suitable flow diagram. (4 marks)

Answer:
Energy flow in ecosystems follows a **unidirectional pathway** because energy cannot be recycled, unlike matter. It is governed by the **laws of thermodynamics**:

1. **First Law (Energy cannot be created or destroyed):** The total amount of solar energy remains constant but changes form (light → chemical → heat).
2. **Second Law (Energy transformation is inefficient):** At each trophic level, around **90% of energy is lost as heat** during respiration and metabolic activities, leaving only ~10% available to the next level (10% law).

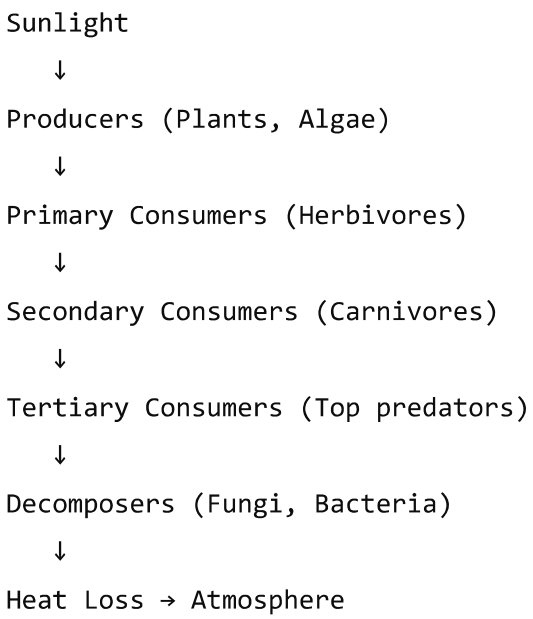
Pathway of energy flow:

- **Sunlight (Primary source):** Enters the ecosystem as radiant energy.
- **Producers (Autotrophs):** Convert solar energy into chemical energy (glucose) via photosynthesis.
- **Primary consumers (Herbivores):** Obtain energy by feeding on producers.
- **Secondary and tertiary consumers (Carnivores/Omnivores):** Gain energy by feeding on herbivores or other carnivores.
- **Decomposers (Bacteria, fungi):** Break down dead organisms, releasing organic matter and nutrients, which indirectly support energy capture by producers.

Features:

- Energy flow is **linear and unidirectional**.
- Each step is called a **trophic level**.
- Energy flow can be represented as **food chains, food webs, or ecological pyramids**.

Schematic diagram (Energy flow):



b) Describe the role of nutrient cycling in maintaining ecosystem balance. (3 marks)

Answer:
Nutrient cycling, also called **biogeochemical cycling**, is the process through which essential elements (carbon, nitrogen, phosphorus, sulphur, water) circulate between the **abiotic environment** (soil, water, air) and **biotic components** (plants, animals, microbes).

Steps in nutrient cycling:

1. **Input phase –** Nutrients enter ecosystems through weathering of rocks, atmospheric deposition, or human inputs (fertilizers).
2. **Uptake and assimilation –** Producers absorb inorganic nutrients (e.g., nitrate, phosphate, CO_2) and convert them into organic matter.
3. **Transfer phase –** Nutrients are transferred through food chains (plant → herbivore → carnivore).
4. **Return phase –** Decomposers mineralize organic matter, returning nutrients back to soil, water, or air.

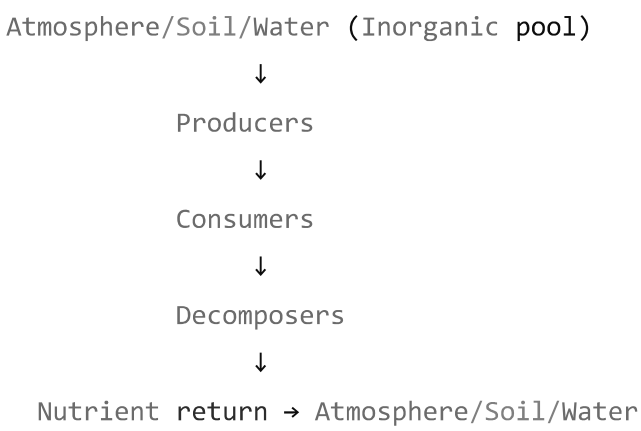
Role in ecosystem balance:

- Maintains **homeostasis** by regulating nutrient availability.
- Prevents **nutrient depletion** in soils.
- Connects **abiotic resources** with **biotic productivity**.
- Enhances **resilience** of ecosystems to disturbances.

Example cycles:

- **Carbon cycle**: Regulates climate by controlling CO_2 concentration.
- **Nitrogen cycle**: Ensures availability of nitrates for plant growth.
- **Phosphorus cycle**: Critical for DNA, ATP, and cellular metabolism.

Schematic diagram (General nutrient cycle):



---

c) Mention two human activities that disturb these cycles. (3 marks)

Answer:

1. **Deforestation and land-use change**
   - Reduces the ability of forests to absorb carbon dioxide.

- Causes **carbon cycle imbalance** → contributes to global warming.
- Loss of vegetation alters water and nutrient retention in soils.

2. **Excessive use of fertilizers and industrial activities**
   - Introduces high amounts of nitrogen and phosphorus into ecosystems.
   - Causes **eutrophication** of water bodies → algal blooms → oxygen depletion → fish deaths.
   - Excessive nitrogen oxides from industries contribute to **acid rain**, disturbing soil nutrient balance.

Other disturbances (for enrichment):

- Burning fossil fuels (enhances CO_2 and SO_2 emissions).
- Mining activities (disturb phosphorus and sulphur cycles).
- Overgrazing and intensive agriculture (depletes soil fertility).

Schematic diagram (Human disturbance):