

CUET · BIOLOGY · CLASS XII · CODE 304

Ecosystem

CUET unit: Ecology and Environment → Ecosystem

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Snapshot

- Establishes the ecosystem as a functional unit of nature where biotic and abiotic components interact; classified into terrestrial (forest, grassland, desert) and aquatic (pond, lake, river, estuary), plus man-made (crop field, aquarium).
- Defines the four functional attributes that NTA repeatedly tests: **productivity, decomposition, energy flow, nutrient cycling**.
- Quantitative anchors NTA loves: 10 per cent law of energy transfer (Lindemann), PAR = <50% of incident radiation, plants capture 2–10% of PAR, global NPP \approx 170 billion tons (dry), ocean NPP \approx 55 billion tons despite covering \sim 70% of Earth's surface.
- Introduces pyramids of number, biomass and energy — and the famous inverted biomass pyramid in the sea (phytoplankton < zooplankton/fishes); pyramid of energy is always upright.
- Closes with nutrient cycling (gaseous — carbon; sedimentary — phosphorus) and ecosystem services (e.g., purification of air and water by forests).

Detailed Notes

2.1 Core concepts

- An ecosystem is a functional unit of nature where living organisms interact among themselves and with the surrounding physical environment; sizes range from a small pond to a forest or sea, and the entire biosphere is the global ecosystem (NCERT §12 intro, p. 205).
- Ecosystems are broadly divided into **terrestrial** (forest, grassland, desert) and **aquatic** (pond, lake, wetland, river, estuary); crop fields and aquaria are man-made ecosystems (NCERT §12 intro, p. 205).
- The interaction of biotic and abiotic components yields a characteristic physical structure for every ecosystem; the two main structural features are **species composition** (list/enumeration of species) and **stratification** (vertical distribution of species, e.g., trees at top, shrubs middle, herbs/grasses at bottom of a forest) (NCERT §12.1, p. 206).
- The four functional aspects of an ecosystem are: (i) Productivity, (ii) Decomposition, (iii) Energy flow, (iv) Nutrient cycling (NCERT §12.1, p. 206).

- In a pond, the abiotic component is water with dissolved substances and bottom soil; autotrophs are phytoplankton, algae and floating/submerged/marginal plants; consumers are zooplankton and free-swimming/bottom-dwelling forms; decomposers are fungi, bacteria and flagellates abundant at the bottom (NCERT §12.1, p. 206).
- **Primary production** = biomass or organic matter produced per unit area over a time period by plants during photosynthesis; expressed in g m^{-2} (weight) or kcal m^{-2} (energy). Rate of biomass production = **productivity**, in $\text{g m}^{-2} \text{yr}^{-1}$ or $\text{kcal m}^{-2} \text{yr}^{-1}$ (NCERT §12.2, p. 207).
- **GPP** = rate of production of organic matter during photosynthesis. A considerable amount of GPP is utilised by plants in respiration (R). **$\text{NPP} = \text{GPP} - \text{R}$** . NPP is the biomass available for consumption by heterotrophs (herbivores + decomposers). **Secondary productivity** = rate of formation of new organic matter by consumers (NCERT §12.2, p. 207).
- Annual NPP of the whole biosphere \approx **170 billion tons (dry weight)** of organic matter; oceans contribute only **55 billion tons** despite occupying $\sim 70\%$ of Earth's surface (NCERT §12.2, p. 207).
- **Decomposition** = breakdown of complex organic matter into inorganic substances (CO_2 , water, nutrients) by decomposers; **detritus** (dead leaves, bark, flowers, animal remains and faecal matter) is the raw material (NCERT §12.3, p. 207).
- Steps of decomposition (operate simultaneously): **fragmentation** (detritivores like earthworms break detritus into smaller particles), **leaching** (water-soluble inorganic nutrients percolate into soil horizon and get precipitated as unavailable salts), **catabolism** (bacterial and fungal enzymes degrade detritus into simpler inorganic substances), **humification** (forms dark amorphous humus, colloidal, resistant to microbial action, reservoir of nutrients), **mineralisation** (humus is further degraded to release inorganic nutrients) (NCERT §12.3, pp. 207–208).
- Decomposition is largely **oxygen-requiring**; slower if detritus is rich in **lignin and chitin**, quicker if rich in **nitrogen and water-soluble sugars**; **warm and moist** conditions favour decomposition while **low temperature and anaerobiosis** inhibit it (NCERT §12.3, p. 208).
- Sun is the only energy source for ecosystems (except deep-sea hydrothermal vents). **PAR** (photosynthetically active radiation) = less than 50% of incident solar radiation; plants capture only **2–10% of PAR**, and this small fraction sustains the entire living world (NCERT §12.4, p. 209).
- Energy flow obeys the first and second laws of thermodynamics; it is **unidirectional** — sun \rightarrow producers \rightarrow consumers \rightarrow decomposers (NCERT §12.4, p. 209).
- A simple **grazing food chain (GFC)** is: Grass (Producer) \rightarrow Goat (Primary Consumer) \rightarrow Man (Secondary Consumer); the **detritus food chain (DFC)** begins with dead organic matter and is dominated by saprotrophic fungi and bacteria (NCERT §12.4, pp. 209–210).

- In **aquatic** ecosystems, GFC is the major energy conduit; in **terrestrial** ecosystems, a much larger fraction of energy flows through the DFC. The interconnection of GFC and DFC forms a **food web** (NCERT §12.4, p. 210).
- Trophic levels: producers (1st), primary consumer/herbivore (2nd), secondary consumer/carnivore (3rd), tertiary consumer/top carnivore (4th, e.g., man, lion) (NCERT §12.4 Fig. 12.2, p. 210).
- **Standing crop** = mass of living material (biomass) or number per unit area at a particular time at each trophic level; biomass is measured in fresh or dry weight, with dry weight being more accurate (NCERT §12.4, p. 211).
- **10 per cent law (Lindemann)** — only 10% of the energy is transferred to each trophic level from the lower trophic level; this restricts the number of trophic levels in a grazing food chain (NCERT §12.4, p. 211).
- **Ecological pyramids** — base = producers (1st trophic level), apex = top consumer; expressed as pyramid of (a) number, (b) biomass or (c) energy (NCERT §12.5, p. 212).
- Most pyramids are upright (producers > herbivores > carnivores). Exceptions: pyramid of number for a big tree-insect-bird system can be inverted (or spindle-shaped); the **pyramid of biomass in the sea is inverted** because biomass of fishes far exceeds the standing crop of phytoplankton (NCERT §12.5, pp. 212–213).
- The **pyramid of energy is always upright** and can never be inverted, because some energy is always lost as heat at each transfer (NCERT §12.5, p. 213).
- An ideal energy pyramid: 1,000,000 J sunlight → 10,000 J producers → 1,000 J primary consumer → 100 J secondary consumer → 10 J tertiary consumer; primary producers convert only 1% of incident sunlight into NPP (NCERT §12.5 Fig. 12.4d, p. 213).
- Limitations of ecological pyramids: they do not account for the same species at two or more trophic levels, assume a simple linear food chain (ignoring food webs), and exclude saprophytes despite their vital role (NCERT §12.5, p. 214).
- Nutrient cycling is of two types — **gaseous** (reservoir = atmosphere/hydrosphere; e.g., carbon cycle) and **sedimentary** (reservoir = Earth's crust; e.g., phosphorus cycle). Outputs of ecosystem processes are termed **ecosystem services**, e.g., purification of air and water by forests (NCERT §12 Summary, p. 214).

2.2 Definitions to memorise

| Term | Definition | Page |
|----------------|--------------------------------------------------------------------------------------------------------------|------|
| Ecosystem | Functional unit of nature where living organisms interact among themselves and with the physical environment | 205 |
| Stratification | Vertical distribution of different species occupying different levels in an ecosystem | 206 |
| | | 206 |

| Term | Definition | Page |
|---------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| Species composition | Identification and enumeration of plant and animal species of an ecosystem | |
| Primary production | Biomass or organic matter produced per unit area over a time period by plants during photosynthesis (g m^{-2} or kcal m^{-2}) | 207 |
| Productivity | Rate of biomass production ($\text{g m}^{-2} \text{yr}^{-1}$ or $\text{kcal m}^{-2} \text{yr}^{-1}$) | 207 |
| GPP | Gross primary productivity — rate of production of organic matter during photosynthesis | 207 |
| NPP | Net primary productivity = $\text{GPP} - \text{R}$; biomass available to heterotrophs | 207 |
| Secondary productivity | Rate of formation of new organic matter by consumers | 207 |
| Detritus | Dead plant remains (leaves, bark, flowers) and animal remains including faecal matter — raw material for decomposition | 207 |
| Fragmentation | Breakdown of detritus into smaller particles by detritivores (e.g., earthworm) | 207 |
| Leaching | Water-soluble inorganic nutrients go down into the soil horizon and get precipitated as unavailable salts | 207 |
| Catabolism | Bacterial and fungal enzymes degrade detritus into simpler inorganic substances | 207 |
| Humification | Accumulation of a dark coloured amorphous, colloidal humus, highly resistant to microbial action, that serves as nutrient reservoir | 207–208 |
| Mineralisation | Further degradation of humus by microbes releasing inorganic nutrients | 208 |
| PAR | Photosynthetically active radiation — less than 50% of incident solar radiation | 209 |
| Producers | Green plants (terrestrial: herbs, woody plants; aquatic: phytoplankton, algae, higher plants) | 209 |
| Detritus food chain (DFC) | Food chain that begins with dead organic matter; dominated by saprotrophic fungi and bacteria | 210 |
| Trophic level | Specific place an organism occupies in a food chain based on source of nutrition | 210 |
| Standing crop | Mass of living material (biomass) or number per unit area at a trophic level at a given time | 211 |
| 10 per cent law | Only 10% of the energy is transferred to each trophic level from the lower trophic level | 211 |
| Ecosystem services | Products of ecosystem processes, e.g., purification of air and water by forests | 214 |

2.3 Diagrams / processes to remember

- **Figure 12.1 (p. 208)** — Decomposition cycle in a terrestrial ecosystem: tree → leaf fall → detritivores/fungi/bacteria → leaching → further decomposition by earthworms/mites → organic-rich soil → tree.
- **Figure 12.2 (p. 210)** — Trophic levels: Producer (phytoplankton, grass, trees) → Primary Consumer/Herbivore (zooplankton, grasshopper, cow) → Secondary Consumer/Carnivore (birds, fishes, wolf) → Tertiary Consumer/Top Carnivore (man, lion).
- **Figure 12.3 (p. 211)** — Energy flow through trophic levels with heat loss at each step; producer → herbivore → carnivore → top carnivore + parallel detritus channel.
- **Figure 12.4a (p. 212)** — Pyramid of numbers (grassland): 5,842,000 producers → 7,08,000 primary consumers → 3,54,000 secondary consumers → 3 tertiary consumers.
- **Figure 12.4b (p. 212)** — Upright pyramid of biomass (dry weight kg m^{-2}): P=809, PC=37, SC=11, TC=1.5.
- **Figure 12.4c (p. 212)** — Inverted pyramid of biomass: P=4, PC=21 (small phytoplankton standing crop supports large zooplankton standing crop).
- **Figure 12.4d (p. 213)** — Ideal pyramid of energy: 1,000,000 J sunlight → 10,000 J producers → 1,000 J PC → 100 J SC → 10 J TC; producers fix only 1% of incident sunlight as NPP.

2.4 Common confusions / NTA trap points

- **PAR vs incident solar radiation vs PAR captured.** PAR is **less than 50%** of incident radiation; of this PAR, only **2–10%** is captured by plants. Don't confuse "50%" (PAR fraction) with "2–10%" (capture efficiency).
- **GPP – R = NPP.** NPP is what is left after respiration losses; it is NOT the same as GPP. NPP is the biomass available to heterotrophs.
- **Pyramid of energy is ALWAYS upright** — even in the sea. Only pyramid of number and pyramid of biomass can be inverted.
- **Inverted biomass pyramid in the sea** — phytoplankton (producers) have small standing crop because of high turnover; fishes have higher biomass.
- **Carbon = gaseous cycle** (reservoir: atmosphere/hydrosphere). **Phosphorus = sedimentary cycle** (reservoir: Earth's crust). NTA loves to swap these.
- **Decomposition rate** — slower with lignin/chitin; faster with nitrogen and sugars. Warm + moist favours decomposition; low temperature + anaerobiosis inhibit it.
- **Detritivores ≠ decomposers.** Detritivores (e.g., earthworms) do fragmentation; decomposers (fungi, bacteria) do catabolism, humification and mineralisation.
- **Aquatic vs terrestrial energy flow** — in aquatic ecosystems GFC dominates; in terrestrial ecosystems a much larger fraction goes through DFC.

Practice MCQs

Q1. According to the 10 per cent law of Lindemann, if the energy available at the producer level in a grazing food chain is 20,000 J, the energy available to the secondary consumer (carnivore) will be:

- A. 2,000 J
- B. 200 J
- C. 20 J
- D. 100 J

Q2. In the formula $GPP - R = NPP$, the term R refers to:

- A. Reproduction losses of plants
- B. Respiration losses of plants
- C. Radiation losses to the atmosphere
- D. Rainfall-related runoff losses

Q3. Which of the following statements about the productivity of the biosphere is correct?

- A. Annual NPP of the biosphere is ~170 billion tons; oceans contribute ~55 billion tons despite occupying ~70% of Earth's surface.
- B. Annual NPP of the biosphere is ~55 billion tons; oceans contribute ~170 billion tons.
- C. Annual NPP of the biosphere is ~170 billion tons; oceans contribute ~115 billion tons, more than land.
- D. Annual NPP of the biosphere is ~70 billion tons; oceans contribute ~50 billion tons.

 **12 more MCQs + answer key**

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PYQ Alignment

Ecosystem is among the highest-yielding chapters in CUET (UG) Biology, typically contributing 4–6 direct MCQs annually across CUET 2023, 2024 and 2025. NTA's favourite hooks here are the 10 per cent law (numerical), the percentage of PAR (less than 50% vs 2–10% capture), GPP/NPP/secondary productivity definitions, the five steps of decomposition (especially leaching vs catabolism vs humification), and the inverted biomass pyramid of the sea. Statement-based, match-the-following and assertion–reason items dominate, with at least one calculation question almost every cycle.

CUET 2025 — Actual PYQs from this chapter

Q.3 (CUET 2025) Choose the correct formula showing the relationship between Gross Primary Productivity (GPP), Respiration losses (R), and Net Primary Productivity (NPP).

- A) $GPP = R / NPP$
- B) $GPP = 2NPP + R$
- C) $GPP = NPP - R$
- D) $GPP - R = NPP$

Tests: aligns with §2 (ecosystem) **Answer:** Not in extracted key — verify against official NTA key

Q.27 (CUET 2025) If a man is eating fish as food, which trophic level is he in?

- A) First
- B) Second
- C) Third
- D) Fourth

Tests: aligns with §2 (ecosystem) **Answer:** Not in extracted key — verify against official NTA key

Q.29 (CUET 2025) A small standing crop of phytoplankton supporting large zooplankton crop represents:

- A) Inverted pyramid of biomass
- B) Upright pyramid of biomass
- C) Upright pyramid of energy
- D) Inverted pyramid of energy

Tests: aligns with §2 (ecosystem) **Answer:** Not in extracted key — verify against official NTA key

Q.33 (CUET 2025) Humification leads to:

- A) Soil erosion
- B) Soil conservation

- C) Accumulation of humus
- D) Accumulation of salts

Tests: aligns with §2 (ecosystem) **Answer:** Not in extracted key — verify against official NTA key

Q.39 (CUET 2025) Percentage of photosynthetically active radiation (PAR) in solar radiation is:

- A) 100%
- B) 50%
- C) 1–5%
- D) 2–10%

Tests: aligns with §2 (ecosystem) **Answer:** Not in extracted key — verify against official NTA key

CUET 2024 — Actual PYQs from this chapter

Q.37 (CUET 2024) Mineralisation releases:

- A) Inorganic nutrients from detritus and humus formation
- B) Organic nutrients from humus
- C) Inorganic nutrients from humus
- D) Organic & inorganic nutrients from detritus

Tests: aligns with §2 (ecosystem) **Answer:** Not in extracted key — verify against official NTA key

Q.38 (CUET 2024) In which ecosystem biomass of primary consumers exceeds producers?

- A) Forest
- B) Grassland
- C) Desert
- D) Sea

Tests: aligns with §2 (ecosystem) **Answer:** Not in extracted key — verify against official NTA key

Q.42 (CUET 2024) Ecological pyramid is always upright for:

- A) Energy
- B) Biomass
- C) Numbers
- D) Consumers

Tests: aligns with §2 (ecosystem) **Answer:** Not in extracted key — verify against official NTA key

CUET 2023 — Actual PYQs from this chapter

Q.35 (CUET 2023) Natural interconnections of food chain is:

- A) GFC
- B) DFC
- C) Food web
- D) Biomass

Tests: aligns with §2 (ecosystem) **Answer:** Not in extracted key — verify against official NTA key

Q.36 (CUET 2023) Correct statements regarding food chain: (A) Primary carnivores are tertiary consumers. (B) Energy flow from sun → producers → consumers is unidirectional. (C) Death of organism initiates detritus food chain. (D) Plants are primary consumers.

- A) A and B only
- B) A and D only
- C) B and C only
- D) C and D only

Tests: aligns with §2 (ecosystem) **Answer:** Not in extracted key — verify against official NTA key

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