Collegedunia NCERT Notes

Class 12 Biology NCERT Notes Chapter 12 Ecosystem — Full-colour diagrams, NEET-ready

Chapter 12: Ecosystem

Class 12 Biology — NCERT 2026-27 (Rationalised Syllabus)

Why this chapter matters

Ecosystem is one of the most predictable NEET scoring chapters in the Ecology unit. Every year, 2–3 direct questions appear on **productivity (GPP / NPP / 10% law)**, decomposition steps, trophic-level mathematics and ecological pyramids. For boards, the decomposition sequence, the GPP–R–NPP relation and the inverted pyramid in oceans are recurring short-answer favourites. The figures (12.1 through 12.4) are testable verbatim — memorise them along with the prose.

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1 Ecosystem — Structure and Function

An **ecosystem** is a functional unit of nature where living organisms interact among themselves and with the surrounding physical environment. The size ranges from a small puddle to the entire biosphere; for study, ecologists split it into two basic categories.

- **Terrestrial ecosystems** — forest, grassland, desert.
- **Aquatic ecosystems** — pond, lake, wetland, river, estuary.
- **Man-made ecosystems** — crop fields, aquaria.

The interaction of biotic and abiotic components produces a characteristic physical structure for each ecosystem type. Two structural features matter most:

- **Species composition** — identification and enumeration of the plant and animal species present.
- **Stratification** — vertical distribution of species in different layers. In a forest: *trees* occupy the top stratum, *shrubs* the middle, *herbs and grasses* the bottom.

The four functional components of any ecosystem

Productivity + Decomposition + Energy flow + Nutrient cycling

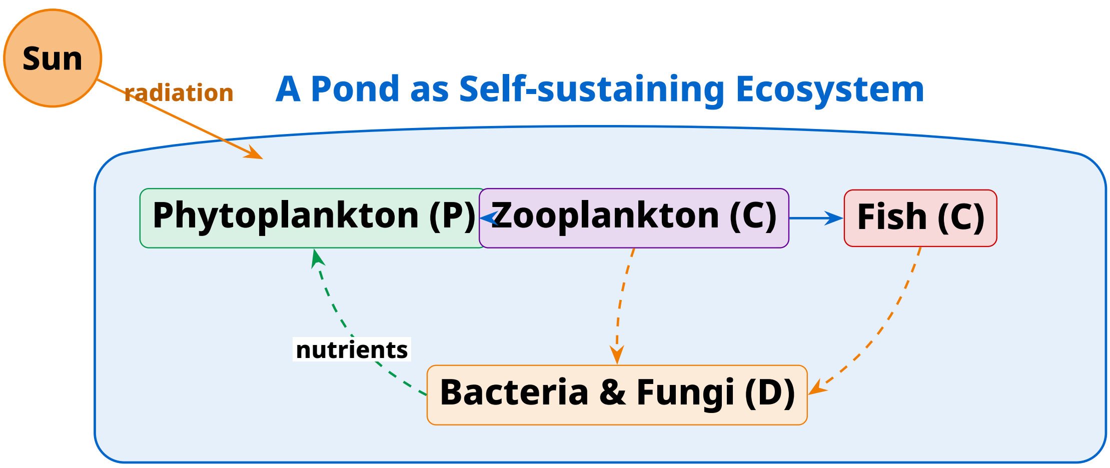
These are the four processes that knit biotic and abiotic factors into a functioning unit. The chapter examines productivity, decomposition and energy flow in depth; nutrient cycling is treated as a Beyond-NCERT extension for NEET.

1.1 The Pond — a model self-sustaining ecosystem

NCERT uses a small pond to illustrate every ecosystem function in miniature. The pond is shallow, bounded, and exhibits all four functional components clearly.

- **Abiotic** — water with dissolved inorganic and organic substances, plus the rich soil deposit at the bottom; solar input and the daily/seasonal cycles of temperature, day-length and climate regulate the rate of every function.
- **Autotrophs** — phytoplankton, algae and floating, submerged and marginal plants at the edges.
- **Consumers** — zooplankton, free-swimming nekton, and bottom-dwelling benthic forms.
- **Decomposers** — fungi, bacteria and flagellates (especially abundant at the bottom).

The pond performs every function of the biosphere as a whole: photosynthetic conversion of inorganic to organic matter, consumption of autotrophs by heterotrophs, decomposition and mineralisation, and the **unidirectional flow of energy** toward higher trophic levels with progressive dissipation as heat.



P = producer C = consumer D = decomposer

The energy current is one-way

Energy enters as solar radiation, is captured by autotrophs, transferred to consumers and decomposers, and ultimately leaves as heat. Nutrients cycle (atoms return to the soil/water pool) but energy does not — it is dissipated. This is a direct consequence of the second law of thermodynamics applied to ecosystems.

Decoding NCERT pond figures

When NCERT asks "label the abiotic / biotic / decomposer components" for a pond diagram, always start with **water + dissolved minerals + bottom soil** (abiotic) before listing organisms. Many students lose a mark by mentioning only living things.

2 Productivity

A constant input of solar energy is the basic requirement for any ecosystem to function. **Primary production** is the amount of biomass (organic matter) produced per unit area over a time period by plants during photosynthesis.

- Units of **primary production**: g m^{-2} (weight) or kcal m^{-2} (energy).
- Units of **primary productivity** (the rate): g $m^{-2}\,yr^{-1}$ or kcal $m^{-2}\,yr^{-1}$.

2.1 Gross vs Net Primary Productivity

Plants do not keep all the carbohydrate they make; a substantial fraction is burnt for their own respiration. The NCERT-defined relation is:

The fundamental productivity equation

$$\boxed{\text{NPP} = \text{GPP} - R}$$

where

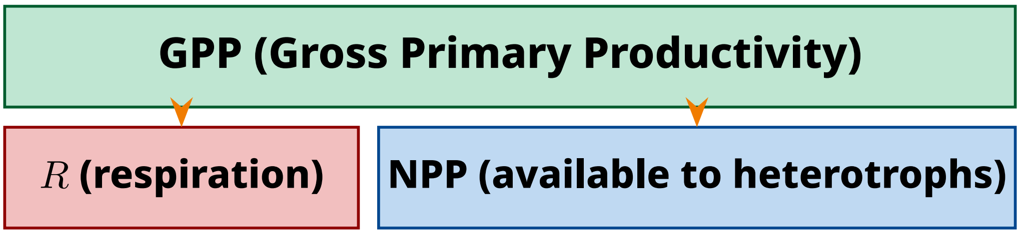
- **GPP (Gross Primary Productivity)** = rate of production of organic matter during photosynthesis.
- R **(Respiratory losses)** = organic matter the plant itself oxidises to run metabolism.
- **NPP (Net Primary Productivity)** = biomass available for the consumption of heterotrophs (herbivores and decomposers).

Numerical example. If a grassland fixes 1800 g $m^{-2}\,yr^{-1}$ of organic matter through photosynthesis (GPP), and respiratory losses are 600 g $m^{-2}\,yr^{-1}$, the net amount left for grazers is:

$$\text{NPP} = \text{GPP} - R$$

$$\text{NPP} = 1800 - 600$$
$$\text{NPP} = 1200\ \text{g m}^{-2}\,\text{yr}^{-1}$$

Secondary productivity is defined as the rate of formation of new organic matter by consumers — i.e., how efficiently herbivores and carnivores convert ingested food into their own body mass.



$$\textbf{GPP} = R + \textbf{NPP}$$

NPP is the herbivore's pay-cheque

Only NPP — not GPP — can support the entire heterotrophic world. If plants respired away all the carbon they fixed (NPP $\to 0$), no animal life would be possible regardless of how high GPP rose. This is why drought-stressed forests, which respire away more of their fix during heat-waves, can become net carbon sources even though they look "green".

2.2 Productivity of the biosphere

NCERT gives one striking factual nugget that NEET asks repeatedly:

- Annual NPP of the whole biosphere $\approx$ **170** billion tonnes (dry weight) of organic matter.
- Of this, oceans contribute only **55** billion tonnes, despite covering $\sim$70% of Earth's surface.
- Rest ($\sim$115 billion tonnes) is produced on land.

The low oceanic share is attributed to nutrient limitation (phosphorus, nitrogen, iron are scarce in open-ocean surface waters), reduced light penetration with depth, and the small standing crop of phytoplankton.

Memorise the biosphere figures

170 / 55 / 115 (Total / Ocean / Land in billion tonnes per year). NEET has set numerical-recall MCQs on these numbers — write them on the inside cover of your revision notebook.

GPP vs NPP units

GPP, NPP and R all share the same units (g m^{-2} yr^{-1}) — they are rates. A common error is to write GPP as "1800 g m^{-2}" (production) instead of "1800 g m^{-2} yr^{-1}" (productivity). The textbook is precise: *production* is the amount, *productivity* is the rate.

3 Decomposition

Decomposers (mainly bacteria, fungi, and some invertebrate detritivores) break down complex organic matter into inorganic substances — carbon dioxide, water, and mineral nutrients — and return them to the soil/water pool. The earthworm is the classical "farmer's friend" because it accelerates this process and aerates the soil.

The raw material for decomposition is **detritus** — dead plant parts (leaves, bark, flowers), dead animal remains, and faecal matter.

3.1 The five steps of decomposition

NCERT lists exactly five steps. They do not run strictly in sequence; in nature, all five operate simultaneously on the detritus heap (refer Fig. 12.1 below).

1. **Fragmentation** — detritivores such as earthworms break detritus into smaller particles, vastly increasing the surface area available for microbial enzyme attack.
2. **Leaching** — water-soluble inorganic nutrients percolate down into the soil horizon and may get precipitated as unavailable salts.
3. **Catabolism** — bacterial and fungal extracellular enzymes degrade detritus into simpler inorganic substances.
4. **Humification** — accumulation of a dark-coloured amorphous substance called **humus** in the upper soil; humus is highly resistant to microbial action, colloidal, and acts as a nutrient reservoir.
5. **Mineralisation** — further microbial degradation of humus releases inorganic nutrients (NH_4^+, NO_3^-, PO_4^{3-}, K^+, etc.) back into the soil pool, ready for re-uptake by plants.

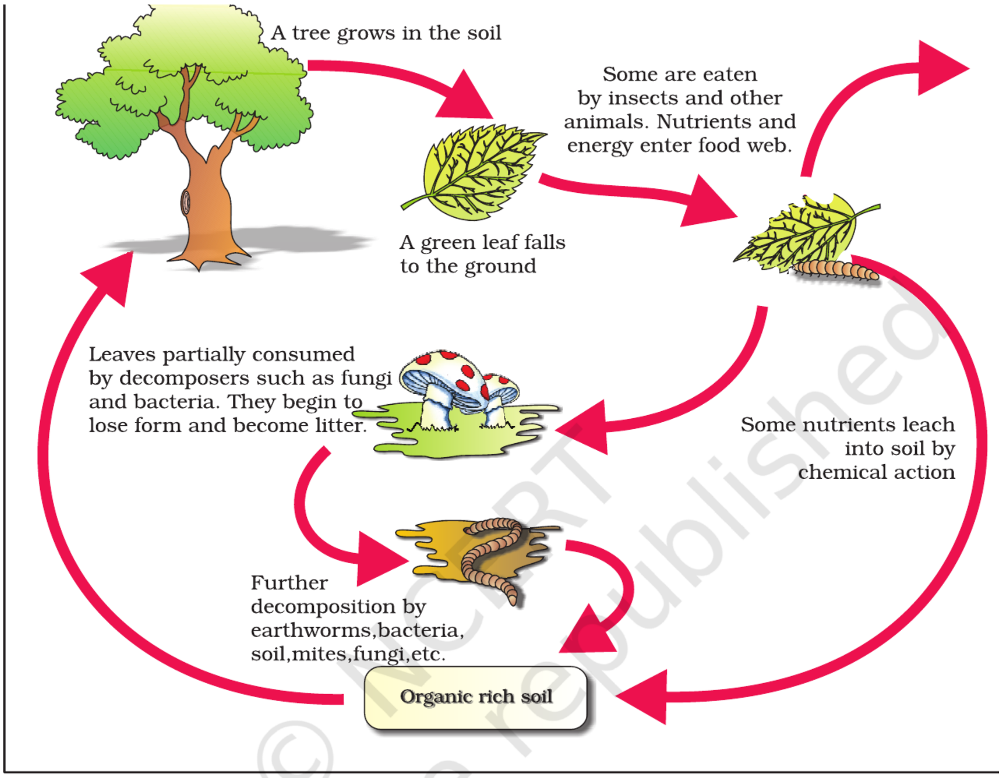


Figure 12.1 Diagrammatic representation of decomposition cycle in a terrestrial ecosystem

Fig. 12.1 (NCERT): Diagrammatic representation of the decomposition cycle in a terrestrial ecosystem. Note that fragmentation, leaching, catabolism, humification and mineralisation operate simultaneously on the same detritus.

Five Foolish Cats Have Long Memories

F–L–C–H–M: **F**ragmentation → **L**eaching → **C**atabolism → **H**umification → **M**ineralisation.
"**F**ive **L**azy **C**ats **H**unt **M**ice" is the order NCERT lists them and is the order assertion-reason questions expect.

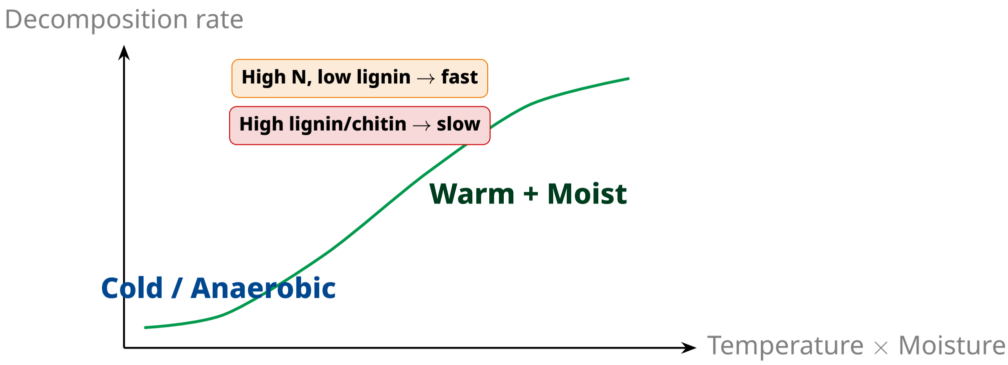
3.2 Factors that control the rate of decomposition

Rate of decomposition

$$\text{Rate} \propto \text{Temperature} \times \text{Soil moisture} \times O_2 \times \frac{1}{\text{lignin + chitin content}}$$

Key dependencies:

- Decomposition is **largely an aerobic** (oxygen-requiring) process.
- Quicker on detritus rich in nitrogen and water-soluble sugars; slower on detritus rich in lignin and chitin.
- Warm + moist conditions accelerate; cold + anaerobic conditions retard.



Why a peat bog never rots

Sphagnum peat bogs in Scotland and Ireland accumulate undecomposed plant matter for millennia because they tick every "slow" box at once: cold, waterlogged (anaerobic), acidic, and rich in lignin. Bog-bodies thousands of years old emerge essentially intact. The same logic explains the formation of coal — carboniferous swamps where decomposition shut down so completely that plant biomass became fossil fuel.

4 Energy Flow

Except for the deep-sea hydrothermal-vent ecosystems (which run on geothermal chemosynthesis), **the Sun is the only source of energy for all ecosystems on Earth**.

4.1 Solar input and capture efficiency

- Less than **50%** of incident solar radiation is photosynthetically active radiation (**PAR**, ∼400–700 nm).
- Plants and photosynthetic bacteria capture only **2–10%** of the available PAR.
- Yet this small fraction sustains the entire living world.

This unidirectional flow — Sun → producers → consumers — complies with both laws of thermodynamics. The first law (conservation) is honoured because no energy is created or destroyed. The second law (entropy) is honoured because ecosystems use the steady solar throughput to maintain the local order that life requires; the universe as a whole still grows in disorder.

Solar accounting at the producer level

$$\begin{aligned} \text{Incident solar} &\to \text{PAR} && \approx 50\% \\ \text{PAR} &\to \text{captured by plants} && \approx 2\text{–}10\% \\ \therefore\ \text{Solar} &\to \text{GPP} && \approx 1\text{–}5\% \end{aligned}$$

4.2 Producers, consumers and food chains

The terminology NCERT insists on:

- **Producers (autotrophs)** — green plants and photosynthetic bacteria. In terrestrial systems mainly herbaceous and woody plants; in aquatic systems phytoplankton, algae and higher plants.
- **Primary consumers (herbivores)** — insects, birds, herbivorous mammals on land; molluscs and zooplankton in water.
- **Secondary consumers (primary carnivores)** — feed on herbivores.
- **Tertiary consumers (secondary carnivores)** — feed on the primary carnivores.
- **Decomposers (saprotrophs)** — fungi and bacteria; meet their energy and nutrient requirements by degrading dead organic matter (*sapro* = to decompose).

NCERT depicts a simple **Grazing Food Chain (GFC)** as:

$$\underbrace{\text{Grass}}_{\text{Producer}} \longrightarrow \underbrace{\text{Goat}}_{\text{Primary consumer}} \longrightarrow \underbrace{\text{Man}}_{\text{Secondary consumer}}$$

The **Detritus Food Chain (DFC)** begins with dead organic matter and is dominated by fungi and bacteria (saprotrophs) which secrete digestive enzymes to break down dead and waste material into simple inorganic substances they then absorb.

4.3 GFC vs DFC — where the energy actually flows

Feature	**Grazing Food Chain (GFC)**	**Detritus Food Chain (DFC)**
Starting point	Living producer (plant)	Dead organic matter (detritus)
Dominant organisms	Herbivores, carnivores	Fungi, bacteria, detritivores
Major in	**Aquatic** ecosystems	**Terrestrial** ecosystems
Energy share	Smaller fraction on land	Larger fraction on land
Connection	Often loops into DFC (faeces, death)	Some organisms preyed on by GFC predators

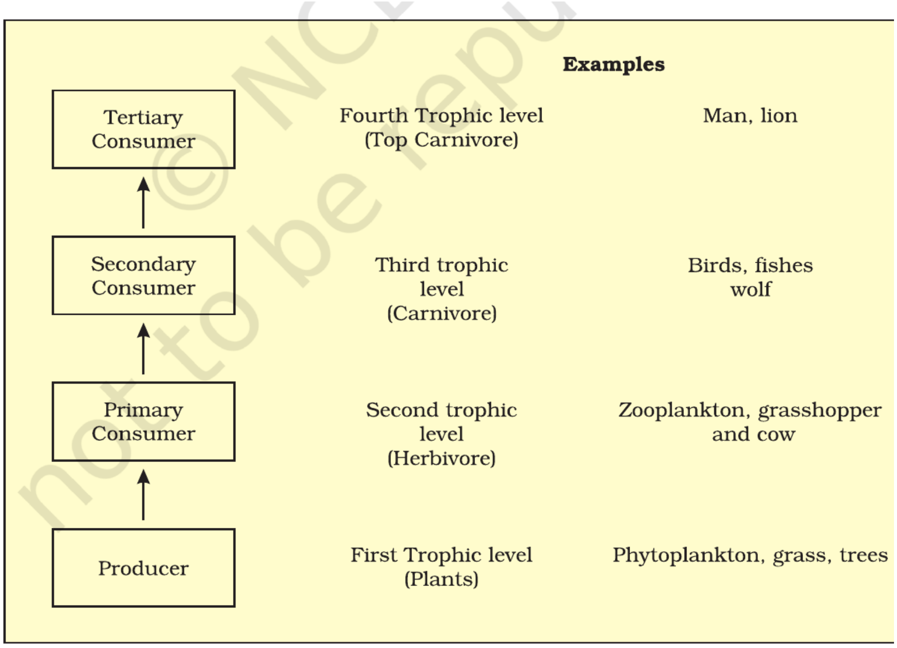


Figure 12.2 Diagrammatic representation of trophic levels in an ecosystem

Fig. 12.2 (NCERT): Diagrammatic representation of trophic levels in an ecosystem — producers at the base, then primary consumers, secondary consumers and tertiary consumers in successive levels.

The natural interconnection of multiple food chains forms a **food web**. Some organisms (cockroaches, crows, humans) are *omnivores* and occupy more than one trophic level simultaneously — which is why a sparrow eating seeds is a primary consumer but the same sparrow eating insects is a secondary consumer.

Trophic level is a functional level, not a species

A given species may occupy more than one trophic level in the same ecosystem at the same time. NCERT explicitly asks the reader: *"Can you work out how many trophic levels human beings function at in a food chain?"* — the answer is up to four (producer-eating, herbivore-eating, primary-carnivore-eating, sometimes top-carnivore-eating).

4.4 Standing crop and the 10% law

Each trophic level carries a certain **standing crop** at any moment — the mass of living organisms (*biomass*) or the number per unit area. Biomass is more accurately measured as **dry weight** (live weight fluctuates with hydration).

The transfer of energy across trophic levels follows Lindeman's **10 per cent law**.

10% Law of Energy Transfer (Lindeman, 1942)

Only **10%** of the energy at one trophic level is transferred to the next; the other 90% is lost as heat, metabolic work and digestive waste.

This is why food chains rarely exceed 4–5 trophic levels — the energy available at level n from a producer base of E_0 is:

$$E_n = E_0 \times (0.10)^{n-1}$$

Worked example. If producers in a meadow fix $E_0 = 10\,000$ J m^{-2} yr^{-1}, the energy available at each higher trophic level is:

$$E_1 = 10\,000 \times (0.10)^0 = 10\,000 \text{ J m}^{-2}\text{ yr}^{-1}$$

$$E_2 = 10\,000 \times (0.10)^1 = 1\,000 \text{ J m}^{-2}\text{ yr}^{-1}$$

$$E_3 = 10\,000 \times (0.10)^2 = 100 \text{ J m}^{-2}\text{ yr}^{-1}$$

$$E_4 = 10\,000 \times (0.10)^3 = 10 \text{ J m}^{-2}\text{ yr}^{-1}$$

By the fifth level there is less than 1 joule left per square metre per year — too little to support a viable predator population. That single arithmetic fact *is* the explanation for short food chains.

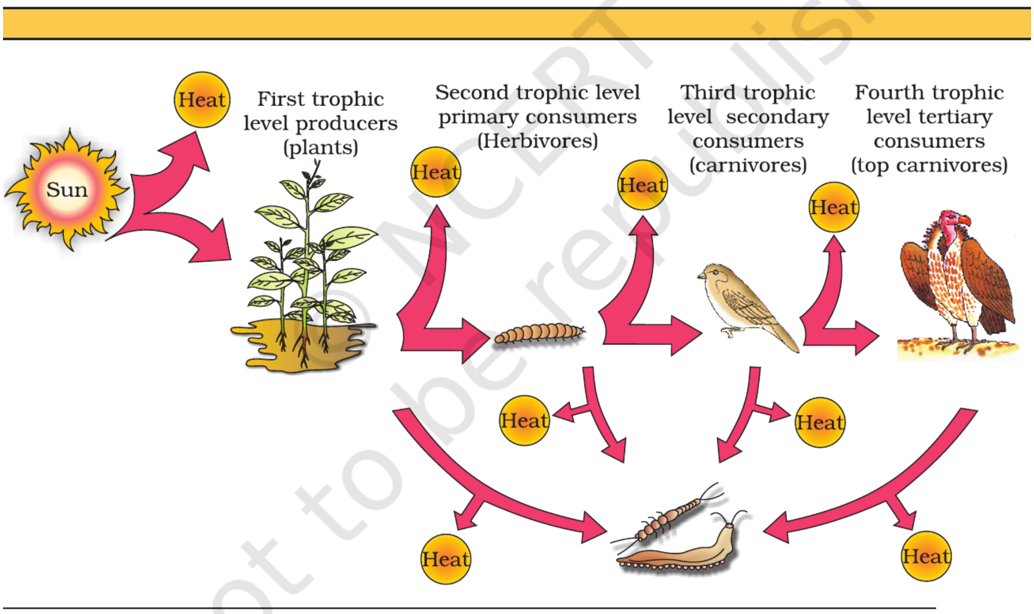


Figure 12.3 Energy flow through different trophic levels

Fig. 12.3 (NCERT): Energy flow through the four classical trophic levels — Producer, Herbivore, Primary Carnivore, Secondary Carnivore. Successive levels lose 90% of incoming energy.

10% is the rule of *thumb*, not of *biomass*

The 10% law refers to **energy transfer**, not biomass transfer. Biomass transfer efficiency varies (often 5–20%) and depends on the type of organisms; energy efficiency is the universal heuristic. Don't quote "10% of the biomass is transferred" — that is wrong even though the numbers happen to coincide for many examples.

NEET shortcut — compound the loss

For any "calculate the energy reaching the n-th trophic level" question, just compute $E_0 \times 10^{-(n-1)}$. Don't draw the pyramid step-by-step — it wastes time and invites arithmetic slips.

5 Ecological Pyramids

A pyramid plots a trophic-level relationship — expressed in number, biomass or energy — with the producer base wide and the top-consumer apex narrow. The three NCERT-recognised types:

1. Pyramid of **numbers**
2. Pyramid of **biomass**
3. Pyramid of **energy**

5.1 Pyramid of Numbers

Counts the *number of individuals* at each trophic level. In a grassland ecosystem, nearly 6 million plants support only 3 top-carnivores, giving the classical upright pyramid.

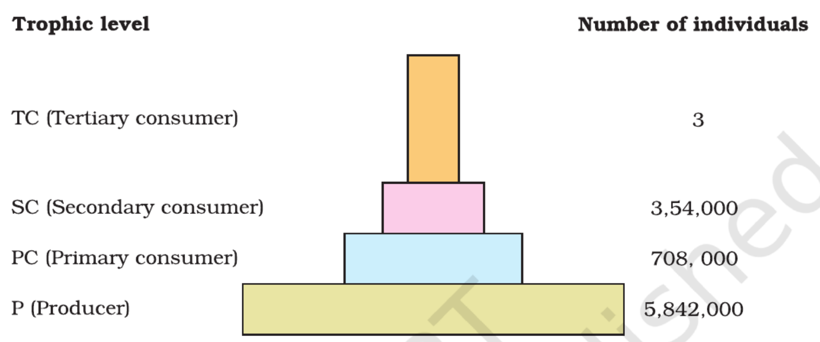


Figure 12.4 (a) Pyramid of numbers in a grassland ecosystem. Only three top-carnivores are supported in an ecosystem based on production of nearly 6 millions plants

Fig. 12.4 (a) (NCERT): Pyramid of numbers in a grassland ecosystem. Only three top-carnivores are supported in an ecosystem based on production of nearly 6 million plants.

A famous **exception**: count the insects feeding on a single big tree, then the small birds eating the insects, then the larger birds eating the small birds. The producer level has just one giant tree, but tens of thousands of insects feed on it — so the pyramid is inverted at the base.

5.2 Pyramid of Biomass

Plots the *dry mass per unit area* (kg m^{-2} in the NCERT figure) at each trophic level. For terrestrial ecosystems, biomass typically falls sharply with trophic level.

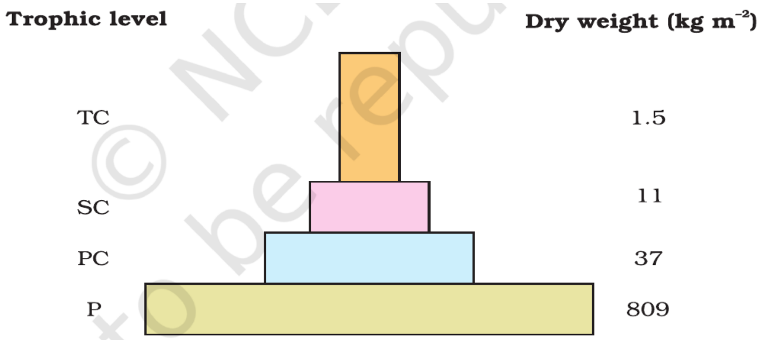


Figure 12.4 (b) Pyramid of biomass shows a sharp decrease in biomass at higher trophic levels

Fig. 12.4 (b) (NCERT): Pyramid of biomass — shows a sharp decrease in biomass at higher trophic levels. Values shown: producer 809, primary consumer 37, secondary consumer 11, tertiary consumer 1.5 (units: kg m^{-2}).

The **paradox of the sea** — in the open ocean, the biomass of fish far exceeds the standing biomass of phytoplankton at any given instant. The pyramid *inverts*.

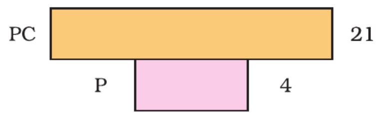


Figure 12.4 (c) Inverted pyramid of biomass-small standing crop of phytoplankton supports large standing crop of zooplankton

Fig. 12.4 (c) (NCERT): Inverted pyramid of biomass — a small standing crop of phytoplankton supports a large standing crop of zooplankton in the ocean.

Why the ocean pyramid inverts

Phytoplankton turn over in days; zooplankton and fish live for months to years. So at a single time snapshot the long-lived consumer biomass is greater than the rapidly-grazed producer biomass. Over a full year, however, the *total production* of phytoplankton is still many times that of fish — only the instantaneous standing crop is inverted, not the annual productivity.

5.3 Pyramid of Energy

Plots the *rate of energy flow* through each trophic level. By the second law of thermodynamics, energy is always lost as heat at each transfer, so the pyramid of energy is **always upright — it can never be inverted**.

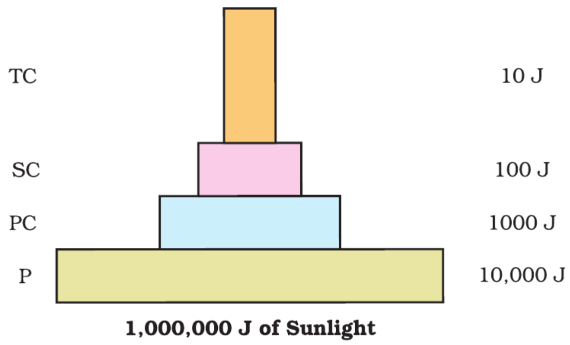


Figure 12.4 (d) An ideal pyramid of energy. Observe that primary producers convert only 1% of the energy in the sunlight available to them into NPP

Fig. 12.4 (d) (NCERT): An ideal pyramid of energy. Observe that primary producers convert only 1% of the energy in the sunlight available to them into NPP. Values: P = 10 000 J, PC = 1000 J, SC = 100 J, TC = 10 J — each step is a 10× loss.

5.4 Comparison and limitations

Feature	Pyramid of Numbers	Pyramid of Biomass	Pyramid of Energy
Unit	Individuals per unit area	g or kg m^{-2} (dry weight)	kcal or J m^{-2} yr^{-1}
Typical shape	Upright in grassland	Upright on land	**Always upright**
Inverted in	A tree-and-insects ecosystem	The open sea (phytoplankton vs zooplankton)	Never
Most reliable	No — ignores size	Partial — snapshot only	**Yes** — obeys 2nd law

Limitations of ecological pyramids (NCERT lists three):

- They do not take into account the same species belonging to two or more trophic levels.
- They assume a simple food chain, which almost never exists in nature; they do not accommodate a food web.
- Saprophytes (decomposers) are not given any place in ecological pyramids, even though they play a vital role.

Pyramid type identification — NEET

If the question says "always upright", the answer is **pyramid of energy**. If it mentions "inverted in oceans", the answer is **pyramid of biomass**. If it mentions "inverted on a single tree", the answer is **pyramid of numbers**. These three pairings have appeared in NEET, AIIMS and CUET MCQs every cycle.

6 Nutrient Cycling [Beyond NCERT — NEET/JEE Extension]

The 2026-27 rationalised NCERT trims the older nutrient-cycle and ecosystem-service sections from this chapter. NEET, however, continues to ask both topics, so the essentials are summarised below.

6.1 Gaseous vs Sedimentary Cycles

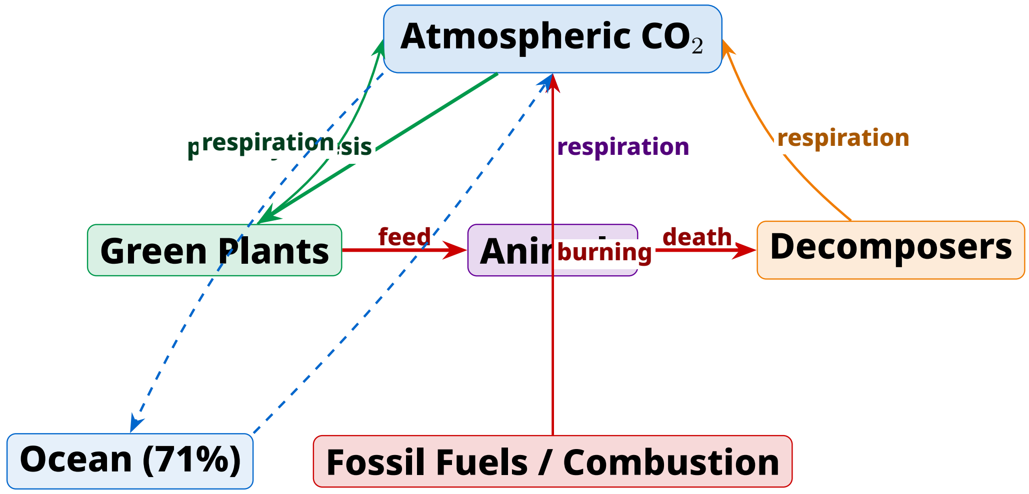
Nutrient cycles (biogeochemical cycles) move elements between living and non-living components of the biosphere.

Feature	Gaseous cycle	Sedimentary cycle
Main reservoir	Atmosphere or hydrosphere	Earth's crust (rocks, soil)
Examples	Carbon, Nitrogen, Water (O_2 too)	Phosphorus, Sulphur, Calcium
Speed of turnover	Fast	Slow (geological)

6.2 The Carbon Cycle

Roughly 71% of all global carbon is dissolved in the oceans; this reservoir regulates atmospheric CO_2. The atmosphere holds only $\sim$1% of the total carbon pool.

- **Carbon fixation**: $\sim 4 \times 10^{13}$ kg of carbon is fixed worldwide each year through photosynthesis.
- **Returns to atmosphere**: respiration (autotrophs + heterotrophs), decomposer activity on detritus, combustion of wood and fossil fuels, volcanic emissions.
- **Sinks**: ocean dissolution, sedimentary rocks (limestone), fossil fuel deposits.



Anthropogenic CO_2 has tilted the cycle

Human activities — burning of fossil fuels, large-scale deforestation, cement manufacture — add $\sim$10 Gt of carbon to the atmosphere each year, of which roughly half is absorbed by oceans and the rest accumulates, driving atmospheric CO_2 above 420 ppm in 2024 (versus the pre-industrial 280 ppm). This is the engine of present-day climate change.

6.3 The Phosphorus Cycle

A model **sedimentary** cycle. The reservoir is rocks containing phosphates.

1. Weathering releases phosphates into the soil solution.
2. Plants absorb phosphate ions ($H_2PO_4^-$, HPO_4^{2-}) through roots.
3. Animals get phosphorus by eating plants or other animals.
4. Decomposers return phosphorus to the soil pool.

Carbon vs Phosphorus cycle — a key contrast

- **No gaseous phase** for phosphorus (no PH_3 in atmosphere of consequence).
- No respiratory release of phosphorus (unlike CO_2 for carbon).
- Excretion (urine, faeces) and decomposition are the main return routes to soil.
- Phosphorus is often the **limiting nutrient** in freshwater ecosystems.

7 Ecosystem Services [Beyond NCERT — NEET/JEE Extension]

The benefits humans derive freely from healthy ecosystems are called **ecosystem services**. Robert Costanza and colleagues (1997) attempted a global valuation of these services.

- Costanza et al. valued the average price tag of the biosphere's services at **US$ 33 trillion per year**.
- For context, global GNP at the time was **US$ 18 trillion per year**.

Healthy forests alone contribute through:

- Purification of air and water
- Mitigation of droughts and floods
- Cycling of nutrients
- Generation of fertile soils
- Pollination of crops (estimated 25% of total services)
- Climate stabilisation
- Storage of biodiversity
- Aesthetic, cultural and spiritual value

The 6:2:1 weighting (Costanza et al.)

Of the 17 categories of services Costanza listed: **soil formation** accounts for ~50% of the value, **recreation & nutrient cycling** together for ~10%, and **climate regulation & habitat services** together for another ~6%. Direct material output (food, raw material) is a comparatively small share — the bulk of nature's value is regulatory and supportive, not extractive.

8 Quick Reference — Formulas, Facts and Figures

Master formula sheet — Ecosystem

$$\begin{aligned}
\text{NPP} &= \text{GPP} - R \\
\text{Energy at level } n &= E_0 \times (0.10)^{n-1} \\
\text{Biosphere NPP} &\approx 170 \text{ Gt yr}^{-1} \text{ (dry wt)} \\
\text{Ocean NPP} &\approx 55 \text{ Gt yr}^{-1} \\
\text{Land NPP} &\approx 115 \text{ Gt yr}^{-1} \\
\text{PAR fraction} &\approx 50\% \text{ of incident solar} \\
\text{Plant capture of PAR} &\approx 2\text{–}10\%
\end{aligned}$$

Term	One-line definition
Ecosystem	Functional unit of nature; biotic + abiotic interacting.
Stratification	Vertical layering of species in an ecosystem.
GPP	Total organic matter produced via photosynthesis per unit area per time.
NPP	GPP minus respiratory losses; biomass available to heterotrophs.
Secondary productivity	Rate of formation of new organic matter by consumers.
Decomposition	Conversion of detritus to inorganic substances.
Detritus	Raw material for decomposition (dead leaves, faeces, etc.).
Catabolism (in decomp.)	Enzymatic breakdown by bacteria + fungi.
Humification	Formation of humus (resistant, colloidal, nutrient reservoir).
Mineralisation	Release of inorganic nutrients from humus.
Standing crop	Mass or number of organisms at a trophic level at one time.
Trophic level	Functional feeding level (Producer = T1, Herbivore = T2, ...).
10% law (Lindeman)	Only 10% of energy passes to the next trophic level.
Pyramid of energy	Always upright; obeys second law of thermodynamics.

Top 7 one-mark recall facts for NEET

1. Biosphere NPP $\approx$ 170 billion tonnes; ocean share $\approx$ 55 Gt.
2. GPP $-$ R $=$ NPP.
3. Decomposition order: **F**–**L**–**C**–**H**–**M**.
4. Decomposition needs O_2; slow if detritus is rich in lignin/chitin.
5. Only 10% of energy transfers per trophic level (Lindeman, 1942).
6. Pyramid of energy is *always* upright.
7. Pyramid of biomass is inverted in the sea; pyramid of numbers is inverted on a single big tree.