The Living World: Ecosystems

AP Environmental Science

Introduction to Ecosystems

An **ecosystem** is all the living things (biotic) and non-living things (abiotic) in an area, interacting together. Organisms depend on each other and on their physical environment, and interactions like **predation**, **competition**, and **symbiosis** (mutualism, commensalism, parasitism) shape the community.

Terrestrial Biomes

A **biome** is a large region defined by its climate and characteristic life. **Terrestrial biomes** (deserts, grasslands, tropical rainforest, temperate forest, taiga, tundra) are determined mainly by temperature and **precipitation**. Each has plants and animals adapted to those conditions.

The two images below sit at opposite ends of the precipitation scale, which is why their life looks so different:

A tropical rainforest: hot and wet all year, giving dense layered plant life and the richest biodiversity of any land biome

A desert : very low precipitation, so only sparse drought-adapted life survives

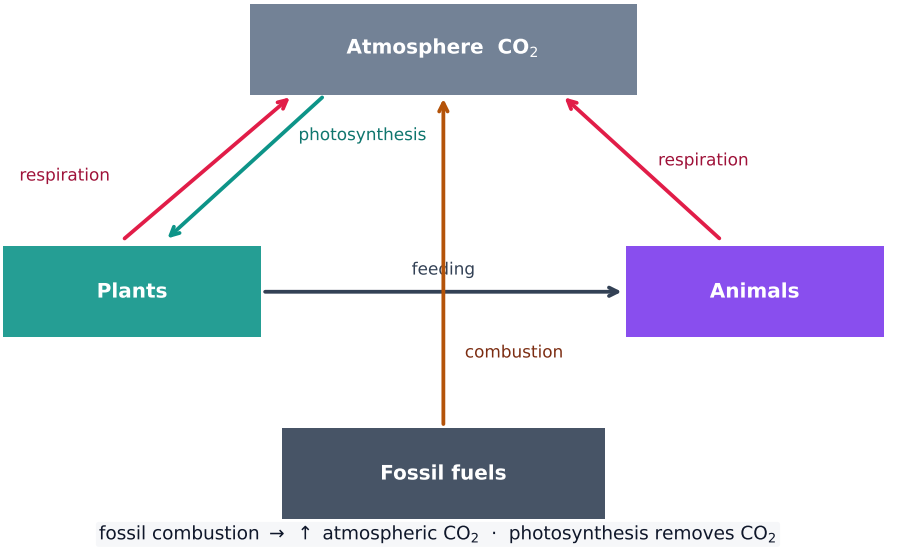
Aquatic Biomes

Aquatic biomes cover more of Earth than land. Freshwater (streams, lakes, wetlands) and marine (open ocean, coral reefs, estuaries) systems differ in **salinity** , sunlight, and nutrients. **Estuaries** (where rivers meet the sea) and coral reefs are especially productive and biodiverse.

A coral reef : warm, sunlit, shallow water makes it one of the most productive and biodiverse of all biomes

The Carbon Cycle

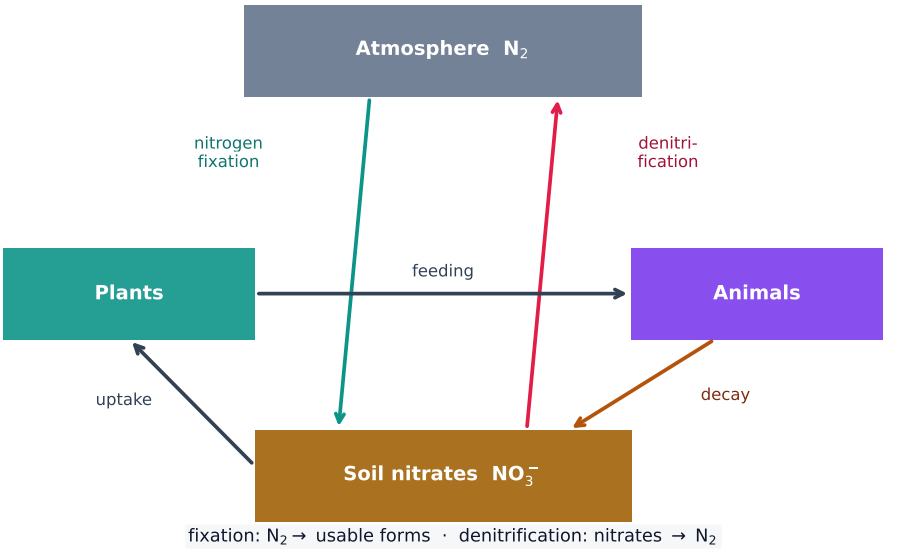
The **carbon cycle** moves carbon between the atmosphere, organisms, oceans, and rocks. **Photosynthesis** removes CO_2; **respiration**, **decomposition**, and burning **fossil fuels** return it. Burning fossil fuels adds carbon far faster than natural processes remove it.



The carbon cycle moves carbon among the atmosphere, living things, and fossil fuels

The Nitrogen Cycle

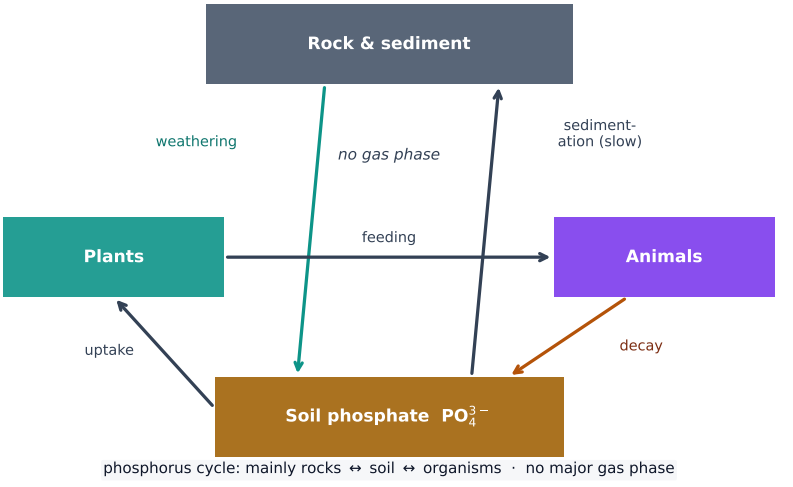
The **nitrogen cycle** makes nitrogen usable for life. **Nitrogen fixation** (by bacteria) converts atmospheric N_2 to ammonia; nitrification and assimilation pass it through organisms; **denitrification** returns N_2 to the air. Fertilizer adds reactive nitrogen, which can pollute water.



The nitrogen cycle: N_2 is fixed into soil nitrates, passed through food, and returned to the air by denitrification

The Phosphorus Cycle

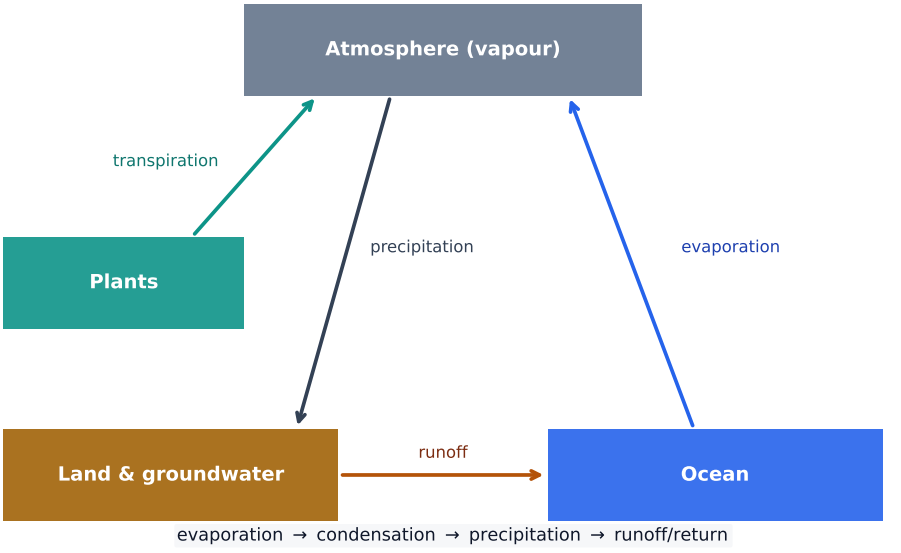
The **phosphorus cycle** has **no atmospheric (gas) stage** – phosphorus moves through rock, soil, water, and organisms. It is slow and often the **limiting nutrient** for growth, so added phosphorus (fertilizer, detergents) can trigger algal blooms.



The phosphorus cycle: rock weathers to soil phosphate and slowly sediments back, with no gas phase

The Hydrologic (Water) Cycle

The **water cycle** moves water by **evaporation**, **transpiration** (from plants), **condensation**, **precipitation**, and runoff. It distributes fresh water and shapes climate; human use and land changes can alter its flow.



The water cycle: evaporation and transpiration lift water to the air; precipitation and runoff return it

Primary Productivity

Primary productivity is the rate at which producers capture energy (usually by photosynthesis). **Gross primary productivity (GPP)** is the total captured; **net primary productivity (NPP)** is what remains after the producers' own respiration – the energy available to the rest of the ecosystem. Warm, wet, sunlit systems (rainforests, reefs) are most productive.

> **Worked example.** If producers in a grassland capture 20,000 kcal/m^2/yr of energy (GPP) and burn 8,000 kcal/m^2/yr in their own respiration, then NPP = GPP $- R =$ 20,000 $-$ 8,000 = 12,000 kcal/m^2/yr. Only that NPP – not the full GPP – is available to the consumers above.

Trophic Levels

Organisms occupy **trophic levels**: **producers** (make their own food), then primary, secondary, and tertiary **consumers**, with **decomposers** recycling nutrients at every level. Each level depends on the energy captured below

it.

Energy Flow and the 10% Rule

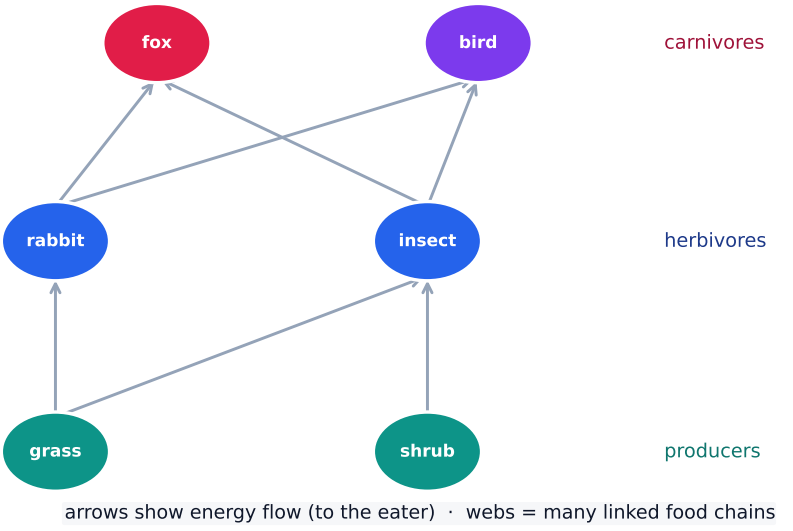
Energy flows **one way** through an ecosystem and is lost as heat at each transfer. The **10% rule**: only about 10% of the energy at one trophic level passes to the next; the other 90% powers life processes and escapes as heat. This is why food chains are short and top predators are few.

> **Worked example.** Continuing from 12,000 kcal/m^2/yr of NPP at the producer level, the primary consumers receive about 10% = 1,200 kcal, secondary consumers ≈ 120 kcal, and tertiary consumers only ≈ 12 kcal. After three transfers the energy has shrunk a thousand-fold – the arithmetic reason a fourth or fifth trophic level rarely has enough to support it.

An energy pyramid: only about 10% of energy passes to the next trophic level

Food Chains and Food Webs

A **food chain** is a single line of who-eats-whom; a **food web** links many chains into a realistic picture of feeding relationships. Because species are interconnected, removing one (especially a **keystone species**) can disrupt the whole web.



A food web links many food chains; arrows point the way energy flows

Exam tips

- Remember **energy flows and is lost** (the 10% rule) while **matter cycles** (carbon, nitrogen, phosphorus, water).
- Apply the 10% rule down a food chain and know **NPP = GPP − respiration** (only NPP is available to consumers).
- Learn each biogeochemical cycle's stores and how humans disturb it (burning fossil fuels adds CO_2; fertiliser adds nitrogen/phosphorus).
- Producers are most abundant because so little energy reaches the top.
- Use correct units and show your arithmetic on the free-response math questions (no calculator – keep numbers round).