

Ecosystems

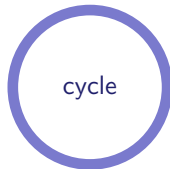
AP Environmental Science ■ Unit 1

AP Environmental Science



What we will cover

- 1 Ecosystems and niches
- 2 Biomes
- 3 Biogeochemical cycles
- 4 The water cycle
- 5 Primary productivity
- 6 Energy flow and food webs





Ecosystems and niches

An **ecosystem** = living things + their non-living surroundings.

- **biotic** vs **abiotic** factors
- organism → **population** → **community** → ecosystem

A **niche** is a species' full "job."
Two species can't share one – **competitive exclusion**.



Coral reef biome

The three ways organisms interact

predation

one organism eats another – the predator's numbers track the prey's

competition

two organisms need the same limited resource; one is excluded or the two divide the niche

symbiosis

a long-term association: *mutualism* (both gain), *commensalism* (one gains, one unaffected), *parasitism* (one gains, one is harmed)

An ecosystem is the **biotic** (living) and **abiotic** (non-living) parts of an area *interacting*. Take the interactions away and you have a list, not an ecosystem.



Biomes

A **biome** is a large region set by its climate: terrestrial by temperature & precipitation; aquatic by salinity.

Biomes band by latitude:
rainforest at the equator →
tundra at the poles.



Tropical rainforest: high temp and precip

Two biomes at opposite ends of the precipitation scale

Tropical rainforest

Hot and wet all year: dense layered plant life and the richest biodiversity of any land biome.

Desert

The dry end: sparse, widely spaced plants, water-storing tissue and animals active at night.

Why they differ

Terrestrial biomes are set mainly by temperature and **precipitation** – the same sunlight, a different water budget.

Deserts, grasslands, tropical rainforest, temperate forest, taiga and tundra: place any of them by naming its temperature *and* its rainfall.

Aquatic biomes cover more of Earth than land does

freshwater

streams, lakes, wetlands – low **salinity**

marine

open ocean, coral reefs, estuaries – high salinity

estuary

where a river meets the sea; nutrient-rich and **exceptionally productive**

coral reef

warm, shallow, sunlit – the most **biodiverse** marine system

Aquatic biomes are sorted by **salinity, sunlight and nutrients** – the same three variables, in every question about them.



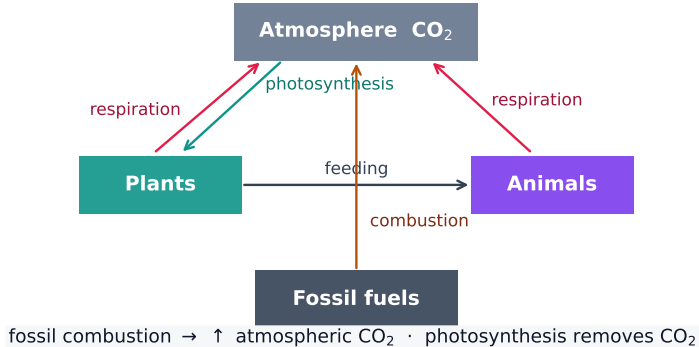
The carbon cycle

Carbon moves through a **biogeochemical cycle** :

- **photosynthesis** pulls CO_2 in
- **respiration & combustion** return it

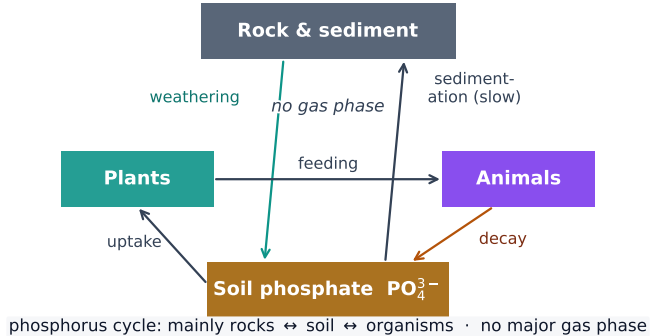
Burning **fossil fuels** moves ancient carbon to the air far faster than nature removes it.

The carbon cycle, in detail



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

The Phosphorus Cycle



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

Nitrogen and phosphorus

Nitrogen is a **limiting nutrient** : air N_2 is unusable until bacteria fix it.

■ **fixation** → **nitrification** → **denitrification**

Phosphorus has **no gas phase** – rock-based and slow. Excess of either ⇒ **eutrophication** .

The nitrogen cycle, move by move

Nitrogen fixation

Bacteria convert atmospheric N_2 into ammonia – the step that makes nitrogen usable at all.

Nitrification

Other bacteria turn ammonia into nitrites and then nitrates, the form roots take up.

Assimilation

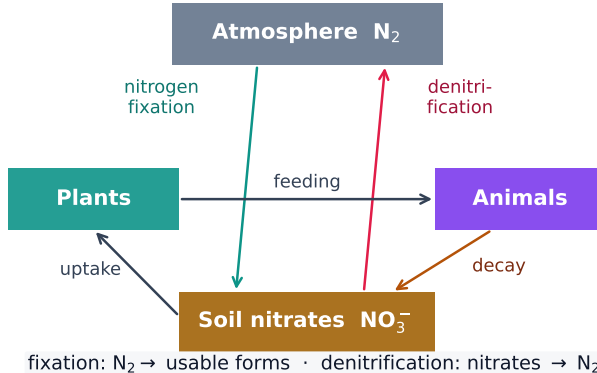
Plants build nitrates into proteins; animals get theirs by eating.

Denitrification

Bacteria return N_2 to the air, closing the **nitrogen cycle**.

Fertilizer short-circuits the cycle by adding reactive nitrogen directly – the surplus runs off and pollutes water.

Nitrogen and phosphorus, in detail



Nitrogen cycles through the **air**, phosphorus only through **rock** and water. An excess of either causes **eutrophication**.

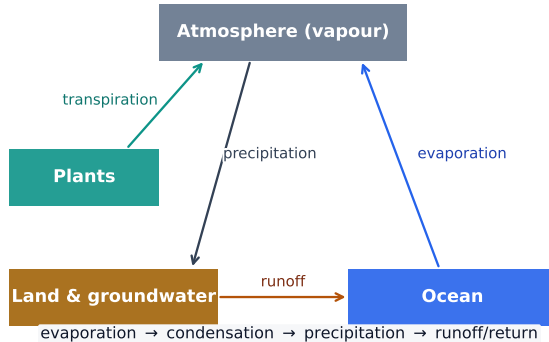
The water cycle

The **hydrologic cycle** is Sun-powered:

- **evaporation + transpiration**
- **runoff & infiltration** to an **aquifer**

Paving with **impervious surfaces** blocks infiltration → more flooding.

The water cycle, in detail



The **hydrologic cycle** is Sun-powered: water leaves the surface by **evaporation** and **transpiration**, and returns as **runoff** or **infiltration** into an **aquifer**. Paving blocks the infiltration, so more rain becomes runoff and flooding gets worse.



Primary productivity

Primary productivity is the rate producers store energy as **biomass** .

- **GPP** : total energy captured
- **NPP** : what is left after **respiration**

High where sun, warmth, water & nutrients meet: rainforests, estuaries, reefs, wetlands.

The key relationship

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

NPP is the energy actually available to **consumers** – the ecosystem's food supply.

Worked example – GPP, respiration, NPP

Grassland producers capture 20,000 kcal/m²/yr (GPP) and burn 8,000 in their own respiration. Find NPP.

- $NPP = GPP - R$
- $= 20,000 - 8,000$
- $= 12,000 \text{ kcal/m}^2/\text{yr}$

Only the **NPP** – not the full GPP – is available to the consumers above. Producers spend the difference staying alive.



Energy flow and the 10% rule

Energy flows *one way* up the **trophic levels** and is lost as heat.

■ **producers** → **consumers** → **decomposers**

Only $\sim 10\%$ passes up each level (2nd law of thermodynamics) – so chains stay short.

Energy flow and the 10% rule, in detail



Energy flows *one way* up the **trophic levels** and is lost as heat.

Worked example – the 10% rule, level by level

With $12,000 \text{ kcal/m}^2/\text{yr}$ of NPP at the producers, how much reaches the secondary consumers?

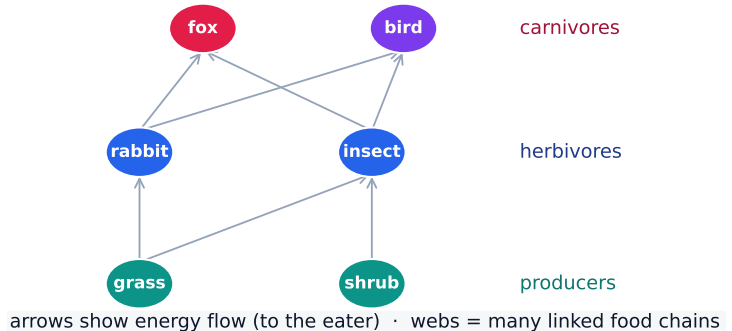
- primary consumers: $10\% \times 12,000 = 1,200$
- secondary consumers:
 $10\% \times 1,200 = 120 \text{ kcal/m}^2/\text{yr}$
- the other 90% leaves as **heat**, waste and unconsumed tissue

Each level keeps about a tenth. That is why food chains are **short** and why eating lower down feeds more people.

Food chains and food webs

A **food chain** is one path; arrows point the way energy flows (food → eater). A **food web** links many chains.

A **keystone species** (sea otter) shapes the whole web; an **indicator species** warns of stress.



Terrestrial Biomes



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

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 **$\text{NPP} = \text{GPP} - \text{respiration}$** (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).



Unit 1 – key takeaways

1

Ecosystems

biotic + abiotic; niche; competitive exclusion; symbiosis

2

Cycles

carbon, nitrogen, water recycle matter; P has no gas phase

3

Productivity

$NPP = GPP - R$ sets the food supply

4

Energy flow

~10% per level; food webs + keystone species

Check yourself

- 1 Which two abiotic factors define a terrestrial biome?
- 2 Which nutrient cycle has no gas phase?
- 3 Write the equation linking NPP, GPP, and R.
- 4 About what fraction of energy passes up one trophic level?



Answers 1. temperature and precipitation 2. phosphorus 3. $\text{NPP} = \text{GPP} - R$
4. about 10%