

Ecosystems

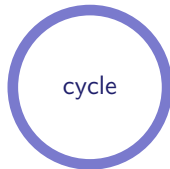
AP Environmental Science ■ Unit 1

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



1

Ecosystems

Ecosystems and niches

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

- **biotic** 生物的 vs **abiotic** 非生物的因素
- organism → **population** 种群 → **community** 群落 → ecosystem

A **niche** 生态位 is a species' full "job." Two species can't share one – **competitive exclusion** 竞争排斥原理.



Coral reef biome

The three ways organisms interact

predation 捕食

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

competition 竞争

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

symbiosis 共生

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.

2

Biomes

Biomes

A **biome** 生物群系 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** 降水 – 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 淡水 streams, lakes, wetlands – low **salinity** 盐度

marine 海洋 open ocean, coral reefs, estuaries – high salinity

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

coral reef warm, shallow, sunlit – the most **biodiverse** 生物多样的 marine system

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

3

Cycles

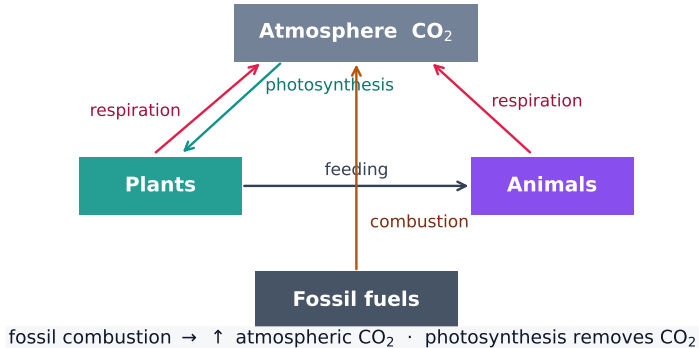
The carbon cycle

Carbon 碳 moves through a **biogeochemical cycle** 生物地球化学循环:

- **photosynthesis** 光合作用 pulls CO_2 in
- **respiration** 细胞呼吸 & **combustion** 燃烧 return it

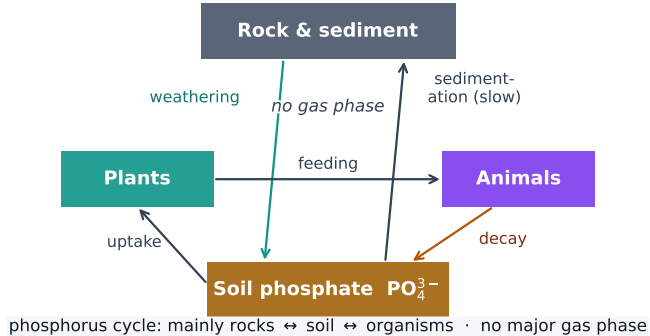
Burning **fossil fuels** 化石燃料 moves ancient carbon to the air far faster than nature removes it.

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 氮 is a **limiting nutrient** 限制性养分: air N_2 is unusable until bacteria fix it.

■ **fixation** 固氮作用 → **nitrification** 硝化作用 → **denitrification** 反硝化作用

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

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

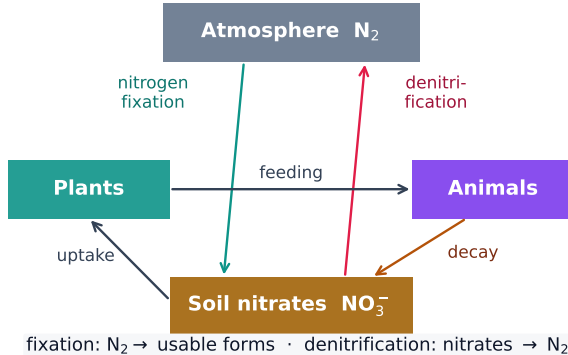
Plants build nitrates into proteins; animals get theirs by eating.

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** 富营养化.

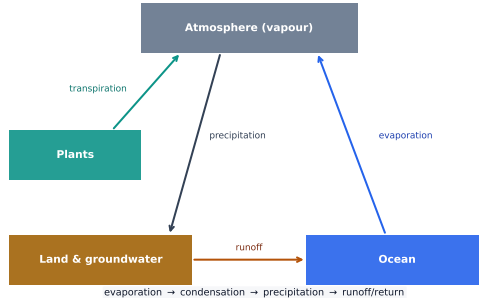
The water cycle

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

- **evaporation** 蒸发 + **transpiration** 蒸腾作用
- **runoff** 径流 & **infiltration** 下渗 to an **aquifer** 含水层

Paving with **impervious surfaces** 不透水面 blocks infiltration → more flooding.

The water cycle, in detail



The **hydrologic cycle** 水循环 is Sun-powered: water leaves the surface by **evaporation** 蒸发 and **transpiration** 蒸腾作用, and returns as **runoff** 径流 or **infiltration** 下渗 into an **aquifer** 含水层. Paving blocks the infiltration, so more rain becomes runoff and flooding gets worse.

4

Productivity

Primary productivity

Primary productivity 初级生产力 is the rate producers store energy as **biomass** 生物量.

- **GPP** 总初级生产力: total energy captured
- **NPP** 净初级生产力: what is left after **respiration** 呼吸作用

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** 消费者 – 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.

5

Energy flow

Energy flow and the 10% rule

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

■ **producers** 生产者 → **consumers** 消费者 → **decomposers** 分解者

Only ~ 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** 营养级 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?

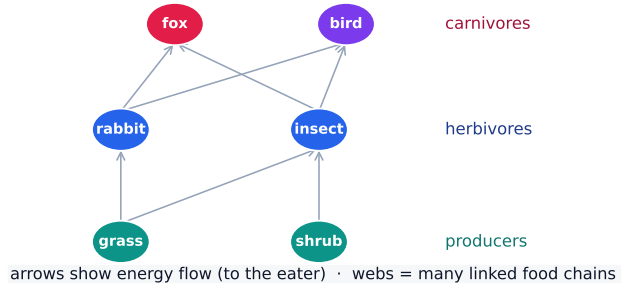
- primary consumers: $10\% \times 12,000 = 1,200$
- secondary consumers:
 $10\% \times 1,200 = 120 \text{ kcal/m}^2/\text{yr}$
- the other 90% leaves as **heat**, waste and unconsumed tissue

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

A **keystone species** 关键种 (sea otter) shapes the whole web; an **indicator species** 指示物种 warns of stress.



Terrestrial Biomes



A desert 沙漠: 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 ; 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).

6

Recap

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%