

# Ecosystems

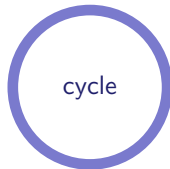
AP Environmental Science ■ Unit 1

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



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# Ecosystems

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# 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.



*A coral reef packs many niches into one ecosystem*

# The three ways organisms interact

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## predation 捕食

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

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## competition 竞争

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

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## symbiosis 共生

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

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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.

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**Biomes**

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# 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

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### Tropical rainforest

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

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### Desert

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

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### Why they differ

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

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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.

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Cycles

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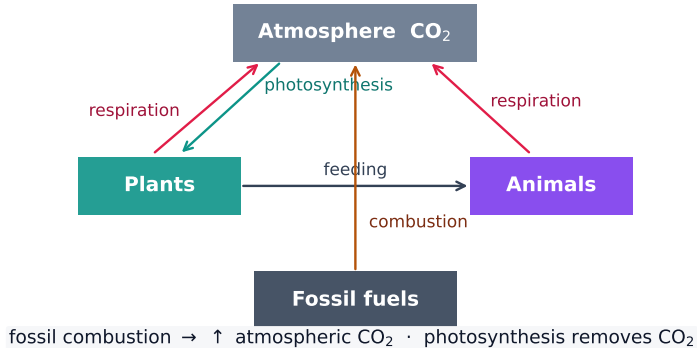
# The carbon cycle

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

- **photosynthesis** 光合作用 pulls  $\text{CO}_2$  in
- **respiration** 细胞呼吸 & **combustion** 燃烧 return it

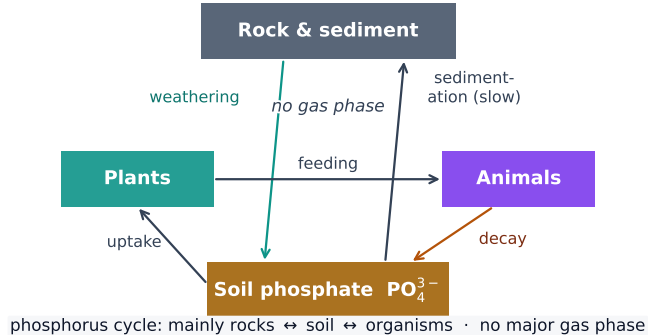
Burning **fossil fuels** 化石燃料 moves ancient carbon to the air far faster than nature removes it.

# 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

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## Nitrogen fixation

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

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## Nitrification

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

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## Assimilation

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

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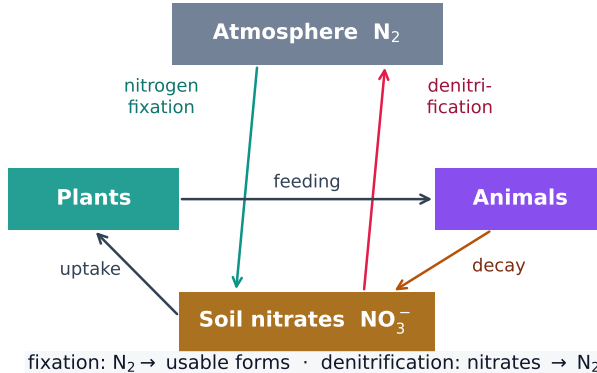
## Denitrification

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

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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.

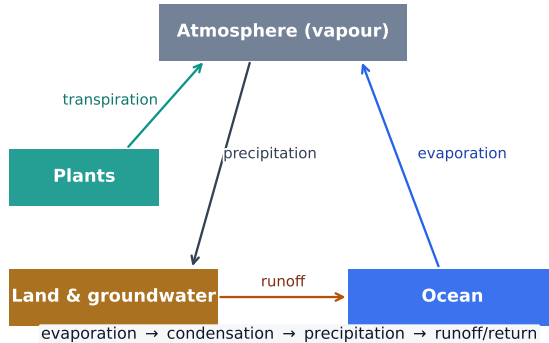
# The water cycle

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.

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# Productivity

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# 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/m<sup>2</sup>/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.

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## Energy flow

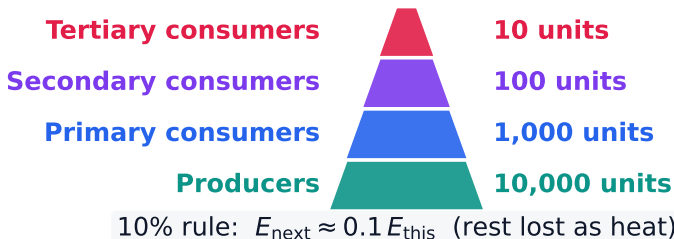
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## Energy flow and the 10% rule

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.



## Worked example – the 10% rule, level by level

**With 12,000 kcal/m<sup>2</sup>/yr of NPP at the producers, how much reaches the secondary consumers?**

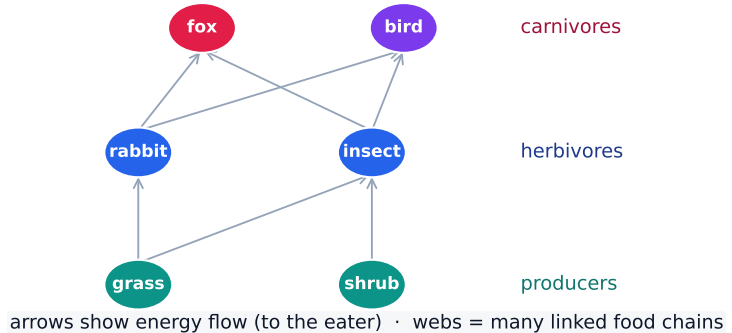
- primary consumers:  $10\% \times 12,000 = 1,200$
- secondary consumers:  
 $10\% \times 1,200 = 120 \text{ kcal/m}^2/\text{yr}$
- the other 90% leaves as **heat**, waste and unconsumed tissue

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  $\text{CO}_2$ ; 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).

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Recap

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# Unit 1 – key takeaways

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## Ecosystems

biotic + abiotic; niche; competitive exclusion; symbiosis

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## Cycles

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

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## Productivity

$NPP = GPP - R$  sets the food supply

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## 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%