# Ecology

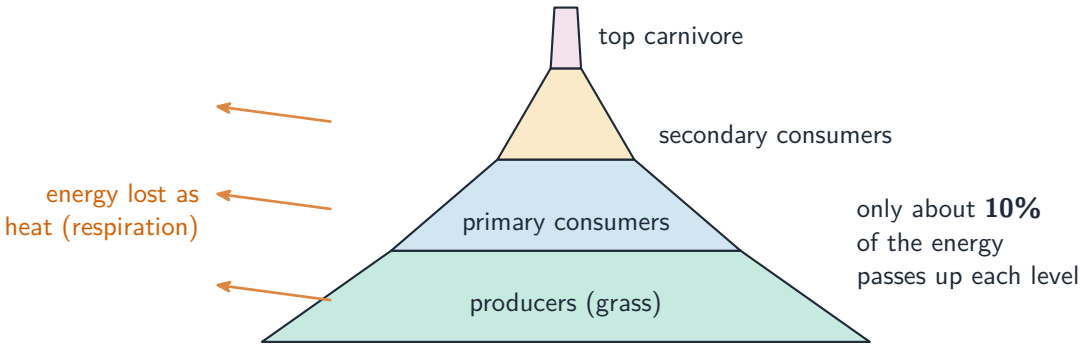
AP Biology

## Responses to the Environment

Organisms sense and respond to their surroundings in ways that aid survival and reproduction. **Behaviors** may be **innate** (inherited, like reflexes and instincts) or **learned**. Responses such as migration, hibernation, and phototropism, and signals between organisms, are shaped by natural selection because they improve fitness.

## Energy Flow Through Ecosystems

Energy enters most **ecosystems** 生态系统 as sunlight, is captured by **producers** 生产者 (photosynthesizers), and passes to **consumers** 消费者 along a **food chain** 食物链. Each level is a **trophic level** 营养级. Only about **10%** of energy transfers up each level (the rest is lost as heat), so food chains are short and producers are the most abundant. Energy **flows** through and is lost, while matter (carbon, nitrogen) **cycles**.

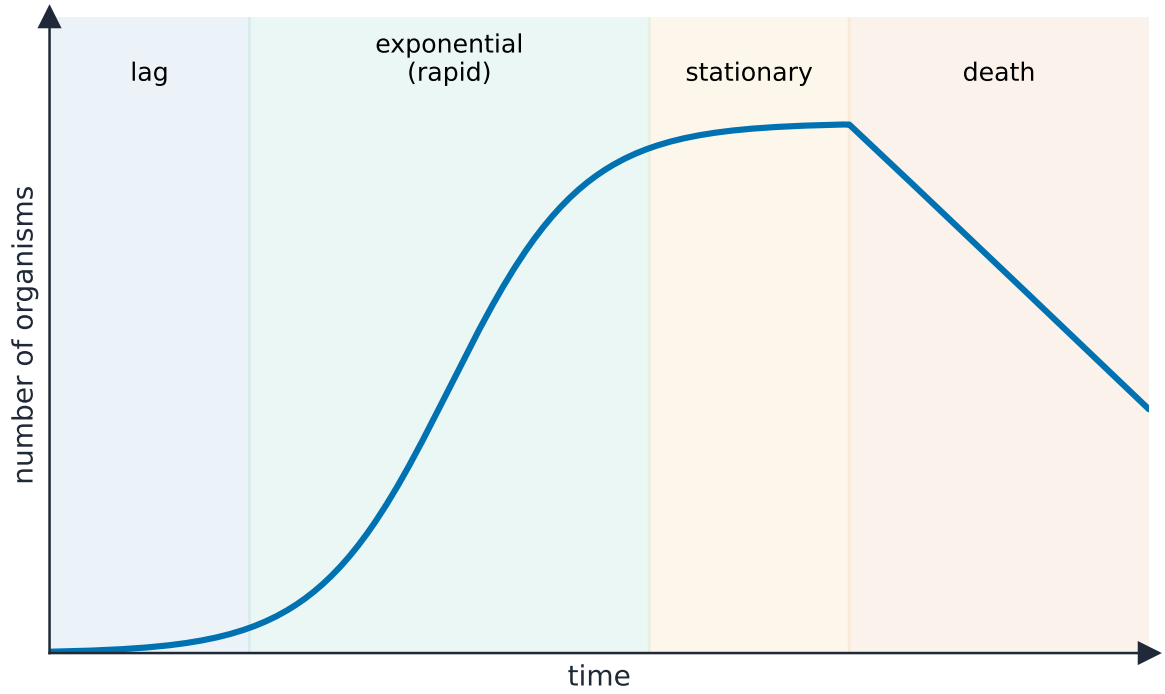



*Only about 10% of the energy passes to the next trophic level*

**Worked example.** Suppose producers capture 10,000 kcal. Applying the 10% rule, primary consumers receive about 1,000 kcal, secondary consumers 100 kcal, and tertiary consumers only 10 kcal. Losing 90% as heat at every step is exactly why food chains rarely exceed four or five levels –there is too little energy left to support another.

## Population Ecology

A **population** 种群 is the individuals of one species in an area. Its growth depends on birth, death, immigration, and emigration. **Exponential growth** 指数增长 ($J$-shaped) happens with unlimited resources; **logistic growth** 逻辑斯蒂增长 ($S$-shaped) levels off at the **carrying capacity** 环境容纳量 $K$ –the maximum the environment can sustain – following $\frac{dN}{dt} = r_{\max} N \frac{K - N}{K}$.




*Population growth: lag, exponential, then levelling off at the carrying capacity*

**Worked example.** A population has $r_{\max} = 0.5$ yr$^{-1}$, carrying capacity $K = 1000$, and current size $N = 400$. Then $\dfrac{dN}{dt} = 0.5 \times 400 \times \dfrac{1000 - 400}{1000} = 0.5 \times 400 \times 0.6 = 120$ individuals per year. The $\frac{K-N}{K}$ term is why growth is fastest near $N = K/2$ and slows toward zero as $N$ approaches $K$.

# Effect of Density on Populations

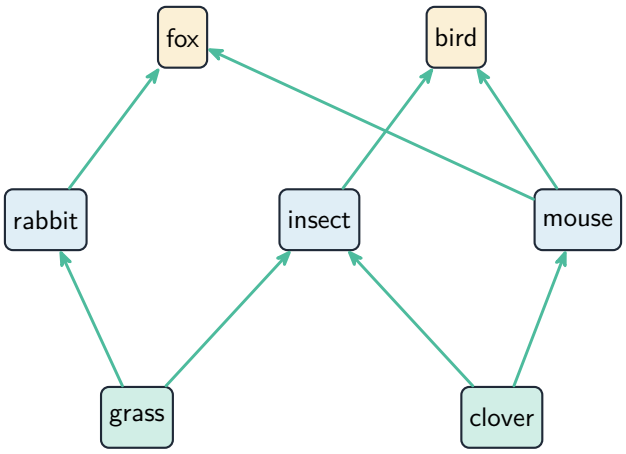
Some factors depend on crowding, others do not:

- **Density-dependent** 密度制约 factors intensify as a population grows –competition, predation, disease.
- **Density-independent** 非密度制约 factors act regardless of density –weather, natural disasters.

These factors regulate population size around the carrying capacity.

# Community Ecology

A **community** 群落 is all the interacting populations in an area. Key interactions: **competition** 竞争 (for shared resources), **predation** 捕食, **symbiosis** 共生–**mutualism** (both benefit), **commensalism** (one benefits, other unaffected), and **parasitism** (one benefits, other harmed). These relationships shape which species coexist.




*A food web links several food chains together*

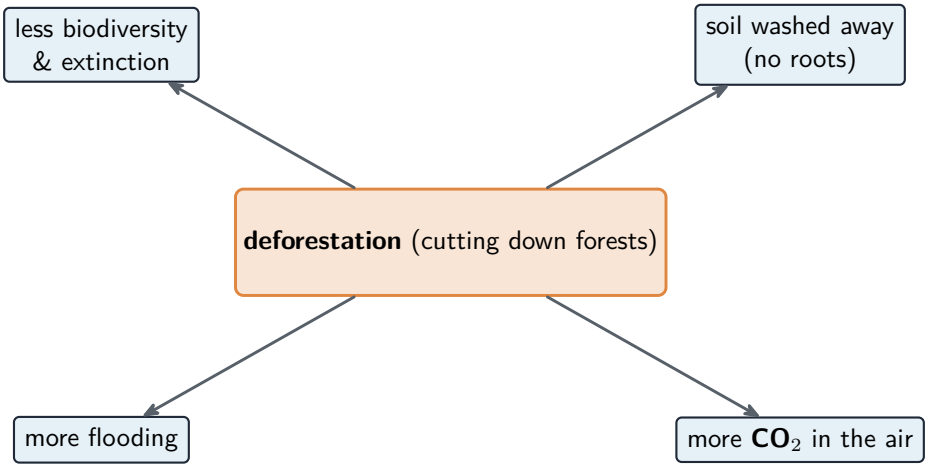
## Biodiversity

**Biodiversity** 生物多样性 is the variety of life –genes, species, and ecosystems. Higher diversity generally makes a community more **resilient** 有韧性, better able to withstand and recover from disturbance. A **keystone species** 关键种 has an outsized effect, so losing it can collapse the community.


*Biodiversity at three levels: genetic, species, and habitat*

## Disruptions in Ecosystems

Ecosystems change from natural and human causes –climate shifts, invasive species, habitat loss, and pollution. A disturbance can trigger **ecological succession** 生态演替 (the community rebuilds over time). Because species are interconnected, a change to one –especially a keystone or a trophic level –can ripple through the whole ecosystem.




*Deforestation lowers biodiversity and causes erosion, flooding, and higher CO2*

# Exam tips

- Apply the **10% rule**: about 90% of energy is lost at each trophic level, so food chains are short.
- Distinguish **exponential** ($J$) from **logistic** ($S$) growth; the latter levels off at the **carrying capacity** ($\frac{dN}{dt} = r_{\max} N \frac{K-N}{K}$).
- Separate **density-dependent** (competition, disease, predation) from **density-independent** (weather) limiting factors.
- Name community interactions (competition, predation, symbiosis) and the effect of a **keystone species**.
- Explain how disturbing one species —especially a keystone or a whole trophic level —ripples through the ecosystem.