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.

Sunflowers face the light: organisms detect and respond to environmental stimuli

The behaviours the CED lists by name

These are the illustrative behaviours an exam question builds its scenario from, so learn what each one *is* and what it *buys the organism*:

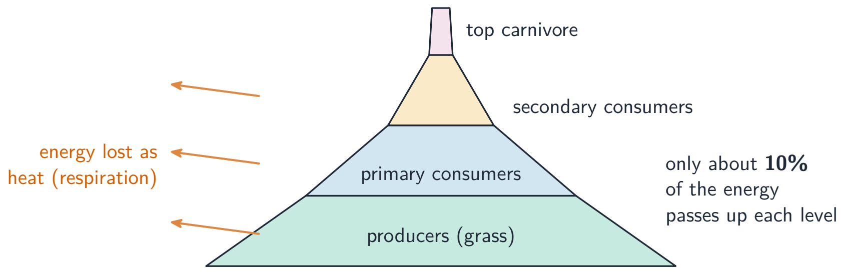
Behaviour	What it is	Why it aids fitness
taxis 趋性	movement **directed** towards or away from a stimulus	reaches food, light or moisture, or escapes a hazard
kinesis 动性	a change in the **rate** of random movement, with no direction	keeps the animal in favourable conditions by moving less there and more elsewhere
nocturnal and diurnal activity 夜行性与昼行性	being active at night, or by day	avoids predators or heat, and matches activity to when food is available
territorial marking 领域标记	scent, sound or visual marks that claim an area	secures food, nesting sites and mates without repeated fighting
coloration 体色	pigmentation in animals and flowering plants	warning, camouflage, mate attraction — and in flowers, attracting pollinators
foraging 觅食 by bees and others	searching for and collecting food	efficient foraging returns more energy than it costs, which is what selection acts on

△ **Taxis and kinesis are the pair most often confused.** Taxis has a *direction*: the woodlouse walks towards the damp. Kinesis has only a *rate*: the woodlouse moves quickly and turns often in dry air and slows down in damp air, so it ends up in the damp without ever steering there.

Life-history strategy 生活史策略 is the pattern of when an organism grows, reproduces and dies, and it too is shaped by selection: a **biennial** plant stores resources in its first year and flowers in its second; **reproductive diapause** pauses development until conditions improve, so offspring arrive when they can survive. Both trade the timing of reproduction against the chance that it succeeds.

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**.

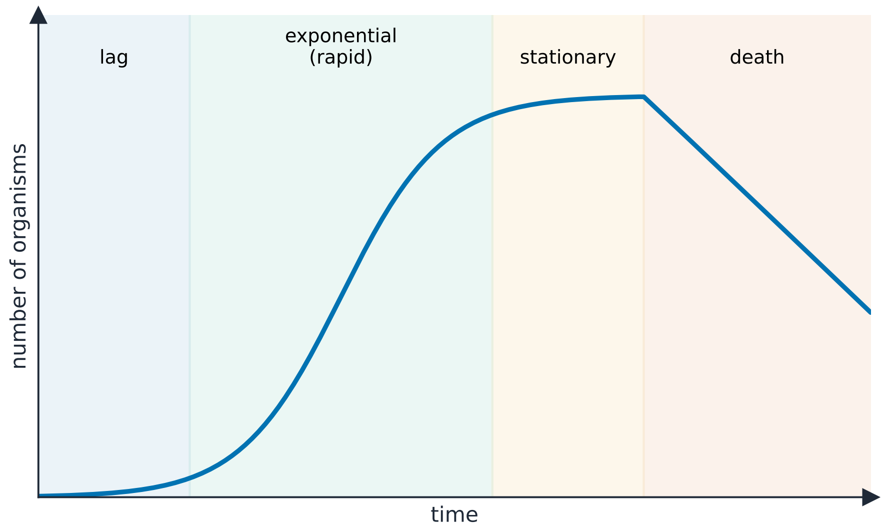


Only about 10% of the energy passes to the next trophic level

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 $r_{\max} = 0.5\ \text{yr}^{-1}$, carrying capacity $K = 1000$, and current size $N = 400$. Then $\frac{dN}{dt} = 0.5 \times 400 \times \frac{1000-400}{1000} = 0.5 \times 400 \times 0.6 = 120$ 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.

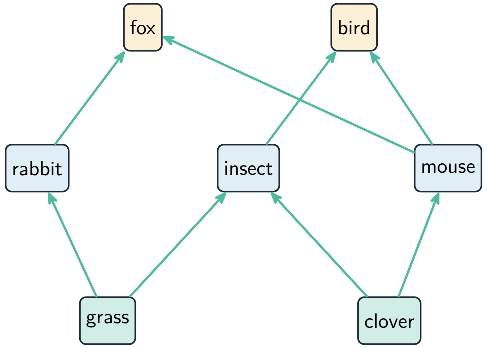
These factors regulate population size around the carrying capacity.

A dense deer herd: density-dependent factors such as disease and food competition intensify as numbers rise

Community Ecology

Clownfish among sea-anemone tentacles — a textbook mutualism

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

Coral reef outcrop: high biodiversity in a productive marine ecosystem

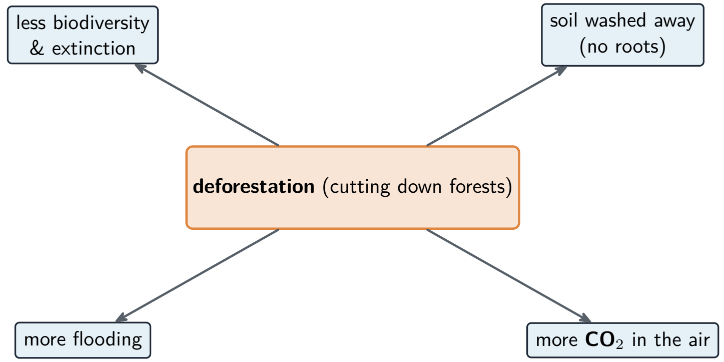
Biodiversity 生物多样性 is the variety of life – genes, species, and ecosystems. Higher diversity generally makes a community more **resilient** 有韧性, better able to withstand and recover from disturbance. A **keystone species** 关键种 has an outsized effect, so losing it can collapse the community.

Biodiversity at three levels: genetic, species, and habitat

Disruptions in Ecosystems

Deforested landscape — habitat loss is a major disruption to 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.