

Organisms and their environment

IGCSE Biology

Energy flow

The **Sun** is the main source of **energy** 能量 for almost all life. Plants capture light energy by **photosynthesis** 光合作用 and store it as chemical energy in food. This energy then passes from organism to organism as they feed. At every step, some energy is lost (mostly as heat from **respiration** 呼吸作用) to the **environment** 环境. Energy flows **one way** —it is not recycled.

Food chains and food webs

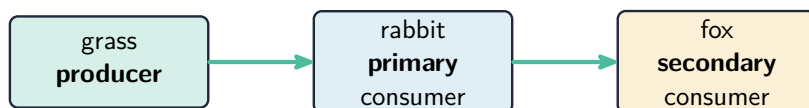


A savanna ecosystem: organisms linked by feeding relationships.

Image: Rasheedhrasheed, CC BY-SA 4.0 (commons.wikimedia.org)

A **food chain** 食物链 shows the transfer of energy from one organism to the next, starting with a producer. Each arrow points in the direction the energy flows:

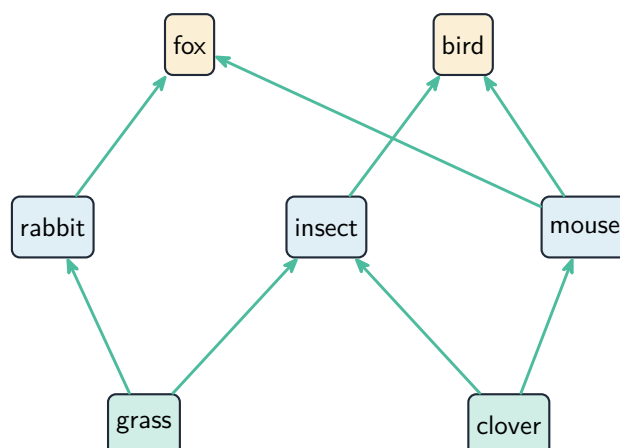
grass → rabbit → fox



each arrow shows energy flowing to the next organism

A food chain: arrows show energy passing from producer to consumers

A **food web** 食物网 is many food chains linked together.



A food web is several food chains linked together

Producers, consumers and decomposers

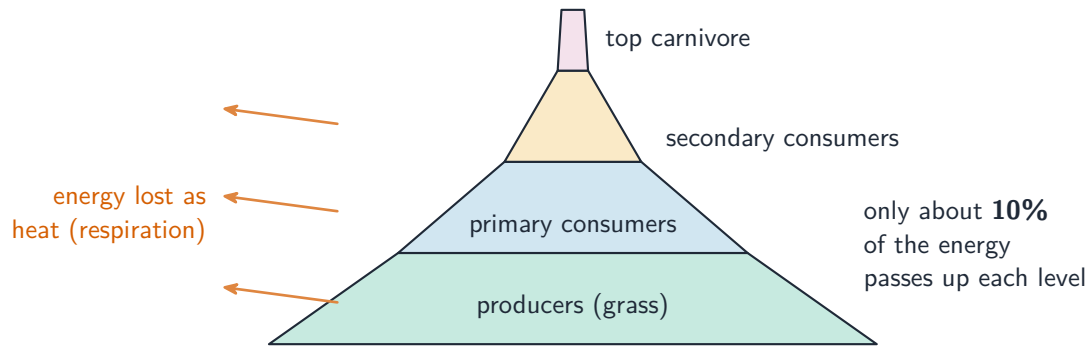
Type	Meaning
producer 生产者	makes its own food (organic nutrients 营养物质), usually by photosynthesis
consumer 消费者	gets its energy by feeding on other organisms
herbivore 食草动物	a consumer that eats plants
carnivore 食肉动物	a consumer that eats other animals
decomposer 分解者	gets its energy from dead or waste material, causing decomposition 分解

Consumers are named by their position: a **primary** consumer eats the producer; a **secondary** consumer eats the primary consumer; then come **tertiary** and **quaternary** consumers.

Trophic levels and pyramids

A **trophic level** 营养级 is the position of an organism in a food chain (producers first, then primary consumers, and so on). You can show a food chain as a **pyramid** 金字塔:

- a **pyramid of numbers** counts the organisms at each level.
- a **pyramid of biomass** 生物量 shows the total mass at each level —usually a better picture, because it does not depend on how big the organisms are.
- (Supplement) a **pyramid of energy** shows the energy at each level —the most useful picture of all.



Only about 10% of energy passes up each level, so the levels get smaller

Energy loss along a chain (Supplement)

Only about 10% of the energy at one trophic level passes to the next. The rest is lost as heat (from respiration), in movement, and in waste. Because so much energy is lost, food chains usually have **fewer than five** trophic levels. It is more energy-efficient for people to eat **crop plants** 农作物 directly than to eat animals that were fed on those crops, because each extra level wastes energy.

Worked example. The producers in a field trap 40 000 kJ of energy. Roughly how much reaches a secondary consumer, and why do food chains stay short? About 10% passes on at each step. Primary consumers receive 10% of 40 000 = **4000 kJ**. Secondary consumers receive 10% of 4000 = **400 kJ** - only 1% of what the plants trapped. After a few levels too little energy is left to support another one, which is why chains rarely pass five levels. Apply the 10% **again at every step**, not once for the whole chain.

Human impact

Humans can damage food webs by:

- **overharvesting** 过度捕捞—taking too many of one species (such as overfishing), so its numbers crash.
- introducing a **foreign species** 外来物种—a new species may have no predators and may crowd out native species.

Nutrient cycles

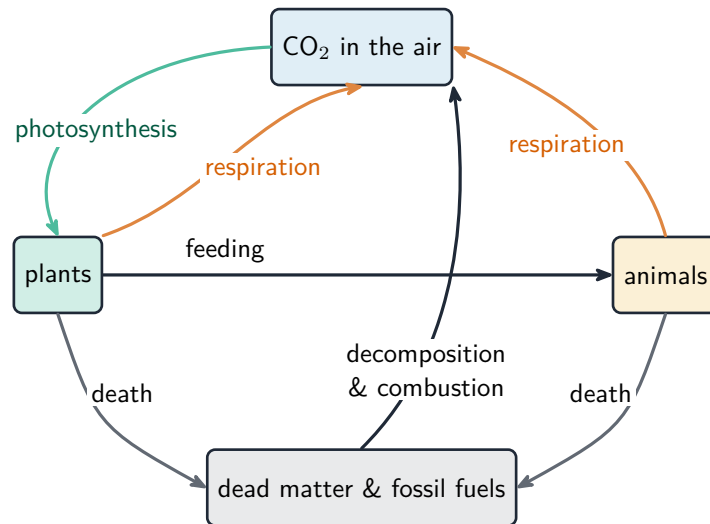
Unlike energy, nutrients are **recycled** —used again and again.

The carbon cycle

In the **carbon cycle** 碳循环:

- photosynthesis removes **carbon dioxide** 二氧化碳 from the air.
- respiration and **combustion** 燃烧 (burning) return carbon dioxide to the air.
- feeding passes carbon from one organism to the next.

- decomposition returns carbon to the air and soil.
- over millions of years, dead organisms can form **fossil fuels** 化石燃料 (coal and oil), which release carbon dioxide when they are burned.

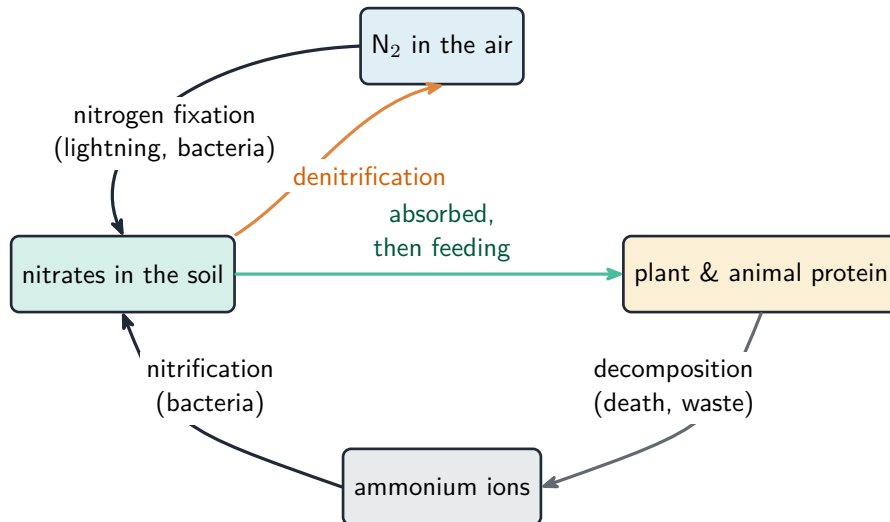


The carbon cycle: photosynthesis removes CO₂ ; respiration, combustion and decay return it

The nitrogen cycle (Supplement)

The **nitrogen cycle** 氮循环 recycles nitrogen for making **proteins** 蛋白质. **Microorganisms** 微生物 do most of the work:

- **decomposition**: decomposers break dead protein down into **ammonium ions** 铵离子.
- **nitrification** 硝化作用: bacteria change ammonium ions into **nitrate ions** 硝酸根离子.
- **nitrogen fixation** 固氮作用: lightning and some **bacteria** 细菌 turn nitrogen gas into compounds that plants can use.
- plants absorb nitrate ions to make **amino acids** 氨基酸 and proteins; animals get them by feeding and **digestion** 消化.
- **deamination** 脱氨基作用 (in the liver) and decomposition release nitrogen compounds again.
- **denitrification** 反硝化作用: some bacteria turn nitrate ions back into nitrogen gas.



The nitrogen cycle: microorganisms move nitrogen between the air, soil and living things

Populations



A coral reef is a rich ecosystem supporting many interdependent species.

Image: Jim E Maragos, U.S. Fish and Wildlife Service, Public domain (commons.wikimedia.org)

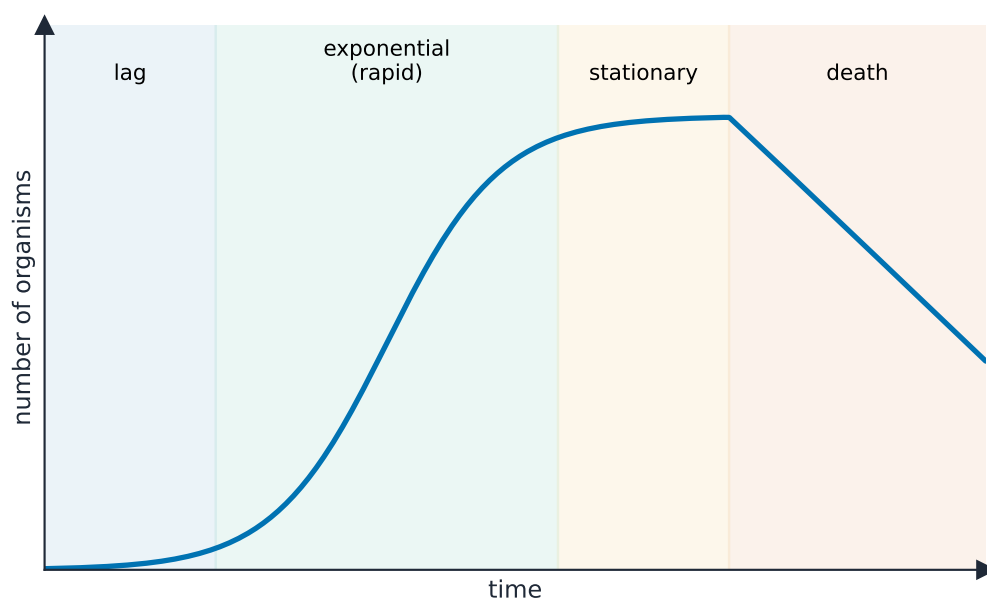
- a **population** 种群 is a group of organisms of one **species** 物种, living in the same area at the same time.
- a **community** 群落 is all the populations of different species in one place.
- an **ecosystem** 生态系统 is the community together with its **environment**, all interacting.

Population growth

The growth of a population depends on the food supply, **competition** 竞争, **predation** 捕食 (being eaten) and disease.

When a population grows in a place with limited **resources** 资源, its growth follows an S-shaped curve with four phases:

Phase	What happens
lag phase 延迟期	slow growth at first, while numbers are still small
exponential phase 对数期	very fast growth, with plenty of food and space
stationary phase 稳定期	growth stops; births = deaths (a limiting factor 限制因素 such as food holds it back)
death phase 衰亡期	numbers fall as food runs out, wastes build up, or disease spreads



A population in a limited space grows in four phases: lag, exponential, stationary, death

Exam tips

- Energy enters from the Sun, flows one way along the chain, and is lost as heat at each step. Nutrients are recycled.
- Food chain starts with a producer; arrows show energy flow. Learn producer, consumer, herbivore, carnivore, decomposer.
- Only ~10% of energy passes up each trophic level, so chains are short and eating plants is more efficient.
- Carbon cycle: photosynthesis respiration and combustion; nitrogen cycle (Supplement): fixation, nitrification, denitrification by microorganisms.
- Population: one species, one area, one time. Learn the four phases of the S-shaped growth curve.