

19.1 Energy flow

Name: _____ Class: _____ Date: _____

Total: 26 marks

KEY WORDS energy 能量 • trophic levels 营养级 • energy flow 能量流动 • respiration 呼吸作用
• excretory products 排泄物

Objective

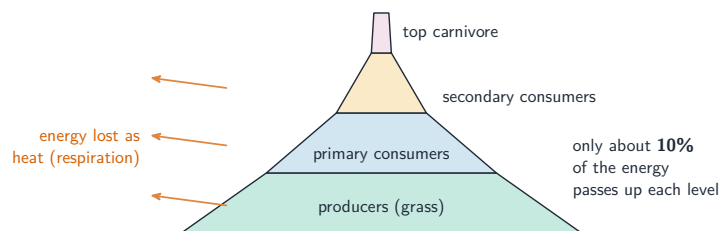
Build the skills to answer exam questions on **energy flow** 能量流动 — the Sun as the source, **trophic levels** 营养级, energy loss, and pyramids.

You must be able to:

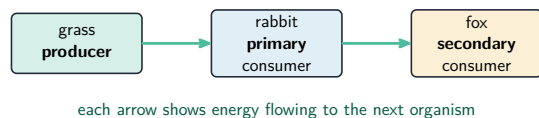
- describe how energy enters and flows through a food chain
- explain why only ~10% of energy passes up each level
- interpret pyramids of numbers, biomass and energy

1 Worked examples

■ Energy loss



Energy enters from the Sun, flows one way, and is lost as heat at each level (~10% passes up)



Energy flows along a food chain

- the rest is lost as heat (respiration), in movement and in waste.

- so chains have fewer than ~5 levels; eating plants directly wastes less energy.

■ Where the energy comes from, and where it goes

Almost all energy in an ecosystem starts as **light energy from the Sun**, captured by producers in **photosynthesis** 光合作用 and stored as chemical energy in glucose. That is why producers are always the first trophic level.

The losses at each transfer, which the exam wants named:

- **respiration** 呼吸作用 — the largest loss, released as **heat** to the surroundings;
- **undigested material** passed out in **faeces** 粪便;
- **excretory products** 排泄物 such as urea, which still contain chemical energy;
- parts of the organism that are **not eaten** — bones, roots, fur.

About **10%** of the energy at one level is passed on. That single figure explains three separate exam answers: why a pyramid of biomass narrows upwards, why food chains rarely exceed four or five levels, and why feeding people on crops supports more people than feeding them on meat — a shorter chain wastes fewer transfers.

Worked example. Producers hold 150 000 kJ; the primary consumers hold 14 000 kJ; the secondary consumers hold 1 200 kJ. Find the efficiency of each transfer.

1. Producers → primary: $\frac{14\,000}{150\,000} \times 100 = 9.3\%$.
2. Primary → secondary: $\frac{1\,200}{14\,000} \times 100 = 8.6\%$.
3. Both are close to the usual 10%, and the small difference is normal variation in how much is respired and excreted.

△ Always divide by the level **below**, and give the unit as a percentage. Dividing the wrong way round gives a number over 100, which should tell you at once that the calculation is upside down.

2 Practice

2.1 State the main source of energy for almost all food chains. [1]

2.2 State the form in which most energy is lost at each trophic level. [1]

2.3 Name three ways in which energy is lost between one trophic level and the next. [3]

2.4 Explain why a pyramid of biomass is usually narrower at the top. [2]

2.5 Explain why feeding a population on crops supports more people than feeding it on beef. [2]

3 Exam-style questions

3.1 Roughly what percentage of energy passes from one trophic level to the next? [1]

- A 1%
- B 10%
- C 50%
- D 90%

3.2 Energy is lost along a food chain.

(a) Explain why food chains usually have fewer than five trophic levels. [2]

(b) Explain why it is more efficient for people to eat crop plants than meat. [2]

3.3 A grassland food chain is: grass → cattle → humans. The grass contains 2 400 000 kJ, the cattle 180 000 kJ and the humans 9 000 kJ.

(a) Calculate the percentage of energy transferred from the grass to the cattle. [2]

(b) Calculate the percentage of energy transferred from the cattle to the humans. [2]

(c) Explain why so much energy is lost at each transfer, naming three losses. [3]

(d) Suggest, with a reason, how the same area of grassland could support more people.[3]

(e) Explain why this food chain could not support a fourth trophic level. [2]

Solutions

2.1 the Sun.

2.2 as heat (from respiration).

2.3 Any three of: heat lost from respiration; undigested material lost in faeces; excretory products such as urea; parts not eaten, such as bones or roots.

2.4 Only about 10% of the energy at each level is passed on to the next, so there is less energy available and therefore less biomass can be supported at each higher level.

2.5 Eating crops is a chain with one transfer instead of two; each transfer loses about 90% of the energy, so a shorter chain wastes less and supports more people from the same land.

3.1 B. About 10% passes up each level.

3.2 (a) energy is lost at each level, so after a few levels too little is left to support another.

(b) eating plants directly is one trophic level; eating meat adds a level, where energy is lost, so it is less efficient.

3.3 (a) $\frac{180\,000}{2\,400\,000} \times 100 = 7.5\%$.

(b) $\frac{9\,000}{180\,000} \times 100 = 5.0\%$.

(c) Any three, one mark each: energy is released as heat during respiration; energy is lost in undigested material in faeces; energy is lost in excretory products such as urea; parts of the organism, such as bones, are not eaten.

(d) Grow crops for people to eat directly instead of grazing cattle; this removes one transfer from the chain; about 90% of the energy is lost at each transfer, so far more of the grassland's energy reaches people.

(e) Only 9 000 kJ reaches the humans, and about 90% of that would be lost again; the roughly 900 kJ remaining is too little to support a population at a fourth level.