

Transfer of energy and matter

International Baccalaureate · IB Diploma · Biology · HL

Scope and prerequisites

This handout covers selected HL topics for the course first assessed in 2025; it is not the whole syllabus.

Prerequisites: read the stated quantities and units, and use arithmetic and the model conditions below.

The examples are original and fictional: they are not real measurements or real student investigations.

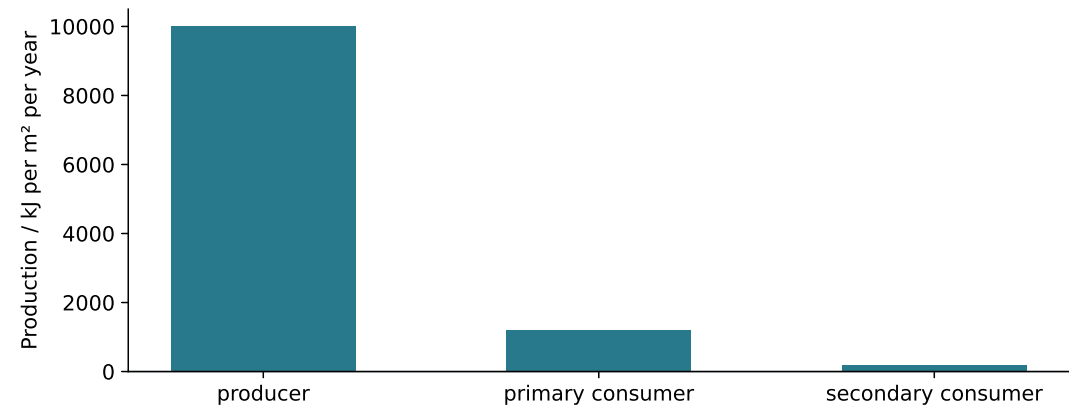
Energy transfer: use production and a stated boundary

■ What would explain this observation?

- Energy available as new biomass usually decreases along a food chain. Energy is conserved overall, but some transferred energy leaves the next-level production pathway.

■ Build the model

- Producers convert an energy input into chemical energy in organic material.
- Consumers obtain material by feeding.
- **Trophic transfer efficiency** compares production available at one level with production at the preceding level over a common area and time.
- Energy can enter detrital pathways, remain in uneaten material, leave in egested waste or be transferred as heat through respiration.
- trophic transfer efficiency: Production at one trophic level divided by production at the preceding level over a common interval.
- **assimilation** : Uptake of digested material into an organism's usable internal pool.



Production falls at each level: 12% then 15% transfer, not a fixed 10%

■ Choose evidence that can test it

- Use the same energy units and period in numerator and denominator.
- Distinguish ingestion, assimilation and production: consumed energy is not all assimilated, and assimilated energy is not all stored as new biomass.
- An energy pyramid records a flow per area per time; a standing biomass snapshot is a different quantity.

In the lab: Analyse attributed or fictional ecosystem budget data. Draw a boundary and arrows for feeding, detritus and heat transfer. Identify which values are measured and which inferred, and check whether the budget includes decomposers. Avoid treating a fixed 10% rule as a universal measurement for every ecosystem.

■ Work from known quantities

- Known: producer production is 10,000 kJ/m²/year and primary-consumer production is 1,200 kJ/m²/year.
- Transfer efficiency is $1,200/10,000 \times 100 = 12\%$.
- Secondary-consumer production of 180 kJ/m²/year gives $180/1,200 \times 100 = 15\%$ for that step.
- These different values show why a universal 10% assumption would misrepresent this dataset.

Your turn: Producer production is 8,000 and primary-consumer production is 800 kJ/m²/year. Calculate transfer efficiency.

■ Check the conclusion and its limits

- Energy is not destroyed when respiration transfers it as heat.
- Material can cycle through an ecosystem, while usable energy flow depends on continuing input.
- A count pyramid or biomass snapshot cannot automatically be substituted into an energy-efficiency calculation.

Not true: Respiration destroys energy instead of transferring it to other forms. Respiration transfers energy to the surroundings as heat - the energy still exists. “Loss” between trophic levels means energy leaves the food chain’s usable flow; conservation is never violated.

Key:

- Producers convert an energy input into chemical energy in organic material.
- Use the same energy units and period in numerator and denominator.
- Watch for: energy is not destroyed when respiration transfers it as heat.

■ Write from a transfer efficiency of 30 percent

- Producer production is 8000 kJ per square metre per year. Primary-consumer production is 2400 in the same units.
- Find the transfer efficiency. Ingestion is not the same as production.