Energy on the Move

Trace energy through a meadow food web

ES.1 "Use mathematical representations to illustrate how the first two laws of thermodynamics demonstrate energy transfers throughout ecosystems, including food chains, food webs, and trophic levels, at various levels of biological organization."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline each statement about where energy goes. Circle the numbers in the table that show one complete energy budget, then number the organisms in order along the food chain.

A Meadow's Energy Budget

1. At the edge of a meadow, grass captures sunlight and builds sugars. Grasshoppers eat grass, frogs eat grasshoppers, and snakes eat frogs. A hawk may eat a snake. In this model, energy is counted across populations in one patch during one year, not inside a single animal. The table follows energy stored in food at each trophic level.

2. The first law of thermodynamics says energy is conserved: energy entering a level equals energy passed to the next level plus energy sent along other paths. The table's "other paths" include uneaten tissues, waste that decomposers can use, and heat released during respiration. These paths move energy to other organisms or into the surroundings.

MEADOW ENERGY MODEL, ONE PATCH OVER ONE YEAR

Organism	Energy entering level (kJ)	Energy passed to next consumer (kJ)	Energy along other paths (kJ)
Grass	1,000	100	900
Grasshoppers	100	10	90
Frogs	10	1	9
Snakes	1	0.1	0.9

3. The second law says each transfer disperses some energy as heat, leaving less available for the next transfer. A food web adds other routes: rabbits eat grass, and hawks eat rabbits. If two routes start with equal food energy and each link passes on the same fraction, the route with fewer links can deliver more energy.

2 ANSWER WITH EVIDENCE

Use the passage

1. What fraction of the energy entering the grasshopper level passes to frogs? Write it as a percentage and explain how the result relates to the second law.

2. Write an equation for the frog level that demonstrates the first law. What does the part not passed to snakes represent?

3. How many times greater is the energy entering the grass level than the energy entering the snake level? Explain why this difference does not violate the first law.

4. In two separate models, each starts with 1,000 kJ in grass and passes 10% at every link. Calculate the energy reaching a hawk by grass → rabbit → hawk and by grass → grasshopper → frog → snake → hawk.

3 YOUR TURN

Your own words

Invent a food web with one producer, two different consumers that eat it, and one predator that eats both consumers. Start with 500 kJ stored in the producer, send 20% to each consumer, then send 20% of each consumer's energy to the predator. Write two arrow chains with kJ labels and one sentence explaining how both laws apply.

Energy on the Move

PART 1 · READ AND MARK

Underline each statement about where energy goes. Circle the numbers in the table that show one complete energy budget, then number the organisms in order along the food chain. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	What fraction of the energy entering the grasshopper level passes to frogs? Write it as a percentage and explain how the result relates to the second law.	**10 ÷ 100 = 10%. Some energy disperses as heat during transfers, so not all of the energy entering the grasshopper level reaches frogs.**
2	Write an equation for the frog level that demonstrates the first law. What does the part not passed to snakes represent?	**10 kJ = 1 kJ + 9 kJ. The 9 kJ follows other paths, including uneaten tissues, waste, and heat, rather than disappearing.**
3	How many times greater is the energy entering the grass level than the energy entering the snake level? Explain why this difference does not violate the first law.	**1,000 ÷ 1 = 1,000 times greater. Energy not reaching snakes follows other paths at earlier levels; it is not destroyed.**
4	In two separate models, each starts with 1,000 kJ in grass and passes 10% at every link. Calculate the energy reaching a hawk by grass → rabbit → hawk and by grass → grasshopper → frog → snake → hawk.	**The rabbit route delivers 1,000 × 0.1 × 0.1 = 10 kJ. The grasshopper, frog, and snake route delivers 1,000 × 0.1 × 0.1 × 0.1 × 0.1 = 0.1 kJ.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

Duckweed (500 kJ) → pond snail (100 kJ) → sunfish (20 kJ)
Duckweed (500 kJ) → tadpole (100 kJ) → sunfish (20 kJ)
The first law accounts for the producer's 500 kJ as 100 kJ to each consumer and 300 kJ along other paths, while the second law explains why some energy disperses as heat instead of reaching the sunfish, which receives 40 kJ total.

For Part 3, accept plausible feeding relationships and different organisms if the two branches account for the producer's energy without counting the same transfer twice. The explanation must distinguish conserved energy from the energy dispersed as heat during transfers.