

How Much Gets Through? Energy per Level and a Caterpillar's Matter Budget

Learning target: I can graph energy at each trophic level, calculate the fraction passed from one level to the next, and account for every gram of matter an animal eats.

Data and graphing

About 45 min

Individual

MS-LS2-3 · practice

MS-LS1-7 · supports

data analysis

independent practice

Name

Date

Period

Directions

Both datasets are teaching datasets: the numbers were invented to be realistic, not measured by a real survey. Part A compares two ecosystems. Graph the pond data with a ruler, show every calculation, and keep units on every number. Percentages should be rounded to one decimal place. Part B tracks matter through a group of caterpillars. Answer in complete sentences where a question asks you to explain.

You will need: This worksheet, Pencil, Ruler, Calculator

Part A: Energy stored at each trophic level

Ecologists estimate how much energy each trophic level stores in new living material over a year, in kilojoules per square meter per year (kJ/m²/yr). The table gives teaching estimates for a shallow pond and a nearby grassland. First-stage consumers eat producers; second-stage consumers eat first-stage consumers; third-stage consumers eat second-stage consumers.

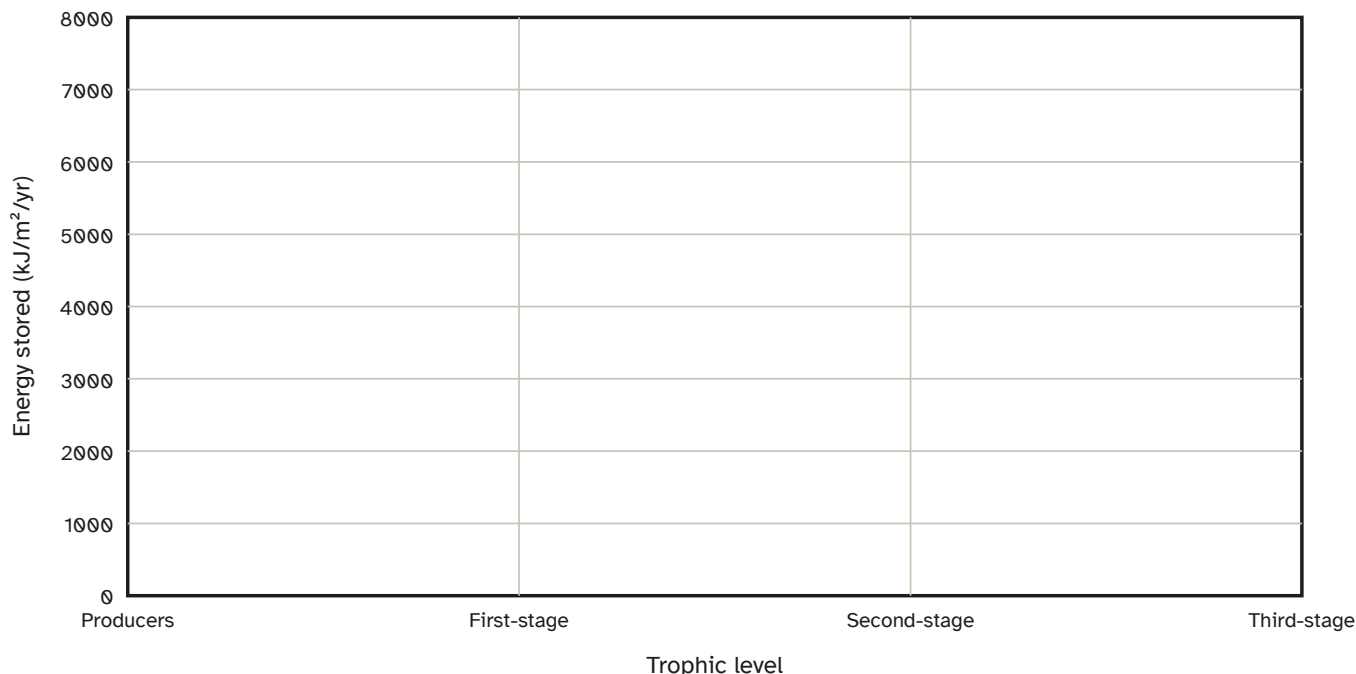
Energy stored in new growth per year at four trophic levels (teaching dataset)

Simulated teaching dataset: the numbers are invented to be realistic, not measured.

Trophic level	Pond (kJ/m ² /yr)	Grassland (kJ/m ² /yr)
Producers	8000	6000
First-stage consumers	900	480
Second-stage consumers	90	60
Third-stage consumers	7	5

Simulated data for teaching. Values are in the realistic range for temperate ponds and grasslands but were not measured at a real site.

Energy stored per year at each trophic level in the pond



- For each step, calculate the percent of energy passed from the lower level to the next: (energy in upper level ÷ energy in lower level) × 100. Fill in all six cells and show one full calculation below the table.

Pond: percent passed on	Grassland: percent passed on
Producers → first-stage consumers	
First-stage → second-stage	
Second-stage → third-stage	

- Find the average of your six percentages. Compare it with the textbook's 10 percent model in one sentence.

- Describe the shape of your bar graph. Why are the last two bars almost impossible to see on this scale, and what does that tell you about how much energy reaches the top of a food chain?

4. What percent of the pond's producer energy ends up stored in third-stage consumers? Show the calculation. Then explain in one sentence why a heron that eats bass needs a lot of pond.

5. A different pond's bass population stores 20 kJ/m²/yr, and bass are third-stage consumers there. Using the 10 percent model exactly, how much energy would that pond's producers need to store each year? Show each step.

6. A student claims, 'Every level always passes on exactly 10 percent.' Does the data support that claim? Write a claim the data **does** support, using your numbers.

Part B: Where does 100 grams of leaf go?

Researchers raised a group of caterpillars in a screened cage on oak branches and tracked the dry mass of everything that went in and came out over one summer. Dry mass means the mass after all the water has been removed, so the numbers compare only the solid material. The table shows what happened to 100 grams of leaf that the caterpillars ate.

Matter budget for 100 g (dry mass) of oak leaf eaten by caterpillars (teaching dataset)

Simulated teaching dataset: the numbers are invented to be realistic, not measured.

What happened to the leaf matter	Dry mass (g)
Passed through and left as droppings	60
Released to the air as carbon dioxide and water during cellular respiration	25
Built into new caterpillar body	15

Simulated data for teaching. The split between droppings, respiration and growth is realistic for leaf-eating insects.

7. Convert each row of the matter budget into a percent of the 100 g eaten.

Percent of the 100 g
Droppings
Carbon dioxide and water from respiration
New caterpillar body

8. Add the three masses. How many grams are unaccounted for? What does that total tell you about whether any matter was destroyed?

9. Suppose birds eat all 15 g of caterpillar and build the same share (15 percent) into their own bodies. How many grams of bird body come from the original 100 g of leaf? Show the calculation.

10. Use both parts of this sheet. Energy and matter **both** shrink from one level to the next. Explain where the missing energy goes and where the missing matter goes, and then explain why only one of them is truly gone from the ecosystem.

Percent in two steps

To find the percent passed on, divide the upper level by the lower level first, then multiply by 100.

Example with made-up numbers: $50 \div 400 = 0.125$; $0.125 \times 100 = 12.5$ percent. Write the division on one line and the multiplication on the next so you can check each step. In q5 you are working backward, so multiply by 10 for each level you go down instead of dividing.

Numbers versus energy

In a 100-hectare grassland valley (one square kilometer), suppose there are about 2,000,000 grass plants, 200,000 grasshoppers, 400 lizards and 4 hawks. Make a second bar chart of these counts, then compare it with the energy pattern. Next, imagine one oak tree holding 20,000 caterpillars. Explain why a pyramid of numbers can be upside down at the bottom while a pyramid of stored energy never is, and what the caterpillar budget in Part B tells you about why.