

Pouring Energy Up the Pyramid: A Water Model of Trophic Levels

Investigation question: If producers capture 1,000 units of energy, how many trophic levels can that energy support, where does the rest go, and how does the answer change if the share passed up is larger or smaller than one tenth?

Physical model

Groups of 4

1 session

Setup 5 · Activity 42 · Cleanup 8 min

MS-LS2-3 · assesses

MS-LS2-1 · supports

Name _____

Group _____

Date _____

Your role today

- ☐ **Pourer:** Transfers water from each level to the next using the correct measuring tool, and pours the remainder into the heat and decomposer jugs as the accountant directs.
- ☐ **Measurer:** Reads every cylinder and syringe at eye level, calls the volume aloud, and confirms it before the pourer continues.
- ☐ **Recorder:** Fills the energy-accounting table row by row and plots the two graphs.
- ☐ **Accountant and checker:** Computes what each level should receive before it is poured, keeps the running totals for the heat and decomposer jugs, and runs the final sum check.

Safety

- Water on the floor is a slip hazard; keep all pouring over the tray and wipe spills at once.
- Food coloring stains skin, clothing and paper; roll up sleeves and keep the recording sheet away from the tray.
- The water is not for drinking; cups and syringes used here go back in the kit, not to mouths.
- Keep phones and calculators off the tray. No hazards beyond water and dye.

Procedure

1. Before pouring, the accountant fills in the 'should receive' column of the round 1 table for levels 2 to 5 using the ten-percent rule (divide by 10 each step), and the group writes a prediction for q1: how many levels will receive at least 1 mL?
2. Level 1 to level 2: measure 100 mL from the producer bottle with the 100 mL cylinder and pour it into the Level 2 cup. Record 100 mL received at level 2. Pour the remaining 900 mL from the bottle into the two jugs, about 600 mL into Heat and 300 mL into Decomposers, using the jug marks as a rough guide. Record the split.
3. Level 2 to level 3: measure 10 mL from the Level 2 cup with the 10 mL cylinder and pour it into the Level 3 cup. Pour the remaining 90 mL into the jugs in the same two-to-one split (about 60 and 30 mL, measured with the 100 mL cylinder). Record.

4. Level 3 to level 4: draw 1 mL from the Level 3 cup with the syringe and squeeze it into the Level 4 cup. Pour the remaining 9 mL into the jugs (about 6 and 3 mL, using the 10 mL cylinder). Record.
5. Level 4 to level 5: draw up the 1 mL from the Level 4 cup and expel 0.1 mL, about two drops, into the Level 5 cup; put the remaining 0.9 mL into the jugs. Record. Try to pass a tenth of the two drops to a sixth level and write what happens in q2.
6. Sum check: pour the Heat jug into the measuring jug and record the volume; do the same for the Decomposers jug; add what is still in the five level cups (level 1 is empty, levels 2 to 5 hold what they received minus what they passed on, which is the 'kept' column). Write the total in q3 and compare it with 1,000 mL.
7. Graph the volume received at each level on the first graph (0 to 1,000 mL). Then graph levels 2 to 5 again on the second graph (0 to 100 mL). Keep both; the analysis asks about them.
8. Round 2: collect the water from the jugs and cups back into the producer bottle, top it up to 1,000 mL, and rerun the transfers using your group's assigned fraction (5, 20 or 30 percent). Compute each 'should receive' value first, measure as before, and stop when the next level would get less than 1 mL. Record the number of levels supported.
9. Report your fraction and the number of levels supported on the class chart. Copy the class results into the round 2 summary table, then answer the analysis questions individually.

Record your observations

Lab 2 recording sheet: Pouring energy up the pyramid

In this model **1 mL of colored water stands for 1 unit of energy**. The producer bottle holds the 1,000 units the plants captured from sunlight this year. At each level only part of the energy is passed up as food; the rest leaves as heat or goes to decomposers in wastes, remains and uneaten parts. A level exists in our model only if it receives at least 1 mL.

Round 1: ten-percent rule of thumb

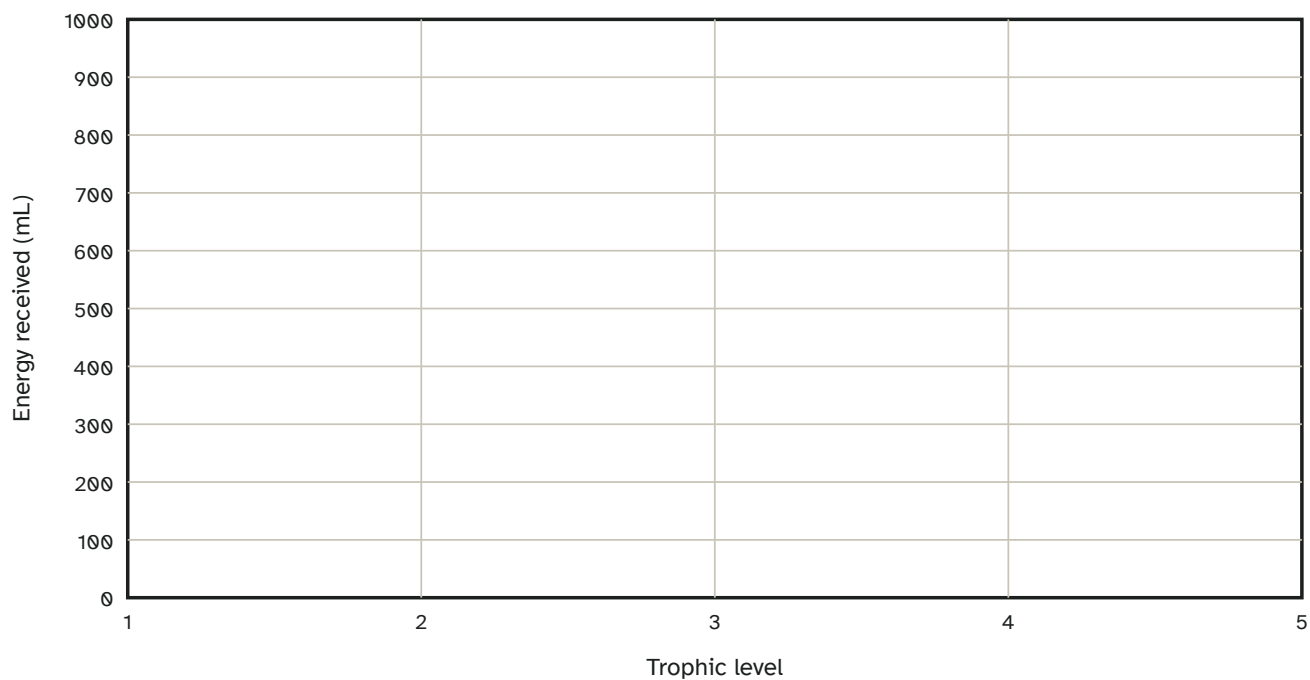
Level	Should receive (mL)	Actually received (mL)	Passed up to next level (mL)	To Heat jug (mL)	To Decomposers jug (mL)	Kept in cup (mL)
1 Producers	1,000	1,000				0
2						
3						
4						
5						
6						

1. Prediction before pouring: how many levels will receive at least 1 mL? Explain your reasoning in one sentence.

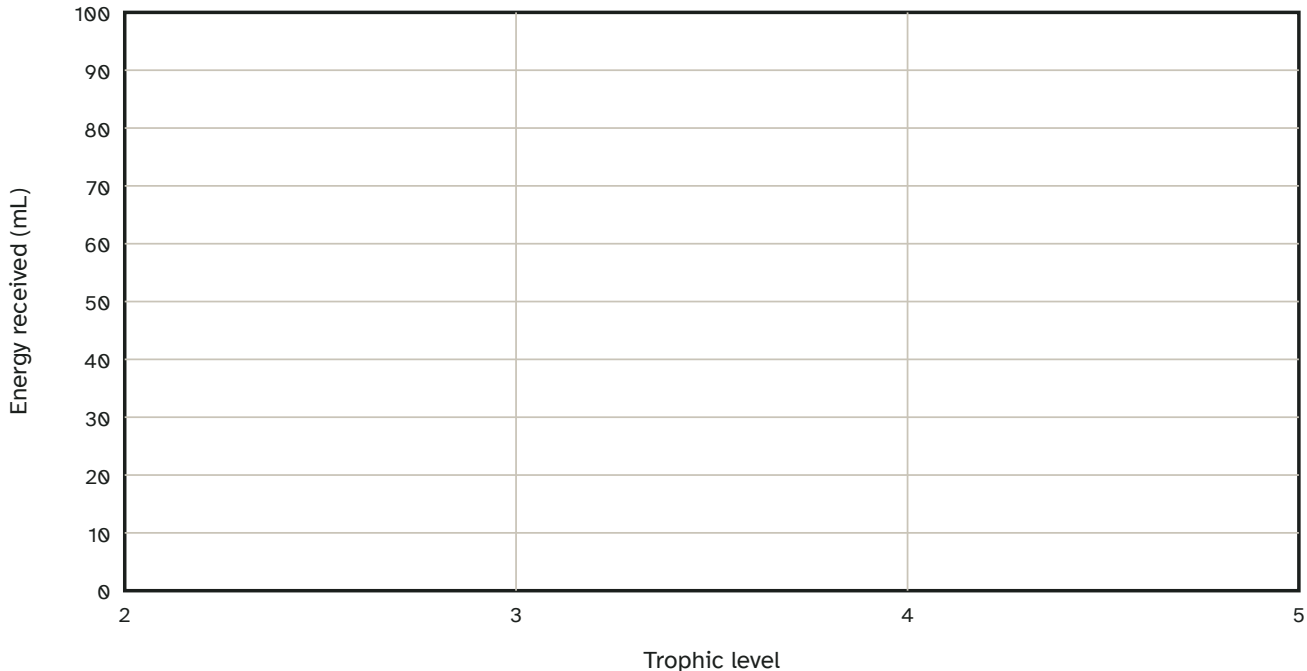
2. What happened when you tried to pass a tenth of level 5's two drops to a sixth level? What does this say about how many trophic levels a food chain can have?

3. Sum check. Heat jug: ___ mL. Decomposers jug: ___ mL. Still in the level cups: ___ mL. Total: ___ mL. How close is this to 1,000 mL, and where did any difference come from?

Energy received at each level (full scale)



Energy received at levels 2 to 5 (zoomed scale)



Round 2: class results for different transfer fractions

Fraction passed up	Level 2 (mL)	Level 3 (mL)	Level 4 (mL)	Level 5 (mL)	Level 6 (mL)	Levels with at least 1 mL
5 percent						
10 percent						
20 percent						
30 percent						

Analysis questions

4. Using your round 1 table, explain in your own words why a food chain that starts with 1,000 units of producer energy cannot feed a sixth level, and why most real food chains have only three to five levels.
-
-
-
-
-

5. Your sum check should come close to 1,000 mL. What does that result say about the phrase 'energy is lost between levels'? Rewrite the phrase so that it is accurate.

6. In the model you could pour the Heat jug back into the producer bottle for round 2. In a real ecosystem, can the heat released by organisms be captured again by producers? Explain where the model stops matching reality.

7. Compare the class results for 5, 10, 20 and 30 percent. Describe the pattern in the number of levels supported, and suggest which kinds of animals (for example cold-blooded versus warm-blooded) might pass on a larger fraction of what they eat, and why.

8. A hawk population at level 5 needs 10 units of energy a year. Using the ten-percent rule of thumb, how many units must the producers capture? Show the calculation. Then explain why a preserve can hold thousands of grasshoppers but only a few hawks.

- 9.** The decomposers jug received a large share of the water. Decomposers are living consumers too. What eventually happens to the energy in that jug in a real ecosystem, and what does that mean for where all of the 1,000 units end up in the long run?

- 10.** This model tracks energy only. Why can it not show matter cycling, and what single change to the model would let it show that matter comes back to the producers?
