

The Vanishing Log: Where Did 9.6 Kilograms Go?

Learning target: I can use measurements from an open cage and a sealed jar to argue where the matter of a decaying log went, and explain why the law of conservation of matter still holds when something seems to disappear.

Claim, evidence, reasoning

About 45 min

Individual

MS-LS2-3 · assesses

MS-LS1-7 · supports

writing

data analysis

Standards connections

MS-LS2-3 (assesses, describing the conservation of matter and defining the boundaries of the system): Students compare an open system (the cage) with a closed one (the jar) and argue, from data, that the log's mass moved to the air and soil rather than disappearing. The argument addresses conservation of matter and system boundaries directly, without chemical equations.

MS-LS1-7 (supports): The explanation rests on decomposers breaking food molecules apart and releasing carbon dioxide and water through cellular respiration. The sheet uses that idea as background and does not ask students to model the rearrangement of molecules.

Purpose: practice · **Time:** about 45 minutes · **Format:** individual

Answers with reasoning

The scenario

Three years ago, a science club placed a freshly cut oak log inside a wire-mesh cage on the ground at the edge of the school garden. The mesh let in air, rain, insects, fungi and bacteria but kept out dogs, raccoons and people. Each spring the club lifted the log out, brushed off loose dirt, weighed it, and put it back. This spring the log was a dark, crumbly shape that fell apart when lifted. The club's question: **the log lost 9.6 kg. Where did that matter go?**

Mass of the caged log, measured each spring (teaching dataset)

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

Year	Mass of log (kg)	Appearance
0	12.0	Fresh, bark tight, pale wood
1	9.1	Bark loose; white fungus threads under bark; beetle holes
2	5.8	Bark gone; wood soft and brown; many insects
3	2.4	Dark, crumbly; breaks apart when lifted

Simulated data for teaching. The pattern is realistic for a log in a mild, moist climate, though most hardwood logs take longer than three years to break down this far.

To test whether decaying matter really disappears, the club also ran a sealed-jar experiment this year. They put 600.0 g of damp oak leaves and 200 g of garden soil (with its bacteria and fungi) into a 1-liter glass jar fitted with a small carbon dioxide sensor, sealed the lid with tape, and placed the whole jar on a balance that reads to 0.1 g every 30 days.

The sealed jar over 90 days (teaching dataset)

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

Day	Total mass of sealed jar (g)	Carbon dioxide inside (ppm)	What the leaves looked like
0	850.0	600	Whole, brown, damp
30	850.0	2100	Spotted with white mold
60	849.9	3800	Dark and soft; pile settling and mold spreading
90	850.0	4900	Dark, limp and partly crumbled; edges blending into the soil

Simulated data for teaching. The balance reads to 0.1 g; the sensor reads carbon dioxide inside the jar.

Field notes from the cage site — 1. The soil directly under the log is darker than the soil 2 m away. A soil test showed 3.1 percent organic matter under the log and 1.2 percent in the comparison spot. 2. The cage mesh was intact all three years; no chunks of wood were found outside it. 3. On warm, damp days a faint earthy smell came from the cage. 4. Rain fell on the log every winter and drained into the soil below.

Warm-up: organize the evidence

1. Calculate the mass the log lost each year (year 0 to 1, 1 to 2, 2 to 3) and the total loss. Which year had the largest loss? Show your work.

Answer: Year 0 to 1: $12.0 - 9.1 = 2.9$ kg. Year 1 to 2: $9.1 - 5.8 = 3.3$ kg. Year 2 to 3: $5.8 - 2.4 = 3.4$ kg. Total: $12.0 - 2.4 = 9.6$ kg (check: $2.9 + 3.3 + 3.4 = 9.6$). The largest loss was in year 2 to 3 (3.4 kg).

Why: Simple subtraction; the loss grows slightly each year as more of the wood is softened and colonized by decomposers.

Also acceptable: None; the values are exact.
2. In the sealed jar, the leaves clearly broke down, yet the total mass stayed at 850.0 g (within 0.1 g). What changed inside the jar as the leaves broke down? Use a number.

Answer: The leaves changed into other things inside the jar: carbon dioxide in the jar's air rose from 600 ppm to 4,900 ppm (about eight times higher), and the leaf pile turned dark, soft and partly crumbled, blending into the soil. The matter changed form and reservoir, but it stayed inside the jar, so the total mass stayed at 850.0 g.

Why: The constant mass plus the rising carbon dioxide is the central evidence that decay converts solid leaf matter into gas rather than destroying it.

Also acceptable: Accept 'the leaves became gas and soil crumbs' with the 4,900 ppm figure.

 - Names the rise in carbon dioxide with a number
 - States that the leaf matter changed form inside the jar

3. The cage and the jar differ in one important way for this argument. What is it, and why does that difference explain why one lost mass and the other did not?

Answer: The jar was sealed (a closed system for matter) and the cage was open to the air and rain. In the jar, gases produced by decomposition had nowhere to go, so the mass stayed the same. In the cage, the same kinds of gases escaped into the atmosphere, and rain carried some dissolved matter into the soil, so the log's mass fell.

Why: This is the system-boundary idea: the difference in boundaries explains the difference in measured mass.

Also acceptable: Accept 'the jar kept everything in; the cage let gas out.'

- Identifies sealed versus open
- Explains that gases escaped from the cage but not the jar

Your argument

Answer: Claim: The log's 9.6 kg was not destroyed. Decomposers (fungi, bacteria and insects) consumed the wood and released most of its matter into the air as carbon dioxide and water vapor through cellular respiration; a smaller part became dark organic matter in the soil under the log. Evidence: (1) The log lost 2.9, 3.3 and 3.4 kg in successive years, 9.6 kg in total, while the mesh stayed intact and no wood was found outside, so the matter did not leave as solid pieces. (2) In the sealed jar the leaves darkened, softened and began to crumble while carbon dioxide rose from 600 to 4,900 ppm and the total mass stayed at 850.0 g, showing that decay turns solid plant matter into gas without any loss of mass when the gas cannot escape. (3) The soil under the log has 3.1 percent organic matter versus 1.2 percent nearby, showing that some of the log's matter entered the soil. (4) Fungus threads, beetle holes and an earthy smell show decomposers were at work. Reasoning: The law of conservation of matter says atoms are not destroyed, so the 9.6 kg must be somewhere. The jar is a closed system: when decomposers break down leaves inside it, the mass stays constant and the carbon dioxide rises, which proves that decomposition converts solid matter into gases. The cage is an open system: the same decomposers produced the same gases, but the open mesh let them escape into the atmosphere, so the balance recorded a loss. The log's matter therefore moved to two reservoirs, mostly the air and partly the soil, and the jar's constant mass is what shows that the cage's 'missing' mass is gas, not nothing.

Why: This is the solved model response. Full credit requires a claim naming both reservoirs (air and soil) and the decomposers; at least three evidence items with numbers, each interpreted; and reasoning that uses conservation of matter and the open-versus-closed comparison to explain why the jar is evidence about the cage.

Also acceptable: A student who claims the matter went only to the air, with strong evidence and reasoning, earns most credit but should be asked about the soil data. A student who claims the matter was 'turned into energy' has a conservation error and cannot earn credit for the claim; see Worksheet 7.

- Claim names air (carbon dioxide and water vapor) and soil as reservoirs and decomposers as the agents
- At least three numbered evidence items with numbers and interpretation
- Reasoning invokes conservation of matter
- Reasoning explains open versus closed system and why the jar's result transfers to the cage

4. A classmate argues: 'Most of the log's mass went into the soil under it.' Using the field notes and your knowledge of decomposers, explain why the soil can account for only a small part of the 9.6 kg and where the rest must have gone.

Answer: The soil under the log did gain organic matter (3.1 percent versus 1.2 percent), but that is a small amount: the darker layer is thin and only directly beneath the log, nowhere near 9.6 kg of extra material. Decomposers use most of what they eat as fuel for cellular respiration, releasing carbon dioxide and water vapor, which left through the mesh into the air. So the air is where most of the mass went, and the soil holds only a small share.

Why: The jar data show that decomposition produces mostly gas; the soil gain is real but minor. Students should reason from the jar's carbon dioxide rise and the limited size of the dark patch.

Also acceptable: Accept an estimate that the soil holds 'maybe a kilogram' as reasonable; the exact share is unknown.

- Acknowledges the soil gain with the numbers
- Argues it is small compared with 9.6 kg
- Names the air (as carbon dioxide and water vapor from respiration) as the main destination

5. If the club had put the whole log in a sealed container big enough to hold it, with a balance underneath, what reading would they expect after three years, and what would they expect the air inside to be like? Explain.

Answer: The balance would still read the same total as at the start (log plus container plus air inside), because nothing could leave the sealed container. The air inside would be very high in carbon dioxide and water vapor (and low in oxygen), because the decomposers would have converted the log's matter into those gases; decay might even slow or stop once the oxygen ran out.

Why: The question transfers the jar result to the log's scale. The oxygen point is a bonus that shows understanding that respiration needs oxygen.

Also acceptable: Accept 'the log would still lose mass but the container would not' as a sophisticated version of the same answer.

- Predicts no change in total mass
- Predicts high carbon dioxide (and water vapor) inside

Scoring rubric

Criterion	4 • Exemplary	3 • Proficient	2 • Developing	1 • Beginning
Claim	Names both reservoirs (air as carbon dioxide and water vapor; soil as organic matter) and the decomposers that moved the matter, in one clear statement.	Names the air as the main destination and the decomposers; the soil is missing or vague.	Names a destination without naming who moved the matter, or names the soil only.	No claim, or a claim that matter was destroyed or became energy.
Evidence	Three or more specific pieces of evidence with numbers from the log data, the jar data and the field notes, each with a sentence saying what it shows.	Three pieces of evidence, but one lacks a number or is not interpreted.	One or two pieces of evidence, or numbers copied without saying what they show.	Evidence missing, invented, or contradicting the data.

Reasoning	Uses conservation of matter explicitly, contrasts the open cage with the closed jar, and explains why the jar's constant mass shows that the cage's missing mass became gas.	Uses conservation of matter and the open-closed contrast but does not explain why the jar result applies to the cage.	Restates evidence without a principle, or states conservation of matter without connecting it to the two systems.	No reasoning, or reasoning that treats mass loss as proof matter was destroyed.
Scientific language and accuracy	Uses decomposer, cellular respiration, reservoir, open and closed system correctly; distinguishes breathing from cellular respiration; no errors.	Terms mostly correct with one minor slip (for example, 'breathe out' for a fungus).	Several terms used loosely (decomposers 'eat up' matter so it is gone; 'weight' and 'mass' confused in a way that changes meaning).	Scientific language absent or consistently wrong.

Teacher notes

Both datasets are simulated. The log loses mass faster than most real oak logs do (three years is quick for a hardwood), but the pattern of accelerating loss as decomposers colonize the wood is realistic. Sealed decomposition jars on a 0.1 g balance hold constant mass while carbon dioxide inside climbs into the thousands of ppm; note that a sealed 1-liter jar holds only enough oxygen for a small fraction of 60 g of leaves to decay, so decay slows as the oxygen is used up, which is why the jar's leaves are only partly broken down at day 90 and why q5's answer mentions oxygen running out. The sealed jar is a safe demonstration if you want to run it (keep it sealed and dispose of the contents in the garden; do not open it indoors, since the air inside is oxygen-poor and smells). The key move in the reasoning is transferring a closed-system result to an open system; students who get the claim right often skip that step, so the rubric's Reasoning row weights it. Watch for the misconception that decomposers 'use up' matter, and for the idea that the log's mass became energy; both are addressed in Worksheet 7. Water also leaves the log as vapor and in drainage, so a claim naming water vapor alongside carbon dioxide is more complete, not less.

Scaffold offered to students: Two columns: what left, what stayed

On scrap paper make two columns headed 'Evidence that matter LEFT the log' and 'Evidence about WHERE it went.' Put the yearly mass losses and the intact mesh in the first column. Put the jar's rising carbon dioxide, the jar's constant total mass, the darker soil, and the earthy smell in the second column. Each item in the second column points to a reservoir: the air (as carbon dioxide and water vapor) or the soil (as dark organic matter). Your Claim names those reservoirs; your Evidence is the two columns; your Reasoning is why a closed jar proves that 'missing' mass became gas.

Extension: Carbon out of the fast cycle

Part of the log's carbon is now dark organic matter in the soil, where it may stay for decades. Under the right conditions, buried plant matter can stay out of the fast carbon cycle for millions of years and become coal. Write a paragraph comparing the cage, the jar and a coal seam as three reservoirs: how long carbon stays in each, what process moves it out, and why burning the coal is different from the decay in the cage even though both release carbon dioxide.