

Fixing Mateo's Desert Notebook: Arrows, Energy and Matter

Learning target: I can find the errors in another student's food web, trophic pyramid and explanations, say what idea went wrong, and rewrite each statement so that it is scientifically accurate.

Error analysis

About 40 min

Individual

MS-LS2-3 · practice

writing

independent practice

Standards connections

MS-LS2-3 (practice): Diagnosing a flawed model of matter cycling and energy flow, and rewriting it, exercises exactly the ideas the PE's model must get right: arrow direction, matter conserved and recycled, energy leaving as heat, and nonliving parts in the cycle.

Purpose: practice · **Time:** about 40 minutes · **Format:** individual

Answers with reasoning

Desert facts Mateo was given — Creosote bushes and desert grasses are the producers. Kangaroo rats eat seeds. Darkling beetles eat dead leaves and seeds. Kit foxes eat kangaroo rats. Golden eagles eat kit foxes and kangaroo rats. Soil bacteria and fungi break down droppings and dead remains. In a teaching model of this web, the producers store 5,000 energy units each year.

Mateo's notebook page

1. I drew the arrow from the kit fox to the kangaroo rat, because the fox eats the rat and the arrow shows who does the eating.
2. Decomposers recycle the energy from dead animals back to the plants, so the desert never needs new energy from the sun.
3. The producers store 5,000 energy units, so using the 10 percent model the kangaroo rats get 500, the kit foxes get 50 and the eagles get 5. Exactly 10 percent is passed on every time in every ecosystem.
4. The 4,500 units of matter that did not pass from the plants to the kangaroo rats were destroyed; they just disappeared as heat.
5. The golden eagle is at the top of the pyramid, so it has the most energy of any organism in the desert.
6. The kit fox does not eat beetles, so a change in the number of kit foxes cannot affect the beetle population.
7. Soil bacteria make nutrients that plants need, so bacteria are producers.
8. A dry year meant fewer seeds, so there were fewer kangaroo rats, so the kit foxes had less to eat. The effect on the foxes is a direct effect of the seed shortage.

Part A: Diagnose

1. Complete the table for all eight statements. Some statements are partly right; mark those 'incorrect' and name only the part that is wrong.

Answer: 1: incorrect; arrow direction (arrows point from food to eater). 2: incorrect; energy is not recycled, matter is. 3: incorrect (arithmetic right); 10 percent is an average, not exact or universal. 4: incorrect; matter is never destroyed, and matter does not become heat. 5: incorrect; the top level has the least energy. 6: incorrect; indirect effects pass through other populations. 7: incorrect; decomposers are consumers, not producers. 8: incorrect; the effect on foxes is indirect (through the rats).

Why: All eight statements contain an error; statement 3's arithmetic is correct but its generalization is not. Students may defend statement 3's first sentence as correct, which is fine if they flag the second sentence.

Also acceptable: Accept 'partly correct' for statement 3 with the second sentence identified as the problem.

- All eight marked incorrect (or statement 3 marked partly correct)
- Each error named in a few words that identify the idea, not just 'wrong'

Part B: Explain and rewrite

2. Statement 1: Explain what a food web arrow actually represents, then rewrite the statement so the arrow is drawn correctly.

Answer: An arrow shows where matter and energy go: from the food to the organism that eats it. Rewrite: 'I drew the arrow from the kangaroo rat to the kit fox, because the matter and energy in the rat become matter and energy in the fox.'

Why: The arrow means 'is eaten by', not 'eats'.

Also acceptable: Accept 'the arrow points toward the eater'.

- States that arrows show the transfer of matter and energy to the eater
- Rewritten arrow runs from rat to fox

3. Statement 2: Mateo has mixed up two different things. Name them, explain which one decomposers really recycle, and rewrite the statement.

Answer: He has mixed up matter and energy. Decomposers recycle matter: they break down remains and droppings and release carbon dioxide and nutrients that plants take in again. They do not recycle energy; the energy in a dead animal is used by the decomposers and leaves as heat. Rewrite: 'Decomposers recycle the matter in dead animals by releasing nutrients that plants can use, but the energy leaves as heat, so the desert always needs new energy from the sun.'

Why: This is the central misconception of the chapter and the one the textbook's own wording ('energy cycles') encourages.

Also acceptable: Accept 'energy flows, matter cycles' with a correct rewrite.

- Names matter and energy as the two things confused
- States that matter (nutrients, carbon dioxide) is recycled
- States that energy leaves as heat and the sun must resupply it
- Rewrite is accurate

4. Statement 3: Check Mateo's arithmetic by showing each step. Then rewrite the second sentence so it is accurate about the 10 percent figure.

Answer: $5,000 \times 0.10 = 500$ (kangaroo rats); $500 \times 0.10 = 50$ (kit foxes); $50 \times 0.10 = 5$ (eagles). Mateo's arithmetic is correct. Rewrite: 'About 10 percent is passed on at each level on average; the real fraction varies between ecosystems and between levels, but it is always a small share.'

Why: The calculation follows the 10 percent model exactly; the error is the word 'exactly' and 'every ecosystem'.

Also acceptable: Accept division by 10 at each step.

- Three multiplication steps shown with the correct results
- Rewrite says average or approximately, and that it varies

5. Statement 4: Name two places the matter that did not become kangaroo rat actually went, and rewrite the statement. Use the words *matter* and *energy* correctly.

Answer: The matter went into (a) plant material that was never eaten and was broken down by decomposers, (b) kangaroo rat droppings, and (c) carbon dioxide and water released by the rats' cellular respiration; it also includes plant matter still standing. None of it was destroyed, and matter never 'becomes' heat; it is energy that leaves as heat. Rewrite: 'The matter that did not become kangaroo rat is still in the desert: in uneaten plants, in droppings and remains that decomposers break down, and in carbon dioxide released to the air. The energy that was not passed on was mostly released as heat.'

Why: Two errors: destruction of matter, and matter turning into heat. The rewrite must separate matter's fate from energy's fate.

Also acceptable: Accept any two of uneaten plants, droppings, carbon dioxide and water from respiration, and remains eaten by decomposers. Strong answers also notice that the 5,000 units in the desert facts are energy units, so calling 4,500 of them 'units of matter' already mixes the two up.

- Names two destinations for the matter
- States matter is not destroyed
- Separates matter (reused) from energy (heat)

6. Statement 5: What is Mateo confusing about the pyramid? Rewrite the statement to say what the top level actually has.

Answer: He is confusing the position of a level with the amount of energy it holds, and the whole level with one animal. The top level of a trophic pyramid receives the least energy, which is why there are few eagles. Rewrite: 'The golden eagles are at the top of the pyramid, so their level receives the least energy of any level, only about 5 units out of 5,000.'

Why: The pyramid's top is the narrowest layer; 'top' does not mean 'most'.

Also acceptable: A student who adds that a single eagle may hold more energy than a single rat but the level as a whole holds far less is reasoning carefully.

- Identifies that the top level has the least energy
- Rewrite uses the model's numbers or 'least'

7. Statement 6: Use the desert facts to trace one path by which a change in kit foxes could reach the beetles, then rewrite the statement.

Answer: Path: fewer kit foxes → more kangaroo rats survive → the rats eat more seeds → fewer seeds are left for darkling beetles → the beetle population falls. Rewrite: 'The kit fox does not eat beetles, but a change in kit foxes can still affect beetles indirectly, through the kangaroo rats that compete with beetles for seeds.'

Why: An indirect effect passes through one or more populations in between; the desert facts give seeds as the shared food.

Also acceptable: Accept a path through eagles (fewer foxes → eagles eat more rats) only if it ends at a change in beetles with a reason.

- Traces a path through at least one middle population
- Rewrite says the effect is indirect

8. Statement 7: Explain the difference between what bacteria do with nutrients and what producers do with carbon dioxide, water and sunlight. Rewrite the statement.

Answer: Bacteria do not make food. They get their matter and energy by breaking down remains and droppings, which makes them consumers (decomposers); the nutrients they release are leftovers from that breakdown. Producers build sugar and new body material from carbon dioxide and water using energy from sunlight. Rewrite: 'Soil bacteria are decomposers, a kind of consumer; they release nutrients as they break down remains, and the plants (the producers) take those nutrients in.'

Why: Producers are defined by making their own food from nonliving materials with light energy; releasing nutrients is not producing food.

Also acceptable: Accept 'bacteria eat dead stuff, plants make their own food'.

- States that bacteria get energy by consuming remains
- States what producers do with carbon dioxide, water and light
- Rewrite calls bacteria decomposers or consumers

9. Statement 8: Is the effect on the foxes direct or indirect? Rewrite the last sentence correctly, and name one population whose change in that dry year **would** be a direct effect of the seed shortage.

Answer: Indirect. The seed shortage affected the kangaroo rats directly (seeds are their food), and the foxes only through the rats. Rewrite: 'The effect on the foxes is an indirect effect of the seed shortage, passed through the kangaroo rat population.' A direct effect of the seed shortage: the kangaroo rats (or the darkling beetles), because they eat seeds.

Why: Direct means the two populations share an arrow; foxes and seeds do not.

Also acceptable: Accept 'the producers themselves' only if the student explains the dry year acted on the plants, which is a nonliving-factor effect rather than a feeding effect.

- Says indirect with the rat population as the middle step
- Names rats or beetles as a direct effect

Part C: The rule behind the mistakes

- 10.** Several of Mateo's mistakes come from the same confusion. Name it, and write a two-sentence rule he could tape inside his notebook that would prevent statements 2, 4 and 5 at the same time.

Answer: The shared confusion is treating matter and energy as the same thing, or as interchangeable. Rule (example): 'Matter cycles: atoms leave an organism as waste, carbon dioxide and remains, are recycled by decomposers, and are never destroyed. Energy flows one way: it enters as sunlight, most of it leaves as heat at every level, and it is never recycled, so each level above gets less.'

Why: Statements 2 (energy recycled), 4 (matter destroyed, becomes heat) and 5 (top has most energy) all fall to a clear matter-versus-energy rule.

Also acceptable: Accept a rule phrased as 'matter goes around, energy goes through' if each half is explained.

- Names the matter-energy confusion
- Rule states that matter is conserved and recycled
- Rule states that energy flows one way and leaves as heat
- Rule would block statements 2, 4 and 5

Teacher notes

Mateo's page is built from the misconceptions most often seen with this lesson: reversed arrows (statement 1), recycled energy (2, which echoes the textbook's own 'energy cycles' phrasing and must be corrected), 'exactly 10 percent' (3), matter destroyed or turned into heat (4), top equals most (5), no indirect effects (6), decomposers as producers (7) and direct versus indirect confusion (8). The desert facts are simplified but realistic for the Mojave: kangaroo rats are seed eaters, darkling beetles feed on dead plant material and seeds, kit foxes take kangaroo rats, and golden eagles take both. Statement 3's calculation is intentionally correct so that students separate arithmetic from generalization. Use q10 as the exit discussion.

Scaffold offered to students: Two questions for every statement

For each statement ask: (1) Is this about *matter* (atoms, mass, nutrients, carbon dioxide) or about *energy* (sunlight, stored energy, heat)? (2) Does it say something leaves the ecosystem, gets reused, or is destroyed? Matter can leave an organism and be reused, but it is never destroyed. Energy can be used and leaves as heat, and it is never reused by producers. If a statement breaks either rule, it is incorrect.

Extension: Write the next three

Write three new statements about the desert web that each contain a different mistake not already on Mateo's page (for example, about biomass, about what 'top predator' depends on, or about where producers get their matter). Trade with a partner, diagnose each other's statements, and rewrite them. Then decide together which of your six mistakes would be hardest for a seventh grader to notice, and why.