

A Valley of Grass, a Dozen Deer, One Mountain Lion

Learning target: I can describe a pattern in how much living matter each feeding level of an ecosystem holds, connect it to an animal that eats far more than it gains, and write a first explanation to test.

Phenomenon exploration

About 30 min

Individual

MS-LS2-3 · supports

discussion

writing

data analysis

Standards connections

MS-LS2-3 (supports): Students observe the pattern (shrinking mass at each feeding level, food eaten without mass gained) that the chapter's model of matter cycling and energy flow will have to explain. This sheet activates the question; it does not yet build the model.

Purpose: activate · **Time:** about 30 minutes · **Format:** individual

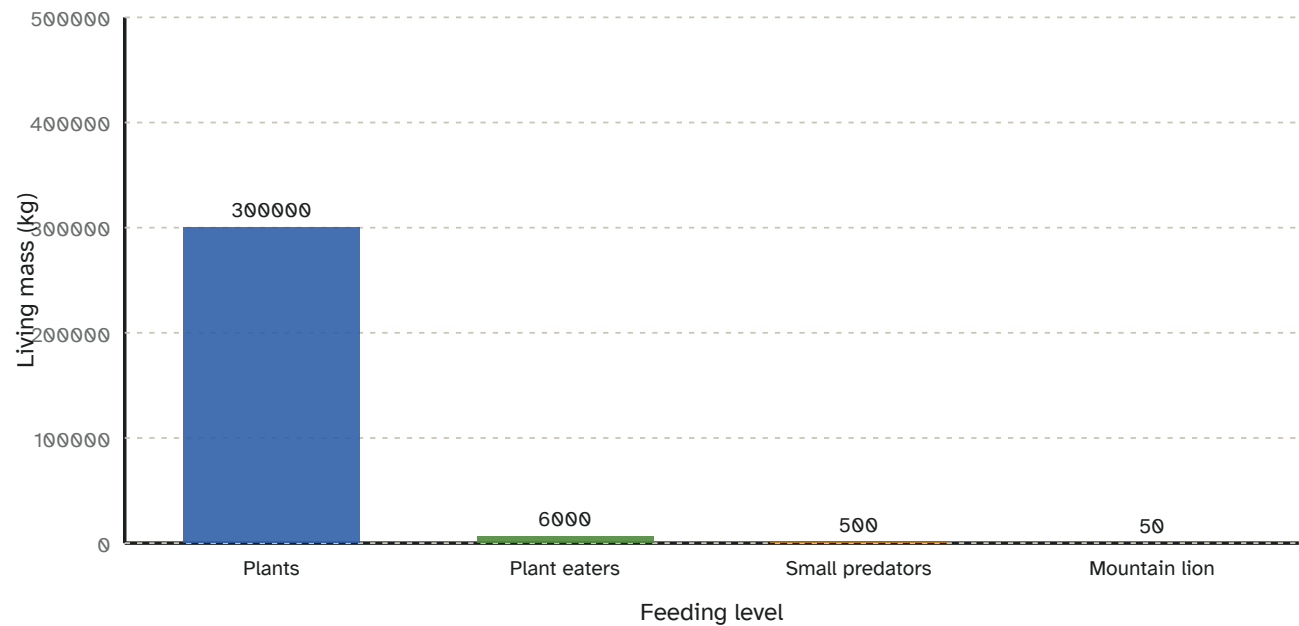
Answers with reasoning

Observation 1: Counting a square kilometer

Imagine a park ranger who is asked to estimate the mass of every living thing in one square kilometer of foothill grassland in central California. She cannot weigh everything, so she samples small plots and scales up. Grasses and scattered oaks cover almost the whole square, so their mass is enormous. Grasshoppers, voles, rabbits and about a dozen mule deer eat the plants. A few coyotes, bobcats, snakes and hawks eat the plant eaters. One mountain lion passes through, and its hunting range is far larger than this one square. The bar chart shows her estimate for each feeding level.

Living mass in one square kilometer of foothill grassland

simulated data



Teaching estimate of the living mass (biomass) at each feeding level in one square kilometer of foothill grassland. The values are invented to show a realistic pattern; they are not a measured survey.

Observation 2: The goat that never gets heavier

The ranger's neighbor keeps one adult dairy goat. The goat eats about 2 kilograms of hay every day, which adds up to roughly 14 kilograms each week. The neighbor weighs the goat every Monday on a livestock scale. Her records for four weeks are below.

Four weeks of hay and weigh-ins for one adult goat (teaching dataset)

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

Week	Hay eaten that week (kg)	Goat's mass on Monday (kg)
0	0	55.2
1	14	55.4
2	14	55.1
3	14	55.3
4	14	55.2

Simulated data for teaching. The goat is a healthy adult that is no longer growing.

Part A: Notice and wonder

1. Write three things you **notice** in the bar chart. At least one must use a number.

Answer: Examples: each level holds far less mass than the one below it; plants hold 300,000 kg while plant eaters hold 6,000 kg; the mountain lion bar is so small (50 kg) it is hard to see on the same scale; the drop from plants to plant eaters is the largest in absolute terms.

Why: Any accurate observation about the chart counts. At least one statement must include a value from the chart.

Also acceptable: Accept observations about the shape ('it looks like steps going down') if paired with at least one numeric notice.

- Three observations drawn from the chart
- At least one uses a number from the chart
- Observations, not explanations

2. Write three questions you **wonder** about after reading both observations. Start each with *why*, *how* or *what would happen if*.

Answer: Examples: Why is there so much less mass at each level? What would happen if the mountain lion left? How can the goat eat 56 kg and stay the same? Where does the grass go after a deer eats it? Would a forest show the same pattern?

Why: Questions should be answerable by investigation or by the chapter's ideas and should arise from the two observations.

Also acceptable: Questions about the method ('How did she estimate the mass of all the grass?') are legitimate science questions and earn credit.

- Three questions
- Each begins with why, how or what would happen if
- Each connects to one of the observations

3. How many times more living mass is there in the plants than in the plant eaters? Show the division.

Answer: $300,000 \text{ kg} \div 6,000 \text{ kg} = 50$. The plants hold 50 times more living mass than the plant eaters.

Why: A ratio of 50 to 1 is realistic for grassland producers versus herbivores. Students should write the division, not just the result.

Also acceptable: Accept '50 times' or '50:1'.

4. Add up all the hay the goat ate in weeks 1 to 4. Then find the change in the goat's mass from week 0 to week 4. Write both numbers with units and compare them in one sentence.

Answer: Hay eaten: $14 + 14 + 14 + 14 = 56 \text{ kg}$. Mass change: $55.2 \text{ kg} - 55.2 \text{ kg} = 0.0 \text{ kg}$. The goat took in 56 kg of food but gained none of it as body mass; the week-to-week wobble of 0.1 to 0.2 kg is just normal variation.

Why: The point is the contrast between a large input and zero net change in the goat's mass.

Also acceptable: Accept a change of 0 kg or 'about 0 kg'; accept a note that week 1 showed +0.2 kg temporarily.

Part B: What you already know

5. From earlier lessons: where do plants get the matter they are made of, and what do all organisms do with the sugar they take in? Use the words *photosynthesis* and *cellular respiration* if you can.

Answer: Plants build their matter from carbon dioxide (from the air) and water (from the soil), using energy from sunlight in photosynthesis to make sugar. All organisms, including plants, break sugar down in cellular respiration to release energy for living; the carbon dioxide and water made in that process leave the organism.

Why: This recalls the previous lessons on photosynthesis and respiration, which the chapter will use to explain where eaten matter goes.

Also acceptable: Accept 'plants make their own food from air, water and light' and 'cells use sugar for energy' as a basic version.

- Plants build matter from carbon dioxide and water (not from soil 'food')
- Organisms break sugar down to release energy
- Mentions that carbon dioxide and water leave the organism, or that plants also respire

Part C: Your first explanation

6. The goat ate about 56 kilograms of hay in four weeks and ended up at the same mass. Matter cannot just vanish. Write your best explanation of where the hay's matter went. Name at least two places.

Answer: Most of the hay's matter leaves the goat again. Some passes straight through as dung (and some as urine). The goat's cells break down much of the digested food in cellular respiration to release energy, and that matter leaves the goat as carbon dioxide she breathes out and as water. Only a small share becomes new body material, and in an adult that is balanced by the body material that is constantly being replaced and shed, so the net change is about zero.

Why: A full-credit answer must say that matter is not destroyed and must name at least two exits: waste (dung, urine) and the carbon dioxide and water from respiration. The chapter will later confirm this explanation.

Also acceptable: A student who says 'the energy in the hay is used up and the rest leaves as waste and breath' has the idea; note later that energy is used, not matter.

- States that matter is not destroyed
- Names dung or other waste as one exit
- Names breathing out carbon dioxide (or respiration) as another exit
- Gives a reason for zero net gain

7. Use your answer to q6 to explain the bar chart. Why might each feeding level hold so much less living mass than the level it eats from? Why would a square kilometer that feeds 300,000 kg of plants hold only one mountain lion?

Answer: At each level, most of the food eaten does not become the eater's body: it leaves as waste and as carbon dioxide and water from respiration, and much of the level below is never eaten at all (it dies and is broken down by decomposers). So only a small fraction of each level's mass can become the next level's mass. Repeating that loss three times means a huge base of plants supports a small mass of plant eaters, a smaller mass of predators, and only enough to feed one large predator that must hunt across many square kilometers.

Why: This is the chapter's central idea stated as a hypothesis. Credit any explanation that links a small fraction passing up at each step to the shrinking bars, and that extends it to the lion.

Also acceptable: Partial credit for 'bigger animals need more food' without the fraction idea.

- Connects the goat's losses to every feeding level
- States that only a fraction of each level becomes the next
- Explains the lion as needing a large area because the top level receives so little

8. What is one measurement the ranger or the neighbor could make to test your explanation? Say what result would support it.

Answer: Examples: collect and weigh the goat's dung for a week and compare with the hay eaten (a large share of the hay mass should appear as dung); measure how much carbon dioxide the goat breathes out; measure how much of a plot's grass is actually eaten by herbivores versus how much dies and decays. A result showing that most of the eaten mass reappears as dung and breath would support the explanation.

Why: The test must be a measurement tied to the student's explanation and must name an expected result.

Also acceptable: Accept 'weigh the goat right after eating and the next morning' with a stated prediction.

- Names a measurable quantity
- States the result that would support the explanation

Keep this page — At the end of the chapter you will reread your answers to q6 and q7 and mark what you would keep, change or add. A first explanation that changes is a sign of learning, not a mistake.

Teacher notes

Both datasets are simulated. The grassland values follow a roughly 50:1, 12:1 and 10:1 drop between levels, which is in the realistic range for temperate grasslands, and the mountain lion value represents a single animal whose range covers many such squares. Expect many students to say the goat's hay 'turns into energy'; do not correct that yet, but note it for W7, where matter and energy are separated. The chart's shrinking bars are about mass, not numbers of individuals; the extension raises that distinction and anticipates the chapter's accuracy note that pyramids of numbers can be inverted. Collect the sheets or have students keep them for the end-of-chapter revisit.

Scaffold offered to students: Sentence starters for Part C

If you are stuck on q6, try finishing these: 'Some of the hay leaves the goat as ____.' 'Some of the hay is used by the goat's body to ____, and what is left over leaves as ____.' For q7, try: 'The plant eaters cannot turn all the grass into their own bodies because ____, so the next level up has even less to eat because ____.'

Extension: A different kind of pyramid

The bar chart shows mass. Now think about *numbers* of individuals instead. Would a chart of how many organisms live at each level have the same shape? Consider a single oak tree covered with thousands of caterpillars. Write a short paragraph arguing whether counting individuals or weighing them gives a better picture of how much food each level offers to the next, and give one case where the two charts would disagree.