

The Antlion's Budget: Dig, Wait, or Move? An Energy Decision

Learning target: I can use an energy budget to compare three strategies for an animal that must store enough energy to grow and change form, model where the matter and energy in its food go, and justify a decision under uncertainty.

Transfer and design

About 55 min

Pairs

MS-LS1-7 · assesses

MS-LS2-3 · supports

engineering design

data analysis

writing

Standards connections

MS-LS1-7 (assesses, the model of food used both to release energy and to support growth): Students build a model of an antlion larva in which the ants it eats are rearranged into carbon dioxide and water (releasing energy for digging and staying alive) and into stored fat and new body (growth), and they use that model to decide between strategies. The task stays at the level of inputs, outputs and energy accounting, within the assessment boundary.

MS-LS2-3 (supports): The budget treats the antlion as one link through which matter and energy from ants pass; this is background for ecosystem-scale energy flow in later chapters and is not assessed here.

Purpose: extend · **Time:** about 55 minutes · **Format:** pairs

Answers with reasoning

The brief — You are advising an antlion larva (as a thought experiment). It lives at the bottom of a cone-shaped pit it dug in loose sand, waiting for ants to slide in. It has 30 days to store enough energy, as body fat, to change into its winged adult form; if it falls short, it cannot complete the change. Its patch of open sand is windy, and wind wrecks the pit about once a week. A sheltered patch under a bush is 2 days' crawl away. Decide: should the antlion keep rebuilding where it is, stop rebuilding and hunt from a damaged pit, or move?

Real antlion facts: antlion larvae dig funnel-shaped pits in dry, loose sand and wait buried at the bottom. When an ant slips in, the larva flicks sand to make it slide down, seizes it with its jaws and digests it. Larvae can survive long gaps between meals, and they eventually form a cocoon in the sand and emerge as winged adults. Digging and sand-flicking are hard work for an animal this small, and that work is powered by cellular respiration using the energy in the ants it ate earlier. The numbers below, however, are invented for this exercise.

Budget rules (teaching numbers; 1 EU = one energy unit, invented for this sheet)

Item	Rule
Staying alive (upkeep)	Costs 2 EU every day, all 30 days, no matter what. This is the energy its cells release just to keep working.
Pit maintenance	Costs 1 EU on every day the antlion hunts from a working pit (flicking out sand that blows in).
Full pit build or rebuild	Costs 9 EU and takes the whole day: no hunting and no maintenance cost that day.
Hunting, open patch, working pit	Gains 6 EU per day from ants caught (about one ant a day).
Hunting, open patch, damaged pit	Gains 2 EU per day; no maintenance is done on a damaged pit.
Hunting, sheltered patch, working pit	Gains 5 EU per day. This is an estimate from one week of counting ants walking past the bush.
Storms	Open patch: wind wrecks the pit on the evenings of days 6, 12, 18 and 24. Sheltered patch: no storm expected in 30 days.
Moving to the sheltered patch	Takes days 1 and 2, costs an extra 3 EU per travel day (6 EU total), no pit and no hunting on those days. Day 3 must be a build day.
Goal	Net stored energy of at least 30 EU (as fat) by the end of day 30. More stored energy makes a larger, healthier adult.

Three strategies**1 Strategy A: Stay and rebuild**

Hunt from the open-patch pit. After each storm, spend the next day rebuilding (9 EU, no hunting), then hunt again from a working pit. Pay maintenance on every hunting day.

2 Strategy B: Stay and wait it out

Hunt from the open-patch pit until the first storm on day 6. Never rebuild. From day 7 on, hunt from the damaged pit (2 EU per day) and pay no maintenance.

3 Strategy C: Move to the bush

Spend days 1 and 2 crawling to the sheltered patch (no hunting, 3 EU extra per day). Build a pit on day 3 (9 EU). Hunt from a working pit on days 4 to 30 with no storms, paying maintenance every hunting day.

Part A: Do the math before you decide

1. Complete the 30-day budget for each strategy. Net stored = energy from ants – (upkeep + maintenance + building or moving). Show the calculation for at least one strategy in full below the table.

Answer: Strategy A: hunting days 26 ($30 - 4$ rebuild days); energy from ants $26 \times 6 = 156$; upkeep 60; maintenance 26; building $4 \times 9 = 36$; net $156 - (60 + 26 + 36) = 156 - 122 = 34$ EU. Strategy B: hunting days 30 (6 from a working pit, 24 from a damaged pit); energy from ants $6 \times 6 + 24 \times 2 = 36 + 48 = 84$; upkeep 60; maintenance 6; building 0; net $84 - 66 = 18$ EU. Strategy C: hunting days 27 (days 4 to 30); energy from ants $27 \times 5 = 135$; upkeep 60; maintenance 27; building or moving $9 + 6 = 15$; net $135 - (60 + 27 + 15) = 135 - 102 = 33$ EU.

Why: The storms on days 6, 12, 18 and 24 each cost one rebuild day, so A has 26 hunting days. B keeps hunting every day but at the damaged rate after day 6. C loses days 1 to 3. Maintenance applies only to hunting days from a working pit, so B pays it for 6 days only.

Also acceptable: If a student charges maintenance on rebuild days, A's net becomes 30; mark it and point to the rule, but do not deduct more than one point. If a student counts 30 hunting days for A, the table will show 180 EU from ants; this is the most common error.

2. Write out the full calculation for Strategy A: count the hunting days, multiply to get the energy from ants, add up all the costs, and subtract.

Answer: Hunting days: $30 - 4 = 26$. Energy from ants: $26 \times 6 \text{ EU} = 156 \text{ EU}$. Costs: upkeep $30 \times 2 = 60 \text{ EU}$; maintenance $26 \times 1 = 26 \text{ EU}$; rebuilds $4 \times 9 = 36 \text{ EU}$; total costs $60 + 26 + 36 = 122 \text{ EU}$. Net stored: $156 - 122 = 34 \text{ EU}$.

Why: Each step uses a rule from the table; the net is positive and just above the goal.

Also acceptable: Accept the same arithmetic in a different order.

3. Which strategies meet the goal of at least 30 EU stored? By how much does each one pass or fail?

Answer: Strategy A meets the goal: 34 EU, which passes by 4 EU. Strategy C meets the goal: 33 EU, which passes by 3 EU. Strategy B fails: 18 EU, which is 12 EU short.

Why: A and C are nearly tied and both pass narrowly; B fails clearly. This sets up the decision as one about risk rather than about the bigger number.

Also acceptable: If the student's Part A numbers differ because of a rule misreading, grade q3 for consistency with their own table.

- Correct pass or fail for all three
- Margin stated for each

Part B: Connect the budget to the science

4. Every cost in the budget (upkeep, maintenance, digging, crawling) is paid by the same process inside the antlion's cells. Name the process, its reactants and its products, and explain why the antlion's upkeep cost continues even on a day when it does nothing.

Answer: Cellular respiration. Reactants: sugar (and other food molecules from the digested ants) and oxygen; products: carbon dioxide and water, with energy released for the cells' work. Upkeep continues on a 'do nothing' day because the antlion's cells never stop working: they keep membranes intact, repair molecules, keep the nervous system ready to sense an ant, and stay warm enough to function. That baseline work needs energy, so the reaction keeps running and the antlion keeps using oxygen and releasing carbon dioxide even while motionless.

Why: The link between 'upkeep' and resting cellular respiration is the point; students should name reactants and products and explain the baseline cost.

Also acceptable: A student who mentions that a resting person still breathes, as evidence of ongoing respiration, is reasoning well.

- Names cellular respiration with reactants and products
- Explains that cells work continuously, so energy is spent even at rest

5. An ant is matter as well as energy. Describe two different things that happen to the atoms of an ant the antlion digests: one that releases the ant's energy and one that adds to the antlion's body. Where does the 'net stored' energy in the budget physically end up?

Answer: (1) Energy release: the ant's sugars and fats (and some protein) are rearranged by reacting with oxygen into carbon dioxide and water, which leave the antlion; this is where the energy for digging and upkeep comes from. (2) Growth and storage: pieces of the ant's proteins are rebuilt into the antlion's own proteins (new body), and spare energy is kept by building fat molecules. The 'net stored' energy in the budget physically ends up as chemical energy in fat molecules in the antlion's body, matter it has built from the ants it ate and will react with oxygen later to power its change into an adult.

Why: The answer must separate the two fates and locate stored energy in a real substance (fat), not as 'energy sitting in the antlion.'

Also acceptable: Accept 'glycogen and fat' for the storage fate.

- Energy-release fate traced to carbon dioxide and water
- Growth or storage fate traced to proteins or fat built from the ant's atoms
- Net stored energy located in fat molecules

Part C: Test the plan against what could go wrong

6. Two things are uncertain. (i) The sheltered patch's 5 EU per day came from one week of counting; recompute Strategy C's net if the real gain is only 4 EU per day. (ii) The storm schedule is an average; recompute Strategy A's net if a fifth storm wrecks the pit on the evening of day 27 and the antlion rebuilds on day 28. Show both calculations and state whether each strategy still meets the goal.

Answer: (i) Strategy C at 4 EU per day: energy from ants $27 \times 4 = 108$; costs unchanged at 102; net $108 - 102 = 6$ EU. Fails the goal (24 EU short). (ii) Strategy A with a fifth storm: hunting days $30 - 5 = 25$; energy from ants $25 \times 6 = 150$; upkeep 60; maintenance 25; rebuilds $5 \times 9 = 45$; costs 130; net $150 - 130 = 20$ EU. Fails the goal (10 EU short).

Why: Both plans that passed in Part A fail under a plausible change, and C is the more fragile: a 1 EU per day error in the ant count wipes out 27 EU. A is sensitive to the storm count but loses only 14 EU per extra storm.

Also acceptable: Accept answers that keep the student's own Part A cost totals if those were internally consistent.

Part D: Decide, justify, and model

7. Choose a strategy and justify it. Your justification must (a) use the net values from Part A, (b) use the results of Part C to say which risk you are accepting and why, (c) explain the trade-off between a one-time cost now and repeated costs later, and (d) say what new information in the first week would make you change your plan.

Answer: A strong response can defend either A or C, for example: 'I choose Strategy A. (a) A stores 34 EU and C stores 33 EU; both pass, B fails at 18. (b) Part C shows C is riskier: if the bush patch gives 4 EU per day instead of 5, C collapses to 6 EU, while an extra storm drops A to 20 EU. The ant count under the bush came from one week, so I trust it less than the storm pattern, which comes from many weeks; I accept the storm risk. (c) C pays a big one-time cost (15 EU and three hunting days) to avoid repeated rebuilds (36 EU); that trade only pays if the sheltered gain is really 5 EU, so the saving is not worth the uncertainty. (d) If two storms hit in the first week, or if the open patch's ants drop below one a day, I would move, because then A's margin is gone and C's risk looks smaller by comparison.' A response choosing C should argue that storms are also uncertain and that a single bad week of storms wrecks A, and should name what first-week information (ant count under the bush confirmed at 5 or more per day) would justify the move.

Why: Grade the reasoning, not the choice. Full credit needs numbers from Part A, the risk comparison from Part C, an explicit one-time-versus-repeated-cost trade-off, and a specific trigger for changing plans.

Also acceptable: A student who proposes a hybrid (start with A, move only if the first week goes badly) has given an excellent answer if the budget consequences of the hybrid are described.

- Uses the net values from Part A
- Uses both Part C recomputations to compare risks
- Explains the one-time versus repeated cost trade-off
- Names specific first-week information that would change the plan
- Rejects Strategy B with a number

8. Draw a model of the antlion as a system for your chosen strategy. Show matter and energy entering (ants, oxygen), the process inside its cells that releases energy, matter leaving (carbon dioxide, water), energy leaving as heat and as work (digging, flicking sand, crawling), and the two places the ant's matter and energy can stay in the antlion (stored fat; new body for growth). Label every arrow and give the model a title.

Answer: A titled system model of the antlion: arrows in labeled 'ants (matter and energy)' and 'oxygen (from air in the sand)'; a box or oval inside the antlion labeled 'cellular respiration in cells (mitochondria)'; arrows out labeled 'carbon dioxide' and 'water'; energy arrows out labeled 'heat' and 'work: digging, flicking sand, crawling'; two internal destinations labeled 'stored fat (net stored energy)' and 'new body (growth from the ants' proteins)'. For Strategy A the work arrow includes 'rebuilding after storms'; for C it includes 'crawling to the bush.' Matter arrows and energy arrows should be distinguishable (for example, solid versus dashed, or two colors).

Why: This is the PE's model: food rearranged through reactions to release energy and to support growth, with matter and energy tracked separately. Full credit needs all inputs, all outputs, the reaction located in cells, both internal destinations and a title.

Also acceptable: A student who adds 'waste not digested' as a matter output is correct; an antlion does produce waste.

- Ants and oxygen enter
- Cellular respiration located inside the antlion's cells
- Carbon dioxide and water leave
- Energy leaves as heat and as named work
- Stored fat and new body shown as destinations inside the antlion
- Matter and energy arrows distinguished; title present

Scoring rubric

Criterion	4 • Exemplary	3 • Proficient	2 • Developing	1 • Beginning
Budget calculations (Part A)	All three nets correct (34, 18, 33) with hunting days counted correctly and one full calculation shown.	Two nets correct; the third has a single rule misread (for example, maintenance charged on rebuild days) with the work shown.	One net correct, or the method is right but arithmetic errors affect two strategies.	Budget incomplete or not based on the rules.
Science connection (Part B)	Names cellular respiration with reactants and products, explains the resting cost, separates the energy-release fate from the growth or storage fate, and locates stored energy in fat.	Names the process and both fates but one explanation is thin (for example, stored energy not tied to a substance).	Names the process; fates confused or matter and energy mixed.	No connection to cellular respiration or to matter conservation.
Decision and justification (Parts C and D)	Both recomputations correct; the decision cites Part A numbers, compares the two risks, explains one-time versus repeated costs, and names a trigger for changing plans.	Recomputations correct; justification uses numbers and risk but omits the trade-off or the trigger.	Decision stated with some numbers; risk or recomputations missing or wrong.	Decision without numbers, or no decision.

System model (q8)	All inputs and outputs labeled, reaction placed in cells, stored fat and growth shown as internal destinations, matter and energy distinguished, title present.	One element missing (for example, water output or the growth destination); otherwise complete and labeled.	Model shows the reaction but omits storage or growth, or has unlabeled arrows.	Model missing or shows energy as matter (for example, energy drawn as a substance that leaves with the waste).
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Teacher notes

The antlion facts in the second block are real; the energy units, costs, storm schedule and ant counts are invented for teaching and are labeled as such. The numbers were chosen so that Strategies A and C nearly tie (34 and 33 EU) and both pass narrowly, while B fails; the decision therefore turns on risk, and Part C shows that C is the more fragile plan (a 1 EU per day error in the ant count costs 27 EU) while A loses 14 EU per extra storm. Accept either A or C with a justification that meets the rubric; reject B. Watch for students charging maintenance on rebuild days or counting 30 hunting days for A. The extension's Strategy D (rebuild after every second storm) gives: storms on days 6 and 18 are followed by rebuilds on days 7 and 19, while the pits wrecked on days 12 and 24 are hunted from at the damaged rate; hunting days 28, of which 16 are from a working pit (days 1 to 6, 8 to 12, and 20 to 24) and 12 from a damaged pit (days 13 to 18 and 25 to 30); energy from ants $16 \times 6 + 12 \times 2 = 120$; costs 60 upkeep + 16 maintenance + 18 rebuilds = 94; net 26 EU, which fails. If students ask how real antlions decide, the honest answer is that they follow simple behavioral rules shaped by natural selection, not calculations; the extension asks them to propose such a rule.

Scaffold offered to students: One strategy, one line at a time

For each strategy, fill the columns in this order and write the day numbers as you go. (1) Hunting days: start with 30 and subtract every day the antlion cannot hunt (rebuild days, travel days, build day). (2) Energy from ants: hunting days $\times$ EU per day; for Strategy B split the days into before and after the first storm. (3) Upkeep is always $30 \times 2 = 60$ EU. (4) Maintenance: 1 EU $\times$ hunting days from a working pit only. (5) Building or moving: 9 EU per build, plus 6 EU of travel for Strategy C. (6) Subtract the costs from the energy from ants.

Extension: A fourth strategy and a real-world check

Invent Strategy D: stay on the open patch but rebuild only after every second storm. Compute its 30-day net and compare it with A and B; explain why a cheaper plan can still be worse. Then write a paragraph on what a real antlion actually 'knows': it cannot count days or calculate, so describe what simple rules of behavior (for example, 'rebuild if no ant arrives for two days') would produce something like the strategy you recommended, and how a scientist could test whether antlions follow such a rule.