

Energy Flow Through Ecosystems

Learning objective 8.2.A Describe the strategies organisms use to acquire and use energy, 8.2.B explain how energy flows and matter cycles through trophic levels, 8.2.C explain how changes in energy availability affect populations, communities, and ecosystems, and 8.2.D explain how the activities of autotrophs and heterotrophs enable the flow of energy within an ecosystem.

Name: _____ Date: _____ Period: _____

Use the tool **Energy Passes Through, Matter Goes Around**. Parts 1 to 3 use **Where the other 90% went**, Parts 4 and 5 use **Flows against cycles**, and Part 6 uses **Who does what**. One sentence holds this entire topic together, and almost every mistake in it is a failure to keep the two halves apart: **energy flows and matter cycles**. Energy enters as sunlight, is degraded to heat at every step, and leaves permanently — so it has to be resupplied. Matter is rearranged between reservoirs and never leaves at all. Keep asking yourself, at every part of this handout, which of the two you are looking at.

Part 1 · The pyramid

Producers capture about **1%** of the sunlight arriving, and each level after that keeps about **10%** of what the level below it had. Fill in every row. The last column is where the topic actually lives — express it as a percentage of what the producers fixed.

Trophic level	Energy here	Passed to the next level	Share of what producers fixed
Producers			
Primary consumers			
Secondary consumers			
Tertiary consumers			
Quaternary consumers			

1. Explain why only about ten percent of the energy at one trophic level reaches the next.

2. Explain why food chains rarely have more than four or five levels, using a number from your table.

Part 2 · Where the missing ninety percent went

This is the part that decides whether you understand the topic. The energy that does not reach the next level has to go **somewhere**. Fill in all four routes and then answer the last column for each — and notice that the four shares add up to all of the loss, so there is no remainder hiding anywhere.

Route	Share of the loss	What happens to it	Does it stay in the ecosystem?
Cellular respiration			
Not eaten			
Not digestible			
Heat lost directly			

3. A student says the missing ninety percent is “still in the ecosystem somewhere”. Explain what is wrong with that.

4. Explain why the sun has to keep shining on an ecosystem, but no one has to keep adding carbon to it.

Part 3 · Turning the sun up and down

Change how much energy enters at the bottom and count how many trophic levels the ecosystem can still support. **Predict first**, in the margin: when the energy supply falls, which trophic level do you think disappears first, and why?

Sunlight	Energy fixed by producers	Trophic levels supported	Highest level that survives
200%			
100%			
50%			
20%			
5%			

5. Explain how a fall in energy availability affects the trophic levels of an ecosystem, and identify which is affected first.

6. Losing a trophic level affects more than the species in it. Explain what happens to the levels below it.

Part 4 · Flows against cycles

The same model tracks both quantities at once for forty steps. Carbon moves between four reservoirs by fixed rules; energy arrives from the sun and a fraction is respired away as heat each step. At step **20** the sun is switched off. Record what each quantity does — and pay particular attention to the two rows after the cutoff.

	At the cutoff (step 20)	Twenty steps later	Change
Energy in the system			
Matter in the system			
Total energy that entered			
Total heat that has left			

7. Explain the difference between saying that energy flows through an ecosystem and that matter cycles within it.

8. After the sun is switched off, every atom the ecosystem ever had is still in it. Explain why the ecosystem dies anyway.

9. Nothing was destroyed in either case — energy is conserved just as matter is. Explain why we still say energy “leaves” and matter does not.

Part 5 • Four cycles

Fill in the reservoirs and processes for each. One of these four is different from the other three in a way that explains most of its behavior — **find it before you read the answer key.**

Cycle	Reservoirs	Processes	Largest reservoir
Water (hydrologic)			
Carbon			
Nitrogen			
Phosphorus			

10. Describe what a biogeochemical cycle is, and state what every one of them demonstrates.

11. Describe the nitrogen cycle, and explain why its largest reservoir is also the least useful one.

12. Identify what makes the phosphorus cycle different from the other three, and explain what follows from it.

Part 6 • Who does what

Autotrophs put energy into the ecosystem; heterotrophs move it around and eventually out. Fill in both columns, then answer the questions about how organisms **use** the energy once they have it.

Group	Autotroph or heterotroph?	Energy source	What it contributes
Photosynthetic autotroph			
Chemosynthetic autotroph			
Herbivore			
Carnivore			
Omnivore			
Decomposer			
Scavenger			

13. Describe how autotrophs capture energy, naming both kinds and stating where each is found.

14. Distinguish between an endotherm and an ectotherm in terms of energy, and state one consequence for the ecosystem.

15. Explain what a net gain and a net loss of energy each do to an organism.

What the model simplifies

The ten percent figure is a teaching convention rather than a measurement. Real transfer efficiencies range from under one percent to more than forty, depending on the organisms — ectotherms pass on far more of what they eat than endotherms, because they are not spending it on heat. What generalises is the direction: most of the energy is lost at every step.

The one percent capture efficiency for producers is an order-of-magnitude figure. Most sunlight arriving at a leaf is the wrong wavelength, misses a chloroplast, or is reflected.

The four loss routes are given illustrative shares that sum to one. The shares are not measurements; what is asserted is that they account for ALL of the loss, so that no student is left believing the remainder is hiding somewhere in the ecosystem.

The carbon model moves carbon between four reservoirs by fixed proportions each step. Real transfer rates vary with season, temperature and what is living there, and a real carbon budget includes the oceans and long-term geological reservoirs this model omits. The property being demonstrated — the total invariant while the distribution moves — does not depend on the particular rates.

Switching the sun off at step twenty is not a thing that happens. It is a way of separating two quantities that are easy to confuse, by removing the supply of one and showing the other is unaffected.

The trophic-level count uses a fixed threshold below which a level is treated as unsupportable. Real ecosystems have no sharp cutoff.

Combustion is included as a carbon-cycle process because the framework names it. It is the only one of the four that is not biological, and the only one that moves carbon out of a long-term reservoir on a human timescale.