AP BIOLOGY · UNIT 8 · TOPIC 8.2

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**. The whole topic rests on one idea: **energy flows and matter cycles**. Energy enters as sunlight, is converted to heat at every step, and leaves the ecosystem, so it must be resupplied. Matter moves between reservoirs and stays in the ecosystem. In every Part, decide which of the two a question is about.

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. Click each trophic level in the tool and record its readouts. Record the last column as a percentage of the energy 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 10 percent of the energy at one trophic level is passed to the next trophic level.

2. Using a value from the Part 1 table, explain why food chains rarely have more than four or five trophic levels.

Part 2 · Where the missing ninety percent went

The energy that does not reach the next level has to go **somewhere**. Record all four routes from The missing ninety percent, itemized table in the tool. The four shares add up to all of the loss.

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 claims that the 90 percent of the energy that does not reach the next trophic level is still stored somewhere in the ecosystem. Evaluate the student's claim.

4. Explain why an ecosystem requires a continuous input of energy from the sun but does not require a continuous input of carbon.

Part 3 · Turning the sun up and down

The Turn the sun up and down table in the tool shows how many trophic levels the ecosystem supports at five levels of sunlight. **Predict first**, in the margin, before you look at the table: when the energy supply falls, which trophic level disappears first, and why? Then record all five rows.

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

5. (a) Using the Part 3 table, describe the effect of decreasing the sunlight on the number of trophic levels the ecosystem supports.

(b) Identify the trophic level that is lost first when the energy supply decreases. Provide reasoning to justify your identification.

6. When the energy supply decreases, the top trophic level of an ecosystem is lost. Predict the effect of losing the top predators on the population of the trophic level they fed on. Justify your prediction.

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. The tool's four readouts fill the Energy in the system and Matter in the system rows. The tool's verdict gives the total energy that entered and the total that had left as heat by the end of the run; no energy enters after the cutoff, so write the same total in both Total energy that entered cells. Calculate the heat that had left by the cutoff as the total energy that entered minus the energy in the system at 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. Describe the difference between the flow of energy through an ecosystem and the cycling of matter within it.

8. After the sun is switched off in the model, all of the matter remains in the ecosystem. Explain why the organisms in the ecosystem cannot survive.

9. Energy and matter are both conserved in the model: by step 40, almost all of the 200,000 units of energy that entered have left as heat. Explain why energy is described as leaving the ecosystem while matter is not.

Part 5 · Four cycles

Click each cycle in the tool and record the reservoirs, processes and largest reservoir it lists. Then add any other major reservoir you know. One of the four cycles differs from the other three in a way that explains most of its behavior: **identify that cycle**.

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

10. (a) Describe a biogeochemical cycle.

(b) Identify the principle that every biogeochemical cycle demonstrates.

11. (a) Describe the nitrogen cycle.

(b) The largest reservoir of nitrogen is the atmosphere. Explain why most organisms cannot use this nitrogen directly.

12. (a) Identify the feature that makes the phosphorus cycle different from the water, carbon and nitrogen cycles.

(b) Explain how this feature affects the availability of phosphorus in ecosystems.

Part 6 · Who does what

Autotrophs put energy into the ecosystem; heterotrophs move it around and eventually out. Complete every column, checking it against the tool's table, 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. (a) Describe how photosynthetic autotrophs and chemosynthetic autotrophs each capture energy.

(b) Identify an environment in which chemosynthetic autotrophs are the producers.

14. (a) Describe the difference between how an endotherm and an ectotherm maintain their body temperatures.

(b) Explain why the same primary production can support more ectothermic consumers than endothermic consumers.

15. (a) Describe the effect of a net gain of energy on an organism.

(b) Describe the effect of a net loss of energy on 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 generalizes 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 stays constant while the distribution moves) does not depend on the particular rates. In this model the carbon flows do not depend on light, so the carbon distribution stops changing once it settles, even after the sun is switched off; in a real ecosystem, losing light would shift carbon toward the atmosphere.

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.