

Energy Flow in Ecosystems

Course: Biology (Grades 9–12) Subject: Science Time: ~50 min standard · ~90 min block

Work mode: Independent · pencil only **SCIENCE**

Name _____	Class period _____	Date _____
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Start Here

This is a **paper investigation**. You will study a diagram of an energy pyramid, read a short passage, and analyze a data table using a pencil. You do **not** need a computer, a lab, or any materials besides this packet and a pencil. There are **no hazards** — nothing is measured, mixed, or built. Work by yourself and do your best thinking. You will do some arithmetic with the "10% rule"; the numbers are chosen so you can do them by hand. Write in complete sentences where you are asked to explain. If a question is hard, skip it, keep going, and come back. Reading the passage quietly aloud to yourself is allowed and encouraged.

START Notice & Wonder

5 min

Think about how many of each kind of living thing you would find in a field: grasses, insects that eat the grass, and hawks that eat other animals.

1 In almost every ecosystem there are a huge number of plants, far fewer plant-eaters, and only a small number of top predators such as hawks or wolves. Write one thing you notice and one thing you wonder about why there are so few top predators compared with plants.

2 Where do you think the energy in a grassland originally comes from, and what do you think happens to most of it as it moves from grass, to grasshoppers, to the animals that eat grasshoppers? Give your best first idea.

Trophic levels, energy pyramids, and the ~10% rule

Energy enters most ecosystems as sunlight. **Producers** (green plants, algae, and some bacteria) capture that energy through **photosynthesis** and store it as chemical energy in food. Every other organism gets its energy by eating. A **trophic level** is a feeding position in a food chain — a step that describes where an organism gets its energy.

- **Producers (1st trophic level)** — make their own food from sunlight. Also called autotrophs.
- **Primary consumers (2nd level)** — **herbivores** that eat producers (for example, a grasshopper eating grass).
- **Secondary consumers (3rd level)** — **carnivores** (or omnivores) that eat primary consumers (a shrew eating a grasshopper).
- **Tertiary consumers (4th level)** — carnivores that eat secondary consumers (a snake eating a shrew). Higher levels (quaternary, etc.) may follow.
- **Decomposers** — bacteria and fungi that break down dead organisms and wastes at every level, returning **matter** (nutrients) to the soil so producers can reuse it.

An **energy pyramid** is a diagram that shows the amount of energy (in kilocalories, kcal) available at each trophic level. It is widest at the bottom (producers) and narrows toward the top, because **energy is lost at every step**.

The ~10% rule: when energy passes from one trophic level to the next, only about 10% is stored in the next level and becomes available to the organisms above it. The other ~90% is lost — used for the organism's own life processes (movement, growth, keeping warm) and released to the surroundings as heat. That lost energy is *not* recycled back up the pyramid. Because so little energy reaches the top, top-level consumers must be few in number.

Matter vs. energy: matter (atoms and nutrients) *cycles* and is reused thanks to decomposers, but energy flows one way — in as sunlight, out as heat — and must be constantly resupplied by the Sun.

Word Bank

producer	an organism that makes its own food from sunlight (autotroph); the 1st trophic level.
consumer	an organism that gets energy by eating other organisms (heterotroph).
decomposer	bacteria/fungi that break down dead matter and return nutrients to the soil.
trophic level	a feeding step in a food chain that shows where an organism gets its energy.
energy pyramid	a diagram of the energy (kcal) available at each trophic level.
10% rule	about 10% of the energy at one level is passed to the next; ~90% is lost as heat.

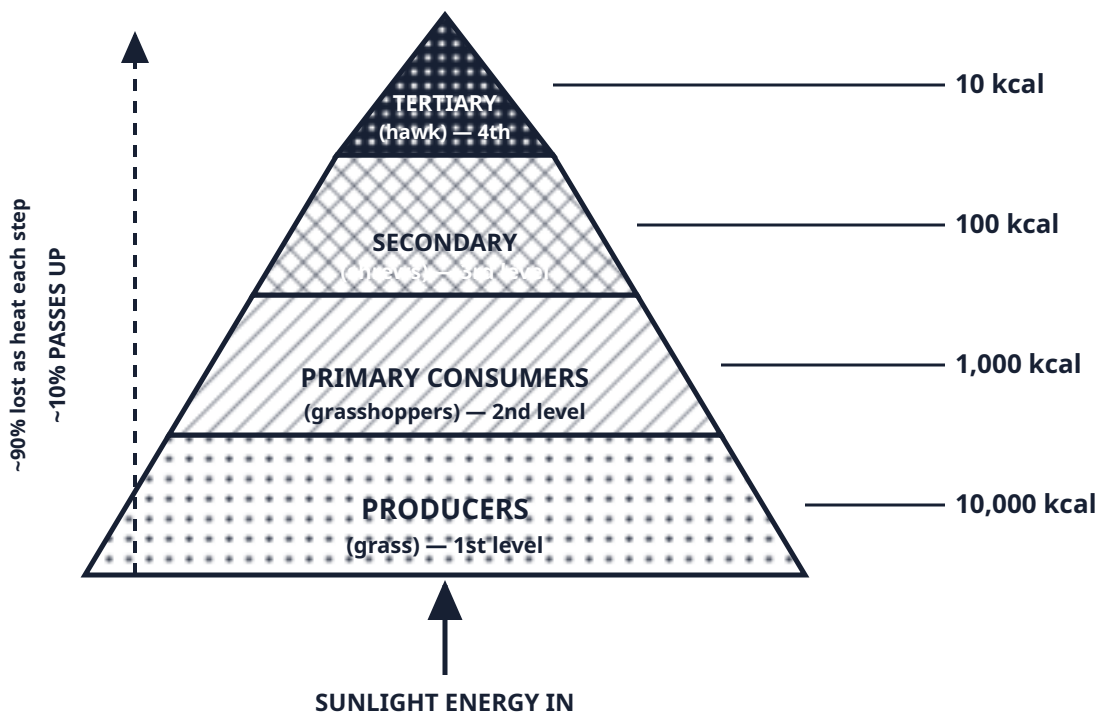


Figure 1. Energy pyramid for a grassland ecosystem. Each band is a trophic level; its width and the value on the right show the energy (kcal) available there. Moving up, each level holds about one tenth of the level below it (the ~10% rule); the dashed arrow marks the ~90% lost as heat at each step. Patterns and labels — not color — carry the meaning, so the figure reads clearly in grayscale.

3 Using Figure 1, name the trophic level that has the most energy available and the one that has the least. In one sentence, explain why the pyramid narrows as you go up.

Table 1 gives the energy measured at each trophic level of the same grassland, plus a list of organisms to classify. Study it, then answer. (These are original numbers for this packet.)

Table 1. Energy available at each trophic level of a grassland ecosystem, in kilocalories per square meter per year (original data).

Trophic level	Example organism	Energy available (kcal/m ² /yr)
1 — Producers	Grass	10,000
2 — Primary consumers	Grasshoppers	1,000
3 — Secondary consumers	Shrews	100
4 — Tertiary consumers	Hawk	10

4 Classify the organisms. For each organism below, write its trophic level number and its role (producer, primary consumer, secondary consumer, tertiary consumer, or decomposer). Use the grassland food chain grass → grasshopper → shrew → hawk, plus soil fungi.

a) Grass _____

b) Grasshopper _____

c) Hawk _____

d) Soil fungi _____

5 Calculate energy passed with the 10% rule. Show your work. Using the 10% rule, about 10% of the energy at one level is passed to the next.

5a. The producers hold 10,000 kcal. About how much energy is passed up to the primary consumers (grasshoppers)? Show $10,000 \times 0.10$.

5b. About how much energy is passed from the primary consumers up to the secondary consumers (shrews)? Show your work.

5c. Compare your answers with the "Energy available" column in Table 1. Do your calculated values match the table? What does that tell you about this ecosystem?

6 Percent transfer. The hawk (tertiary consumer) has 10 kcal available and the shrews (secondary consumers) below it have 100 kcal. Calculate the percent of energy transferred from the shrews to the hawk. Show the formula (energy passed $\div$ energy in lower level $\times$ 100) and your work.

7 Observation vs. inference. Write O if the statement is an observation (a value read directly from Table 1 or Figure 1) or I if it is an inference (a conclusion you reason out).

- ___ a) The producers have 10,000 kcal available.
- ___ b) There can only be a few hawks in this grassland because so little energy reaches the top.
- ___ c) The hawk level has 10 kcal available.
- ___ d) Most of the energy at each level was lost as heat before reaching the next level.

8 Interpret the pyramid shape. In 2–3 sentences, explain what the shape of the energy pyramid (wide bottom, narrow top) tells you about how energy moves through the ecosystem. Use the words trophic level and 10% rule.

9 Predict the effect of removing a trophic level. Suppose a disease kills off almost all the grasshoppers (the primary consumers). Predict what would happen to (a) the grass and (b) the hawks, and explain why using energy flow.

Question 10. A student claims, "Top-level consumers such as hawks are limited in number because of how energy flows through the ecosystem." Using the energy data in Table 1 and Figure 1, write a **claim** answering *why top-level consumers are limited*, support it with **two pieces of evidence** (specific numbers from Table 1 or Figure 1), then explain your **reasoning** using trophic levels and the 10% rule.

Sentence stems you may use: "Top-level consumers are limited because..." · "One piece of evidence is... (from Table 1 / Figure 1)." · "A second piece of evidence is..." · "This limits top consumers because the 10% rule says..."

CLAIM

EVIDENCE (TWO PIECES, WITH NUMBERS)

REASONING

ARTICULATE

Explain the **10% rule** in your own words, as if teaching a friend.

CONNECT

Point to one row of Table 1 or one band of Figure 1 that shows the 10% rule in action. Name the numbers.

EXTEND

Give a **new** example of a food chain (not grassland) and label at least three of its trophic levels.

If you finish early (no new materials needed):

Design a pyramid for a new ecosystem. On the back of this page, invent a food chain for a different ecosystem (for example an ocean, a desert, or a pond). Draw a four-level energy pyramid, label each trophic level with a real organism, and — starting from a producer level of your choice — use the **10% rule** to fill in a reasonable energy value (kcal) for each level. Then write one sentence about what would happen if the top level disappeared.

Block-period extension — multi-step energy-loss chain:

A separate ocean food chain starts with **phytoplankton producers holding 50,000 kcal**. Using the 10% rule at every step, calculate the energy available at each level up the chain: **phytoplankton** → **zooplankton** → **small fish** → **tuna** → **shark** (five levels). Show your work for each step. Then answer: what percent of the *original* producer energy reaches the shark? Explain, using the 10% rule, why very large top predators like sharks need such an enormous area of ocean to survive.

Turn in:

Hand in this whole packet with your name, class period, and date filled in. Make sure questions 1–10 and the ACE box are answered. The early-finisher pyramid and the block-period energy chain are optional but turn them in too if you did them.