Kelp Forest Matter and Energy Practice Set

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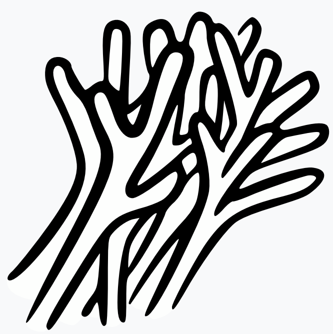
Lesson:

This set is about MODELING a kelp forest, not just naming who eats whom. Two ideas run through every question.

First: matter cycles. The same carbon atom is used again and again, so it always has somewhere to return to.

Second: energy flows one way. It enters as sunlight, moves up through eaters, and leaves as heat — so it never comes back.

Study all three diagrams before you begin. Several questions ask you to judge whether a model shows BOTH patterns, and several ask you to estimate energy using the pyramid. By the end you should be able to look at any ecosystem model and say what it is missing.

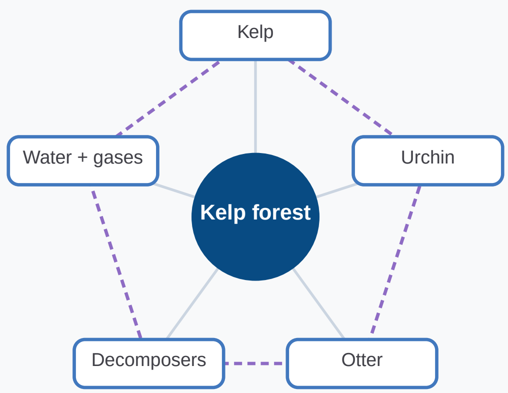


A kelp forest is an ocean ecosystem that grows along rocky coasts. Giant kelp anchors to the seafloor and grows toward the light — sometimes two feet in a single day. Living in and around it are sea urchins that graze on kelp, fish, sea otters that eat urchins, larger sharks, and bacteria too small to see.

But the living things are only half of the system. The nonliving half is sunlight, seawater, dissolved carbon dioxide and oxygen, and nutrients such as nitrogen dissolved in the water. These nonliving parts are not background scenery. They are the pool that matter comes out of and returns to.

Two different things move through this system, and they behave in completely different ways. Keep them separate in your mind as you read: MATTER (atoms of carbon, nitrogen, oxygen) and ENERGY (which does work and can be counted in units).

What the model must show



Four parts every kelp forest model needs. Decomposers return matter to the nonliving pool; energy does not come back.

WORKED EXAMPLE 1 - Is this model complete?

A student draws: kelp -> sea urchin -> sea otter.

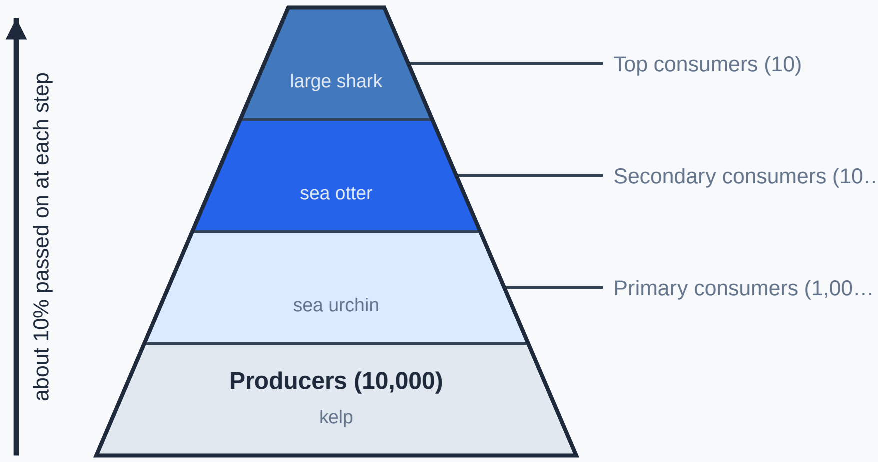
Check it against the four parts in the diagram above.
1. A producer? Yes - kelp.
2. Consumers? Yes - the urchin and the otter.
3. Decomposers? NO. Nothing breaks down the otter when it dies.
4. A nonliving pool? NO. No seawater, no dissolved carbon dioxide, no nutrients.

Verdict: incomplete. This model can show energy moving up, but it cannot answer the question 'where does the carbon in the otter go next?' Its arrows have no way to come back around.

The fix: add decomposers after the otter, add a box for seawater and dissolved gases, then draw an arrow from decomposers back to that box - and from the box back to kelp.

> Kelp uses sunlight, water, and dissolved carbon dioxide to build sugar. This is photosynthesis, and it is the only doorway energy uses to enter the ecosystem. That energy is now stored in kelp tissue.
>
> When a sea urchin eats kelp, only about 10% of the stored energy ends up as new urchin body. Where does the other 90% go? Most is released as heat while the urchin moves, breathes, and stays alive. Some passes straight through, undigested.
>
> That 90% is NOT destroyed. Energy is never created or destroyed. It simply changes into a form the ecosystem cannot pass along any further. Heat drifts out into the water and out of the system for good. This is exactly why energy flows instead of cycling: heat cannot be eaten.
>
> Two cautions. First, 10% is a rough average, not an exact law - real transfers run from about 2% to 20%. Second, the 10% rule describes the step from one organism to the next. It does NOT describe how much of the arriving sunlight kelp captures, which is far smaller, closer to 1%.

Where the energy goes



Each level passes on about 10% of what it received. The rest leaves as heat, which is why the bands shrink.

WORKED EXAMPLE 2 - Reading the pyramid.

Question: Why is the top band so much narrower than the bottom band?

Reasoning: Climb one level and about 90% of the energy drops out as heat. Do that three times and almost nothing is left. Starting from 10,000 units: 10,000 -> 1,000 -> 100 -> 10.

Answer: the bands shrink because each level passes on only about a tenth of what it received.

Why this matters in the real ocean: a kelp forest can feed enormous numbers of urchins, but only a handful of otters and very few large sharks. The pyramid shape is not a drawing style - it is the reason top predators are always rare.

WORKED EXAMPLE 3 - Doing the math.

GOING UP a level: multiply by 0.1.
Kelp holds 8,000 units. How much reaches the otter, two levels up?
  Urchins: 8,000 × 0.1 = 800 units
  Otter: 800 × 0.1 = 80 units
Answer: about 80 units.

GOING DOWN a level: multiply by 10.
An otter needs 60 units. How much energy must the kelp have held?
  Urchins: 60 × 10 = 600 units
  Kelp: 600 × 10 = 6,000 units
Answer: about 6,000 units of kelp energy stand behind 60 units of otter.

Check yourself: if kelp holds 40,000 units, roughly how much reaches a shark four levels up?

Work it out before you read on.
(40,000 -> 4,000 -> 400 -> 40 -> 4 units.)

> Now switch to matter, and watch it behave in a completely different way.
>
> Follow one carbon atom. It starts as carbon dioxide dissolved in seawater. Kelp pulls it in and builds it into a blade. A sea urchin eats the blade, and the atom becomes urchin tissue. A sea otter eats the urchin. Later, when the otter breathes out, produces waste, or dies and is broken down by bacteria, that same carbon atom is released back into the seawater as dissolved carbon dioxide.
>
> Where is it now? Exactly where it started. Kelp can take it up again tomorrow.
>
> Nothing was used up. Atoms are not consumed, only rearranged - matter is conserved, so the same atoms have been going around this loop for millions of years.
>
> Decomposers are what closes the loop. Without bacteria breaking down dead bodies and waste, matter would stay locked inside corpses and the nonliving pool would slowly run dry.

Carbon comes back

1. Carbon dioxide in seawater
the nonliving pool

↓

2. Kelp
builds tissue by photosynthesis

↓

3. Sea urchin and sea otter
carbon moves as food

↓

4. Decomposers
break down waste and dead bodies

(repeats)

Matter returns to where it started. Compare this closed loop with the pyramid, where energy never comes back.

WORKED EXAMPLE 4 - One atom, one full lap.

Track a single carbon atom and name the process at every step.

1. Dissolved CO_2 in seawater — the nonliving pool
2. Into kelp tissue — by photosynthesis
3. Into a sea urchin — by eating
4. Into a sea otter — by eating
5. Back into seawater as CO_2 — by respiration, waste, and decomposition
6. Step 1 again

Now notice what the ENERGY did across those same five steps. It entered once, at step 2, and leaked away as heat at every step afterward. It never reached step 6.

The atom made a complete lap. The energy made a one-way trip.

Same organisms. Same arrows on the page. Two completely different patterns.

> The nonliving parts are the half that students leave out most often - and leaving them out is exactly what breaks a model.
>
> Sunlight, seawater, dissolved carbon dioxide and oxygen, and nutrients are not scenery. They are where matter waits between trips through living bodies.
>
> A model that shows only organisms cannot answer a basic question: where does a carbon atom go after a sea otter dies?
>
> Test any ecosystem model this way. Point to the box a carbon atom returns to. If there is no such box, you are looking at a food chain, not an ecosystem.

> Side by side, the two patterns look like this.
>
> MATTER
> • Enters: it is already here - the same atoms recycle
> • Path: nonliving pool -> producer -> consumers -> decomposers -> back to the pool
> • Shape: a closed LOOP
> • Ends: never; it keeps going around
> • Key player: decomposers, who close the loop
>
> ENERGY
> • Enters: from outside, as sunlight, and it must keep arriving
> • Path: sun -> kelp -> urchin -> otter -> shark
> • Shape: a one-way ARROW that shrinks by about 90% at each step
> • Ends: as heat, which leaves the ecosystem
> • Key fact: heat cannot be eaten, so it cannot come back
>
> This is why an ecosystem needs a constant supply of sunlight, but does not need a constant supply of new atoms.

WORKED EXAMPLE 5 - Judging two models.

Model A: sunlight -> kelp -> urchin -> otter

Model B: sunlight -> kelp -> urchin -> otter -> decomposers, plus a loop carrying matter from decomposers back to the dissolved CO_2 and nutrients in the water, and from there back into kelp. Heat arrows point out of the system at every level.

Which model is better, and why?

Model A shows energy flow only - and even that is incomplete, because it never shows heat leaving. It has no return path of any kind, so it cannot represent matter at all.

Model B shows both patterns at once: one-way arrows for energy that exit as heat, and a closed loop for matter that returns to the nonliving pool.

Verdict: Model B.

The rule worth memorizing: a complete ecosystem model needs straight arrows OUT for energy and a closed LOOP for matter. If every arrow in your model is a straight line, you have drawn only half the story.

> Before you start the questions, check yourself against the four mistakes students make most often.
>
> 1. "Energy is recycled." No. Matter cycles; energy does not. Once energy has become heat, nothing can eat it.
>
> 2. "The other 90% is destroyed." No. Energy is never destroyed. It turns into heat and leaves the ecosystem - which is not the same thing as disappearing.
>
> 3. "Decomposers just clean up the mess." No. Decomposers are what closes the matter loop. Remove them and the nonliving pool slowly empties.
>
> 4. "Nutrients are food for kelp." No. Nutrients are building material. Kelp gets its ENERGY from sunlight and its MATTER from carbon dioxide, water, and nutrients. Extra nutrients cannot replace missing light.
>
> One quick test before every question: is this asking about MATTER (loops, returns, conserved) or ENERGY (one way, shrinks, exits as heat)?

Instructions:

Read each question carefully. Choose the best answer for every kelp forest science problem. Think about how matter cycles and how energy flows in ocean ecosystems.

1. Which statement best describes what happens to energy in a kelp forest?

- ◯ A) Energy is stored in kelp during photosynthesis and stays there permanently.
- ◯ B) Energy cycles through kelp, urchins, and otters, and then returns to the sun.
- ◯ C) Energy is created by kelp and then completely used up by the animals that eat it.
- ◯ D) Energy enters as sunlight, moves through organisms, and eventually leaves as heat.

2. A student says, "The carbon in kelp disappears once a sea urchin eats it." What is the best correction?

- ◯ A) The carbon is destroyed during digestion, which is how the urchin gets energy from it.
- ◯ B) The carbon moves into the urchin's body and can later return to the seawater.
- ◯ C) The carbon stays behind in the kelp, because only energy moves to the urchin.
- ◯ D) The carbon is converted into heat and leaves the ecosystem.

3. At each step up a food chain, about 90% of the energy does not reach the next level. What happens to that 90%?

- ◯ A) It is released as heat, which leaves the ecosystem and cannot be eaten.
- ◯ B) It is destroyed, because living things use energy up.
- ◯ C) It is stored in decomposers and returned to kelp later.
- ◯ D) It stays in the ecosystem as matter that producers can reuse.

4. Matter can cycle through a kelp forest, but energy cannot. Which reason best explains this difference?

- ◯ A) There is far more matter in the ecosystem than there is energy.
- ◯ B) Energy leaves as heat, and no organism can capture heat as food.
- ◯ C) Energy is destroyed each time an organism uses it, so there is none left to cycle.
- ◯ D) Only decomposers are able to move energy, and there are too few of them.

5. Kelp in one patch stores 2,000 units of energy. About how much of that energy ends up stored in the sea urchins that graze on it?

- ◯ A) 1,800 units
- ◯ B) 2,000 units
- ◯ C) 200 units
- ◯ D) 20 units

6. Kelp in a patch stores 5,000 units of energy. Sea urchins graze on the kelp, and sea otters eat the urchins. About how much of that original energy reaches the sea otters?

- ◯ A) 500 units
- ◯ B) 4,500 units
- ◯ C) 5 units
- ◯ D) 50 units

7. A sea otter needs about 90 units of energy. The otter eats sea urchins, and the urchins eat kelp. Working backward down the levels, about how much energy must the kelp have stored to support that otter?

- ◯ A) 180 units
- ◯ B) 9,000 units
- ◯ C) 900 units
- ◯ D) 90 units

8. A single kelp forest supports thousands of sea urchins but only a few sea otters. Which explanation is best supported by the way energy moves through the ecosystem?

- ◯ A) Sea otters are much larger, so fewer of them fit in the same space.
- ◯ B) Sea urchins reproduce far more quickly than sea otters do.
- ◯ C) Sea otters can survive on less food because they store energy more efficiently.
- ◯ D) Only about 10% of the energy reaches the otter level, so far less is available to support them.

9. A student claims, "Decomposers could be left out of a kelp forest model without changing anything important." What is the strongest argument against this claim?

- ◯ A) Decomposers return carbon and nutrients to the water, where kelp can use them again.
- ◯ B) Decomposers are an important food source for sea urchins and sea otters.
- ◯ C) Decomposers send energy back to kelp so that it can be used a second time.
- ◯ D) Decomposers keep energy from being lost as heat at each level.

10. A student's model shows: sunlight to kelp to sea urchin to sea otter. Which change would most improve this model?

- ◯ A) Add decomposers and a nonliving pool of seawater, dissolved gases, and nutrients, with a loop returning to kelp.
- ◯ B) Add more consumers, such as fish and sharks, to the end of the chain.
- ◯ C) Add numbers showing how much food each organism eats per day.
- ◯ D) Add an arrow from the sea otter back to the sun to complete the cycle.

11. Model A shows: sunlight to kelp to sea urchin to sea otter. Model B shows that same chain, plus decomposers, a loop carrying carbon and nutrients back to the seawater and then to kelp, and heat arrows leaving at every level. Which model better represents a kelp forest, and why?

- ◯ A) Model A, because it clearly shows the direction that energy travels.
- ◯ B) Model B, because it shows matter cycling and energy flowing one way.
- ◯ C) Model B, because it shows that both matter and energy cycle through the ecosystem.
- ◯ D) Model A, because a good ecosystem model should include only living organisms.

12. Which sequence best represents matter cycling rather than energy flowing?

- ◯ A) sunlight to kelp to sea urchin to sea otter
- ◯ B) kelp to sea urchin to sea otter to heat released into the water
- ◯ C) dissolved carbon dioxide to kelp to sea urchin to decomposers to dissolved carbon dioxide
- ◯ D) sunlight to kelp to sea otter and back to sunlight

13. Scientists add extra nutrients to a kelp forest. At the same time, a thick algae bloom spreads across the surface and blocks most of the sunlight. What is the most likely result for the kelp?

- ◯ A) Kelp will grow faster, because nutrients are what kelp uses for energy.
- ◯ B) Kelp growth will not change, because kelp does not use nutrients from the water.
- ◯ C) Kelp will grow faster, because it can switch to using nutrients for energy when light is low.
- ◯ D) Kelp growth will be limited, because nutrients supply building material but not energy.

14. A disease kills nearly all the sea otters in a kelp forest. Urchin numbers explode, and the urchins graze the kelp down to bare rock. Which statement best describes what happens to matter and energy in this ecosystem?

- A) Both the matter and the energy leave the ecosystem permanently.
- B) The matter is destroyed along with the kelp, but energy keeps flowing as it did before.
- C) Less energy now enters the ecosystem, while the carbon atoms remain but move along different paths.
- D) Energy keeps entering at the same rate as before, because the amount of sunlight has not changed.

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(Answer Key)

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1. Which statement best describes what happens to energy in a kelp forest?
Hint: Energy does not move in a loop.

Answer: D) Energy enters as sunlight, moves through organisms, and eventually leaves as heat.

Explanation: In a kelp forest, energy enters as sunlight, moves through organisms when they eat, and eventually leaves the system as heat.

2. A student says, "The carbon in kelp disappears once a sea urchin eats it." What is the best correction?
Hint: Matter does not disappear; it cycles through living and nonliving parts.

Answer: B) The carbon moves into the urchin's body and can later return to the seawater.

Explanation: Carbon does not disappear when eaten; it becomes part of the consumer and can return to the ecosystem through processes that recycle matter.

3. At each step up a food chain, about 90% of the energy does not reach the next level. What happens to that 90%?
Hint: Most energy is released during life processes.

Answer: A) It is released as heat, which leaves the ecosystem and cannot be eaten.

Explanation: About 90% of energy is released as heat and does not remain available to be transferred to the next level.

4. Matter can cycle through a kelp forest, but energy cannot. Which reason best explains this difference?
Hint: Compare what happens to matter versus what happens to energy as organisms use them.

Answer: B) Energy leaves as heat, and no organism can capture heat as food.

Explanation: In a kelp forest, matter (like carbon and nutrients) can be reused because it returns through processes such as waste and decomposition. Energy flows in one direction and is lost from the ecosystem mainly as heat when organisms use it, so it does not cycle back for reuse.

5. Kelp in one patch stores 2,000 units of energy. About how much of that energy ends up stored in the sea urchins that graze on it?

Answer: C) 200 units

Explanation: Only about 10% of energy usually moves to the next trophic level, so 10% of 2,000 units is about 200 units stored in sea urchins.

6. Kelp in a patch stores 5,000 units of energy. Sea urchins graze on the kelp, and sea otters eat the urchins. About how much of that original energy reaches the sea otters?
Hint: Use the idea that only a small fraction of energy transfers to the next trophic level.

Answer: D) 50 units

Explanation: Only about 10% of energy transfers to the next trophic level; kelp to sea urchins transfers about 10%, and sea urchins to sea otters transfers about 10% again, giving about 10% of 500 units, or about 50 units.

7. A sea otter needs about 90 units of energy. The otter eats sea urchins, and the urchins eat kelp. Working backward down the levels, about how much energy must the kelp have stored to support that otter?

Answer: B) 9,000 units

Explanation: About 10% of energy transfers to the next trophic level, so working backward: $90 \div 0.1 \div 0.1 = 9{,}000$ units must be stored in the kelp.

8. A single kelp forest supports thousands of sea urchins but only a few sea otters. Which explanation is best supported by the way energy moves through the ecosystem?
Hint: Use the idea that most energy is not passed to the next feeding level.

Answer: D) Only about 10% of the energy reaches the otter level, so far less is available to support them.

Explanation: Energy flows one direction through the ecosystem, and only about 10% of energy usually moves to the next trophic level, leaving less energy to support sea otters.

9. A student claims, "Decomposers could be left out of a kelp forest model without changing anything important." What is the strongest argument against this claim?
Hint: Focus on how decomposers affect matter cycling in an ecosystem.

Answer: A) Decomposers return carbon and nutrients to the water, where kelp can use them again.

Explanation: In kelp forest models, decomposers break down dead organisms and wastes, returning carbon and nutrients to the environment so producers like kelp can use them again.

10. A student's model shows: sunlight to kelp to sea urchin to sea otter. Which change would most improve this model?
Hint: Focus on how matter moves and is reused in a kelp forest system.

Answer: A) Add decomposers and a nonliving pool of seawater, dissolved gases, and nutrients, with a loop returning to kelp.

Explanation: The passage explains that matter cycles repeatedly through living and nonliving parts; adding decomposers and a nonliving pool that returns materials to kelp best improves the model of matter cycling.

11. Model A shows: sunlight to kelp to sea urchin to sea otter. Model B shows that same chain, plus decomposers, a loop carrying carbon and nutrients back to the seawater and then to kelp, and heat arrows leaving at every level. Which model better represents a kelp forest, and why?

Answer: B) Model B, because it shows matter cycling and energy flowing one way.

Explanation: Model B best represents a kelp forest because it shows matter cycling (with decomposers returning carbon and nutrients) while energy flows one direction and is lost as heat at each level.

12. Which sequence best represents matter cycling rather than energy flowing?
Hint: Focus on materials being reused between living and nonliving parts.

Answer: C) dissolved carbon dioxide to kelp to sea urchin to decomposers to dissolved carbon dioxide

Explanation: Matter cycling involves the same materials (like carbon dioxide) moving through organisms and back to the environment again, showing reuse rather than one-way energy flow.

13. Scientists add extra nutrients to a kelp forest. At the same time, a thick algae bloom spreads across the surface and blocks most of the sunlight. What is the most likely result for the kelp?
Hint: Consider how kelp gets energy versus building materials.

Answer: D) Kelp growth will be limited, because nutrients supply building material but not energy.

Explanation: Extra nutrients can supply matter for growth, but blocking sunlight limits energy needed for photosynthesis, so kelp growth becomes limited.

14. A disease kills nearly all the sea otters in a kelp forest. Urchin numbers explode, and the urchins graze the kelp down to bare rock. Which statement best describes what happens to matter and energy in this ecosystem?
Hint: Think about how matter cycles rather than disappearing.

Answer: C) Less energy now enters the ecosystem, while the carbon atoms remain but move along different paths.

Explanation: When kelp is greatly reduced, less energy enters through photosynthesis, but carbon atoms still cycle through different living and nonliving pathways via waste, breathing, and decomposition.