

Follow the Energy: A Twelve-Card Jigsaw Across Earth's Systems

Learning target: I can work with a team to trace the energy behind twelve real events to its source, name the chain of transfers it used, identify which Earth systems it crossed, and defend our map to another group.

Collaborative investigation

About 50 min

Jigsaw

MS-ESS2-1 · practice

MS-ESS2-6 · supports

MS-LS2-3 · supports

collaboration

discussion

visual modeling

Name _____

Date _____

Period _____

Directions

Work in home groups of four. Step 1 (expert round, 10 minutes): each member takes one set of three cards (Set A: cards 1-3; Set B: cards 4-6; Set C: cards 7-9; Set D: cards 10-12), reads them, and meets with the students from other groups who hold the same set to agree on the energy source and chain of transfers for each card. Step 2 (home round, 20 minutes): return to your home group, teach your three cards, and complete the group energy map. Step 3 (defense, 10 minutes): swap maps with a neighboring group and challenge one placement on theirs; answer their challenge on yours. Step 4 (individual, 10 minutes): answer Part C alone.

You will need: Twelve cards per group, cut from the card sheet, Group energy map table, Pencils, Scrap paper for the defense

Twelve event cards (all real events, described in our own words)

1 Card 1: Geyser, Iceland

Every few minutes a geyser hurls boiling water and steam many meters into the air. Rain and snowmelt seep down through cracks, meet rock that is hot from below, boil, and burst back out. Set A.

2 Card 2: Sea breeze, California coast

On a sunny afternoon the beach sand gets much hotter than the sea. Air over the land warms and rises, and cooler air from over the water slides in to replace it. Surfers feel a steady onshore wind by mid-afternoon. Set A.

3 Card 3: Kelp forest, Monterey Bay

Giant kelp grows up to tens of centimeters a day in sunlit water. Sea urchins eat the kelp, sea otters eat the urchins, and all of them lose energy as heat to the water around them. Set A.

4 Card 4: Lava flow, Hawaii

Molten rock rises through the crust and pours out onto the surface, where it cools and hardens into new rock. The magma rose because it was less dense than the solid rock around it, and it was hot because of energy from deep inside Earth. Set B.

5 Card 5: Sinking water, Southern Ocean

Near Antarctica the surface water loses energy to the cold air, and when sea ice forms it leaves its salt behind. The cold, salty water is denser than the water below it and sinks to the sea floor, then creeps slowly north. Set B.

6 Card 6: Steaming compost pile, a school garden

On a frosty morning the compost pile steams. Inside, bacteria and fungi break down leaves and scraps, and the energy they release warms the pile and the air above it. The energy in those leaves was captured from sunlight by plants last summer. Set B.

7 Card 7: Deep mine, South Africa

In the deepest gold mines, about 3 to 4 km down, the rock walls are tens of degrees hotter than the surface, and powerful cooling systems are needed so miners can work. The rock is warmed by energy moving outward from Earth's interior through solid rock. Set C.

8 Card 8: Thunderstorm, Great Plains

On a hot afternoon, warm, moist air near the ground rises in a tall column. High up the air cools, its vapor turns back into droplets that form a cloud, and gravity pulls the rain back down. Set C.

9 Card 9: Hawks on a thermal, California foothills

Hawks circle upward for hundreds of meters without flapping, riding a column of warm air. The sun heated a dark hillside, the hillside warmed the air touching it, and that air rose. Set C.

10 Card 10: Drifting continents, measured by satellites

Satellite tracking shows that continents move a few centimeters each year, about as fast as fingernails grow. They ride on slowly creeping mantle rock that is warmed from below and cooled from above. Set D.

11 Card 11: Melting glacier, Sierra Nevada

In summer, sunlight melts the surface of a mountain glacier. Meltwater runs into streams, carrying ground-up rock flour that turns the water milky, and the streams feed rivers far downhill. Set D.

12 Card 12: Spring plankton bloom, North Pacific

As days lengthen in spring, tiny floating algae near the ocean surface multiply so fast that the water turns green in satellite images. Tiny animals eat the algae, fish eat the animals, and some of the dead material sinks to the deep sea. Set D.

Part A: Expert round (one set per person)

1. Your expert set: _____. For each of your three cards, write (a) the energy source: *sun* or *Earth's interior*, (b) the chain of transfer methods in order (radiation, conduction, convection), and (c) one piece of matter that moves.

Part B: Home group task

1. Lay out all twelve cards. First sort them into two piles by energy source: the sun, or Earth's interior. Experts must justify any card that another member doubts.

- For each card, agree on the chain of transfers. Write it as arrows, for example 'radiation → conduction → convection.' Most cards use two or three methods, in order.
- For each card, list every Earth system involved (geosphere, hydrosphere, atmosphere, biosphere) and the matter that moves. Mark with a star every card in which matter crosses from one system into another.
- Record everything in the group energy map table.
- Find the card that was the hardest to place and write one sentence explaining the group's final decision.
- Prepare a one-minute defense of your map. Every member must be able to explain any card, not just their own set.

Group energy map (fill in)

Card	Energy source	Chain of transfers	Systems involved	Matter that moves	Crosses systems? (star)
1 Geyser					
2 Sea breeze					
3 Kelp forest					
4 Lava flow					
5 Sinking water					
6 Compost pile					
7 Deep mine					
8 Thunderstorm					
9 Hawks on a thermal					
10 Drifting continents					
11 Melting glacier					
12 Plankton bloom					

2. Group answer: Which card was hardest to place by energy source, and what settled it?

3. Group answer: Write the challenge the neighboring group made to your map and how you answered it with evidence from the card.

Part C: Individual accountability (complete alone)

4. Choose one card from a set that was **not** yours. Trace its energy from the source to the end of the card's story, naming the transfer method at each step and the system the energy is in at each step.

5. Every card powered by Earth's interior involves the geosphere, while the sun-powered cards are spread across all four systems. Explain why, using where each source's energy enters Earth's systems.

6. The compost pile (card 6) was warm on a frosty morning with no sunlight on it. Explain why its energy source is still the sun, and what happened to that energy between last summer and this morning.

7. A thirteenth card arrives: 'Tides: twice a day the sea rises and falls along the whole California coast, and the moving water stirs the deep ocean.' Decide whether it belongs in the sun pile, the interior pile, or neither, and explain your reasoning. What does this card tell you about the lesson's statement that all of Earth's energy comes from the sun or Earth's interior?

Trace backward, not forward

To find a card's energy source, start at the end of the story and ask 'where did that energy come from?' until you reach either sunlight or Earth's hot interior. For the kelp card: otters got energy from urchins, urchins from kelp, kelp from sunlight; source: sun. For the geyser: the water got energy from the rock, the rock from the rock below it, and so on down to the interior; source: Earth's interior. Then read the story forward to list the transfer methods in order.

The card that crosses twice

Card 11 (the melting glacier) carries matter from the hydrosphere into the geosphere and back: ice melts, the water picks up rock flour, and the rock flour settles in a lake downstream. Write a fourteenth card about one real California event in which matter crosses between at least three Earth systems in a single story, powered by one source. Then explain which transfer method appears in the most cards on the table and why that method shows up in so many different systems.