

Two Furnaces, One Surface: Where Earth's Energy Comes From

Learning target: I can use evidence from a passage to explain that Earth's systems run on two energy sources, how each one's energy travels, and why one of them matters far more at the surface.

Reading with evidence

About 40 min

Individual

MS-ESS2-1 · practice

MS-ESS2-6 · supports

reading

writing

Name _____

Date _____

Period _____

Directions

Read the passage once without stopping. Read it again with a pencil: number the paragraphs 1 to 7 and circle every number with a unit. Answer in complete sentences. When a question asks for evidence, quote or closely paraphrase the passage and give the paragraph number. One question asks for a calculation; show every step and keep the units.

You will need: This worksheet, Pencil, Scrap paper for notes, Calculator (optional)

Two Furnaces, One Surface

[1] Stand on a beach in the afternoon and two furnaces are working on you at once. One is obvious: the sun, warming your shoulders and the sand. The other is hidden under your feet. About 6,400 kilometers below the beach is the center of Earth, and at that depth the temperature is roughly 5,000 °C or more. Almost everything that moves on Earth, from mantle rock to ocean currents to a seagull, is moved by one of them.

[2] The inner furnace has two fuel supplies. The first is leftover heat. When Earth formed about 4.5 billion years ago, countless collisions and the sinking of heavy iron toward the center released an enormous amount of energy, and a planet this large loses that energy very slowly. The second supply is radioactive decay: tiny amounts of elements such as uranium, thorium and potassium inside the rock break down over time, and each breakdown releases a little energy. This energy leaves the core by conduction into the rock touching it, and then the mantle carries it upward as rock that is warmer and less dense creeps up while cooler, denser rock sinks. The creep is slow, only a few centimeters per year, but it has not stopped for billions of years.

[3] The outer furnace sends its energy a very different way. There is almost no matter between the sun and Earth, so nothing can conduct and nothing can convect across that gap. Instead the sun's energy travels as light, including kinds of light our eyes cannot see, such as infrared. That is radiation. Most of what Earth absorbs is soaked up by the ground and the sea, not by the air itself; the surface then warms the air resting on it by conduction, and that warm, less dense air begins to rise.

[4] How do the two furnaces compare? Averaged over the whole planet, day and night, sunlight delivers about 340 watts to every square meter at the top of the atmosphere. The heat leaking up from Earth's

interior averages about 0.09 watts per square meter. A hundred-watt light bulb's worth of solar energy falls on a patch of ground smaller than a desk, while the interior's contribution to that same patch is less than the glow of a tiny indicator light. For the ocean, the air and living things, the sun is the furnace that counts.

[5] Then why does the inner furnace matter at all? Because its energy arrives from below, and because it is attached to rock. Solar energy warms only the top of things; it cannot reach down and stir the mantle. The interior's energy, small as it is per square meter, is what keeps mantle rock circulating, and that circulation drags the plates of the crust along, lifts mountains, and feeds volcanoes. A geyser is the two furnaces meeting: groundwater that fell as rain (the sun's doing) sinks into cracks, touches rock heated from below (the interior's doing), boils, and bursts back out.

[6] The sun's energy does not land evenly. Earth is a sphere, so sunlight strikes the tropics almost head-on and the polar regions at a slant, spread over more ground. Air and ocean water warmed in the tropics are less dense; near the poles the surface loses energy, and when sea ice forms it leaves its salt behind, so the water left over is both colder and saltier, and therefore denser. Gravity pulls that dense water down to the sea floor, and the gap it leaves is filled by water sliding in from warmer regions. Giant, slow loops in the ocean and the air are the result, and they carry energy from the tropics toward the poles.

[7] Both furnaces end the same way. Energy that reaches the surface eventually leaves Earth as infrared radiation into space. The planet is neither warming up nor cooling down much from year to year because, over a year, what goes out roughly balances what comes in. What happens in between, during the energy's stay, is the weather, the ocean currents, the growth of forests and the slow rearranging of continents. Earth's systems are not powered by energy that is stored forever; they are powered by energy that is passing through.

Questions: cite the passage

1. According to paragraph 2, what are the two fuel supplies of Earth's inner furnace? Name both and give the paragraph number.

2. Paragraph 2 describes energy leaving the core and then moving up through the mantle. Name the two transfer methods in the order they happen and quote the words that tell you rock is moving.

3. Why can the sun's energy not reach Earth by conduction or convection? Use evidence from paragraph 3.

4. Use the two numbers in paragraph 4 to calculate roughly how many times more energy the sun delivers to an average square meter than Earth's interior does. Show the division and round to the nearest hundred.

5. Paragraph 3 says most absorbed sunlight is 'soaked up by the ground and the sea, not by the air itself.' Explain what this means for how air near the surface gets warm, and name the transfer method involved.

6. Paragraph 5 argues that the inner furnace matters even though it delivers far less energy. Give the two reasons the paragraph offers, in your own words, and explain how the geyser example shows both furnaces at work.

7. Paragraph 6 gives two reasons polar surface water becomes denser. State both, then explain what gravity does once the water is denser.

8. The passage ends: Earth's systems 'are powered by energy that is passing through.' Using evidence from at least two paragraphs, explain what the author means, and describe where the energy finally goes.

Two-column notes before the questions

Draw a line down a sheet of scrap paper. Label the left column 'Inner furnace' and the right column 'Sun.' As you read the second time, write every fact about where that furnace's energy comes from, how it travels, how much there is, and what it moves, each with the paragraph number. Most questions can be answered by reading down one column; q6 and q8 use both.

Check the bulb comparison

Paragraph 4 says a hundred-watt bulb's worth of sunlight falls on a patch 'smaller than a desk.' Using 340 watts per square meter, calculate the area that receives 100 watts, and decide whether the claim is fair for a school desk (about 0.4 square meters). Then explain why the real sunlight hitting the beach at noon is much stronger than 340 watts per square meter even though the passage's average number is correct.