4. Energy in the Earth System

Many phenomena on Earth's surface are affected by the transfer of energy through radiation and convection currents. As a basis for understanding this concept:

a. Students know the sun is the major source of energy for phenomena on Earth's surface; it powers winds, ocean currents, and the water cycle.

b. Students know solar energy reaches Earth through radiation, mostly in the form of visible light.

c. Students know heat from Earth's interior reaches the surface primarily through convection.

d. Students know convection currents distribute heat in the atmosphere and oceans.

e. Students know differences in pressure, heat, air movement, and humidity result in changes of weather.

Dear Friends in the Golden State,

My last letter talked about how the energy of heat moves from place to place. Now we are ready to talk about how energy moves and works in the natural systems of the earth—how heat is moved from here to there, in streams of air and water and forces working deep underground—how heat comes to us outwardly from the sun and from within the molten depths of our planet.

But first, do you recall what I told you about the little mint plant that wouldn't die even though it was sealed in a jar?

Well, just as I was working on that puzzle, I was due to receive a visit from my very best friend in the world. He was the greatest scientist of his generation, and he was an American. Do you know whom I'm talking about? I'll give you a hint. His first name was Ben. Anyone? A great scientist? A signer of your Declaration of Independence? Anyone? Bifocals? Electricity? The lightning rod? The Franklin stove? . . . Yes! BENJAMIN FRANKLIN! My best friend!

He told me a story. He said, "You know that I'm deputy postmaster for the American Colonies. What you don't know is, I've been receiving scores of angry letters from the people of America. It seems that it takes longer for mail to get from England to America than from America to England. I'm talking ***weeks*** longer! Your English ships take longer to make the trip to America than our ships take to make the voyage here."

"So your American ships are faster?"

Ben shook his head. "It's not the ships. It's the route they take. The American captains have found a river—a stream flowing in the belly of the sea. It flows up the East Coast of America, and then bends, and then flows all the way across the Atlantic ocean."

I was astonished. "A river, inside the sea? You mean like wind in the air?"

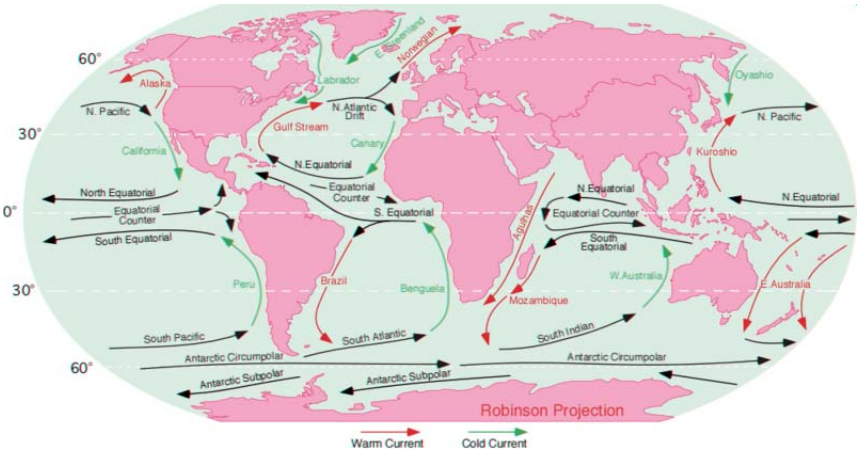
"Yes," he said. "But unlike a wind it always flows in the same direction. Look. "

He showed me this map:

"Ben, do you think there are rivers like this in other oceans? All over the world?"

"There must be, Joseph. There must be! Forces, working upon the sea, which we can only dream about until we get the money to do the research."

Well of course, my dear young Americans of the 21st Century, you know very much more about it than we. Here's a map of the major currents now known to exist:



The primary source of energy for these currents is the wind. And this gets me at last to the subject of this letter: The way that nature moves energy around.

This is such a rich subject that I could go on for a whole book about the very slow convection currents in the molten mantel of the earth, or how wind is made and how hurricanes are powered by warm sea water. But there's not enough time, so I will just talk about the all-important cycle that brings water from the ocean to the sky to the earth and then back to the ocean again.

What drives the water cycle? It is the sun. The sun heats the oceans and evaporates some of the surface. Pure water vapor rises into the air. The sun warms the air and the vapor rises with the rest. The air currents lift the vapor high into the sky where it's much cooler. The coolness condenses the vapor into countless tiny droplets of liquid water. Convection currents keep the cloud from falling to the ground. This is how clouds form. Wind moves the clouds around the globe. When conditions are just right the tiny droplets collect into drops big enough for you to see. These grow too heavy to be held aloft by the convection currents cloud. They fall from the sky as rain. Or if it's cold enough they grow into snowflakes before they fall. Or if a cold wind is tossing them up and down and round and round the little clumps of ice can grow into hailstones.

But most of the water returns to earth in the form of rain. Much falls right back into the ocean. What falls on land flows over the ground. This is what we call surface runoff. It seems like every drop of water wants to get back to the ocean as quickly as possible. But nature has work for it to do on its way down hill.

Some of the runoff soaks into the ground where it can nourish the roots of plants in the dry season. Some evaporates and goes back to the sky to join another cloud. Some flows over the surface of the landscape, into streams and eventually rivers. Some streams are collected in lakes and reservoirs. And some flow straight back into the sea where the water cycle started.

Now here is an important thought you might have missed in all the complexity of the water cycle: When water is taken from the ocean and dropped high in the mountains, a lot of energy is deposited along with those raindrops and snowflakes.

If you had to pump that much water up from the ocean it would take an immense amount of electricity. But since the sun's energy has gotten it up there for us, we can harvest some of that energy in the form of electricity. That's one of the reasons we have so many dams built up in the mountains. The water stored behind the dams generates power that helps light our cities and run our air-conditioning.

But nature has an even larger use for the energy contained in falling water. Remember my letter to you about shaping earth's surface? Remember that water cut the Grand Canyon and shaped the river valleys in California. That moving water brought the sand to the beaches on the coast and the rich earth to the Central Valley? Well, imagine just how much diesel you would use if you had to excavate those valleys and move that material with backhoes, bulldozers, and dump trucks! It boggles the mind! All that energy and much more was required to move the water from the oceans to the High

Sierra. And all that energy was provided, free of charge, courtesy of Mr Sun, who has been doing his job every day of every year for millions of centuries.

I remain, your most enthusiastic provoker of curiosity, and your friend,

Joseph Priestley