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Water Works on the Blue Planet

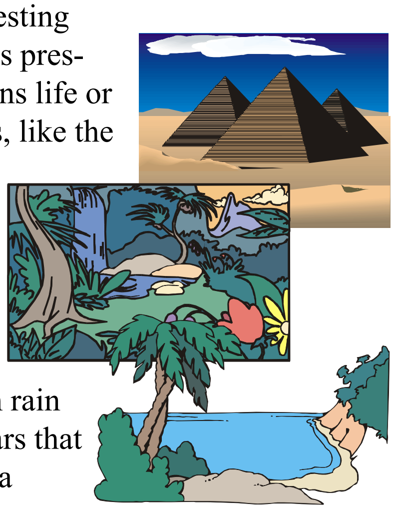
Water, water, every where,
And all the boards did shrink;
Water, water, every where,
Nor any drop to drink.
. . .
And every tongue, through utter drought,
Was withered at the root;
We could not speak, no more than if
We had been choked with soot.

From *The Rime of the Ancient Mariner, Part II*
By Samuel Taylor Coleridge

In Coleridge's poem, the Ancient Mariner is adrift on a windless sea, surrounded by water too salty to drink. (Sorry, we couldn't find a picture of a ship with windless sails!)

When we consider that almost three-fourths of Earth's surface is water, it's hard to imagine there could ever be a shortage. But of all that water, 97.5% of it is too salty to drink. That's how much of the water is in the oceans. As for the rest, we land creatures need to take very good care of it.

Haves and Have-nots



That's the interesting thing about water. Its presence or absence means life or no life. Some places, like the Brazilian rain forest, have a lot of water, while other places, like the Sahara Desert, have none. Some years a place is flooded with rain and snow. Other years that same place is dry as a bleached bone.

But one thing about water doesn't change. There is only a certain amount of water on Earth—no more, no less—and that total doesn't change.

What changes is how it is distributed. The process by which water moves around the planet is called the Water Cycle or—to be technically fancy—the Hydrologic Cycle.

Living on a Fixed Budget

How the water is divided up among the oceans, the land, and the atmosphere is called the Water Budget. Budgets are usually about money. If you have a paying job or receive an allowance, you know how much money you will receive each week or month. You must plan how you will divide this money up to buy the things you need. This process is called budgeting your money.

Earth's water budget, however, is really more like a Monopoly™ game than one person's budget. In real life, you might be able to work more to make more money. Or you might choose to stash your money under your mattress, taking it out of circulation altogether. Monopoly is a board game which pretends to be like real life. In Monopoly, players earn money each time they go around the board. They have chances to buy land, houses, and hotels, and to collect money from other players who land on their property. Players can even get into trouble, losing some of their money or landing in jail.

Unlike in real life, however, in Monopoly the total amount of money available for all the players remains the same. You can't just go printing more Monopoly money when you run short! The game is all about how that fixed amount of money gets spread around. Does one player get rich, leaving the other players poor? Or does the money get distributed more evenly? When each player rolls the dice, makes a move, and then spends money, wealth gets redistributed in some way.

In the Water Cycle "game," wealth (that is, water) gets redistributed by several means. But the difference between this game and Monopoly is that no matter what happens during any particular turn in the Water Cycle game, the "players" all end up with very close to the same amount of wealth they had at the beginning. Who are these players?

The players are the oceans, the land, and the air.

In the Water Cycle game, fair or not, the oceans have and keep almost all the wealth. The total of all the fresh (that is, not salty) water on land, including lakes, rivers, streams, ponds, puddles, bathtubs, kitchen sinks, and all the water under the ground, comes to only 2.4% of Earth's water. The atmosphere contains the rest, only .001% (that's 1/100,000th), in the form of water vapor and clouds.

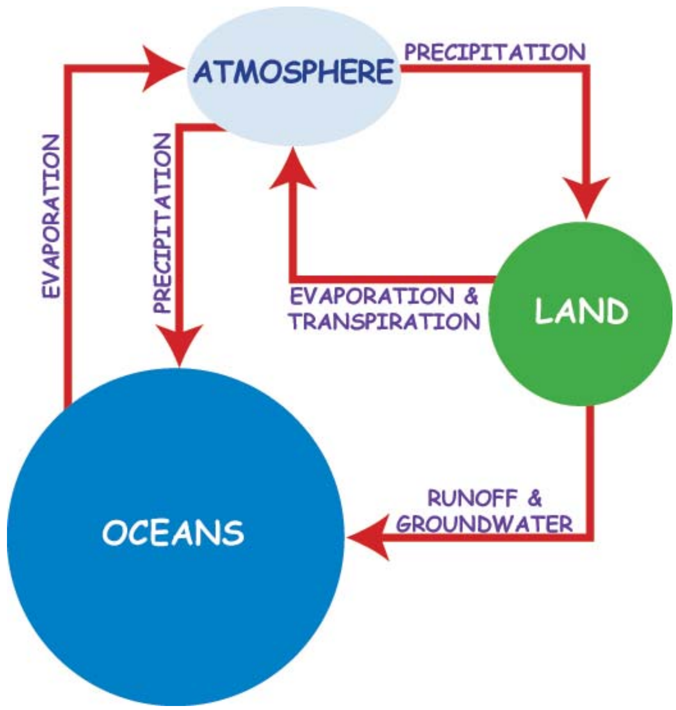
This tiny percentage of the water that is in the atmosphere at any given time is what keeps the whole system moving. The atmosphere is the transportation system that enables the water to, well . . . cycle. Just to give you an idea how hard the atmosphere works to move water around, imagine the entire sky, horizon to horizon, top to bottom, over the whole world being filled with dark, gray clouds. This is how much water the atmosphere can hold. Each year, the total amount of water that gets dumped out of the sky (in the form of rain, hail, snow, sleet, etc.) is 30 times more than the atmosphere's total capacity to hold water!

Water's Ups and Downs

Water gets from Earth's surface into the atmosphere in three different ways: *evaporation, sublimation*, and *transpiration*.

Water gets back from the atmosphere to Earth's surface by *precipitation* and *condensation*.

Water also gets from the land back to the oceans by *runoff* and *groundwater seepage*.



Evaporation is the process of water turning from a liquid to a gas. After a rain, any little dip in the ground becomes a puddle. When the sun comes out, the puddle disappears. Where does the water go? It becomes water vapor (which is an invisible gas) and lifts up into the atmosphere. Water is evaporating off the surface of the oceans all the time. (Luckily for us, the salt is left behind!) Lakes, rivers, swimming pools, all contribute to the water vapor load in the atmosphere. *Sublimation* is the process of water turning from a solid (snow or ice) directly to a gas (water vapor) without melting first.

Transpiration is the process of plants giving off water and oxygen as waste products of photo-

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synthesis. As far as the water is concerned, this process is similar to evaporation, but simply refers to the water coming from the ground up through the plants, rather than coming from the ground directly.

Anyway, once the water vapor gets into the air, it rises and cools, *condensing* into water droplets again. Collections of these water droplets are called clouds. Clouds get pushed great distances by atmospheric winds, and thus become the long-distance trucking industry of the water cycle. This part of the water cycle is called *transport*. Water vapor can also condense out of the atmosphere as dew or frost.

So far, the atmosphere has lifted water into the sky from one place and carried it to another place. Now it sets the water down again in the form of dew, frost, rain, snow, hail, or sleet.

When the water hits land, some of it soaks in and some runs off into lakes, streams, or rivers. The water that soaks in is called groundwater. Groundwater and runoff water all eventually get back to the ocean.

All these processes—evaporation, sublimation, transpiration, condensation, transport, precipitation, runoff, and groundwater seepage—are going on all the time all over the Earth. And still, the total amount of water on our little blue planet remains the same.

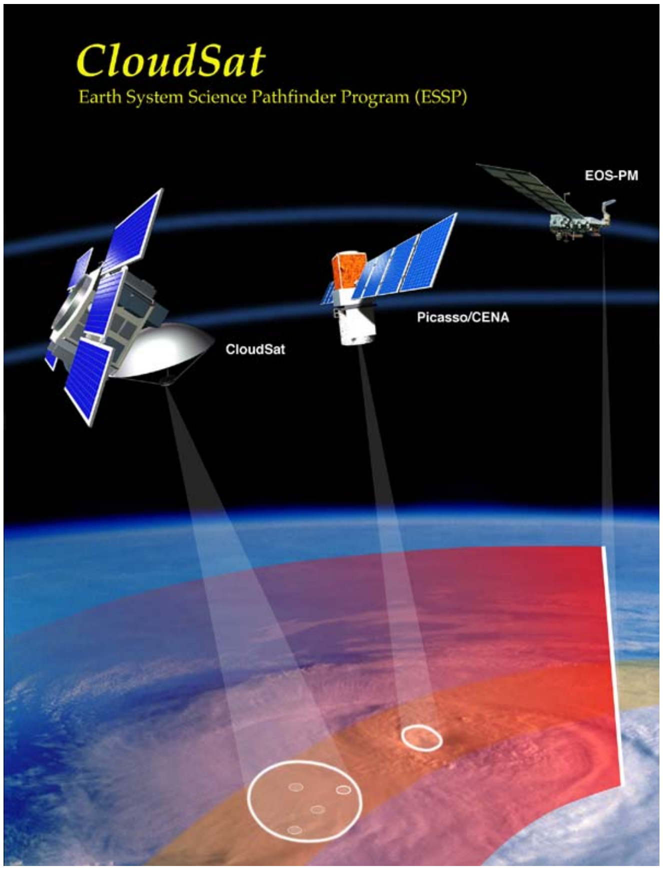
Now for an Illustration

(and an activity for you)

Make a poster (perhaps working in pairs) **or a large mural** (working with the whole class) depicting the Water Cycle on planet Earth. You can include all different kinds of terrain—forests, deserts, farmlands, mountains, plains, rolling hills, cities—all different kinds of clouds, rivers, lakes, streams, calm oceans, angry oceans, glaciers, cross-section views of the underground, rain, blizzards, thunderstorms, hurricanes—whatever seems interesting and dramatic and shows all the different ways water moves up into the air and back down again to the surface. Label the water elements of the picture to show which of the processes of the water cycle are being shown.

If you like, you can cut the clouds out of separate pieces of paper to make a dynamic water transport system. You can show how the clouds "pick up" water from one part of the picture and carry it to another.

Of course what drives evaporation and precipitation are the basic laws of physics. But things could be different and not violate any laws of physics. For example, what do you think would happen if all the continents were well above sea level, but perfectly flat? What if it were warm enough on Earth that all the water was in liquid



form (no ice)? Given that the atmosphere cannot hold any more water than it already does, what if precipitation fell equally on all parts of Earth?

Learning More About Clouds

Clouds are the key element of the water cycle, since they are the transporters that move water from one place on Earth to another. They are also important in determining how much of the sun's energy is absorbed and trapped in the atmosphere. They are thus very important in altering the temperature of the air and Earth's surface. The warmer the air, the more water it can hold. And the warmer the oceans, the faster water evaporates from them. And the more water in the air, the more the sun's energy is trapped, making things still warmer.

It is a very complex cycle, and scientists need to understand better how clouds affect climate. Current weather satellites give scientists information about how clouds look from the top, and even how high they are. But they don't reveal enough about the vertical structure of the clouds to really understand them.

Cloudsat is a space mission that will study clouds, taking 3-D images of them using advanced radar technology. Cloudsat will orbit Earth, flying in formation with other satellites that take cloud measurements using different kinds of instruments. Cloudsat will measure how much liquid water and ice are in the clouds at what heights, and how these measurements affect the clouds' ability to reflect or trap the sun's energy. Data collected by the satellites will be combined to give a better understanding than we have ever had before of how clouds work and how they affect climate all over Earth.

Cloudsat will be launched in 2003. It is a joint project between Colorado State University, NASA's Jet Propulsion Laboratory, the Canadian Space Agency, the U.S. Air Force, and the U.S. Department of Energy. To learn more about Cloudsat, see http://cloudsat.atmos.colostate.edu/.

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