Learning Lesson: Water, Water Everywhere

OBJECTIVE	Discover the different water ratios in the earth's total water supply.
OVERVIEW	The students will estimate how much water they think can be found in various locations on the earth in all its states; solid, liquid, and gas.
TOTAL TIME	20 minutes
SUPPLIES	Eight (8) 1000 ml beakers Plastic cup Eyedropper
PRINTED/AV MATERIAL	None
TEACHER PREPARATION	This can be done as a class demonstration or you can divide the students into pairs should you have enough glass jars. You can also shorten this experiment by using crushed ice instead of cubed ice. The crushed ice will chill the water quicker, causing condensation sooner.

Background

Water is the most abundant and important substance on Earth. It is essential to life and is a major component of all living things. There are approximately 336,000,000,000,000,000,000 gallons of water on the earth, existing in three states; solid, liquid and gas. The sources for this water storage are the oceans, icecaps & glaciers, ground water, fresh-water lakes, inland seas, soil moisture, atmosphere, and rivers.

Procedure

1. Label beaker 1 "oceans" and fill it with 1000 ml of water.

2. Label the following beakers: beaker 2 "glaciers & icecaps", beaker 3 "groundwater", beaker 4 "fresh-water lakes", beaker 5 "inland seas", beaker 6 "soil moisture", beaker 7 "atmosphere", and beaker 8 "rivers".

3. Inform the students that the earth's total water supply has been reduced to 1000 ml as indicated in beaker 1.

4. Ask the students how much water must be transferred from beaker 1 and placed in each of the remaining beakers.

5. After all beakers have some water in them, write their estimates on the chalk board.

6. Pour all water back into beaker 1, dry beakers 2 through 8, and add any water necessary to return beaker 1 to 1000 ml.

7. Transfer the following amounts of water from beaker 1 to each of the remaining beakers.
    2. Glaciers & icecaps - 21.4 ml
    3. Groundwater - 6.1 ml
    4. Fresh-water lakes - 0.09 ml
    5. Inland seas - 0.08 ml
    6. Soil moisture - 0.05 ml
    7. Atmosphere - 0.01 ml
    8. Rivers - 0.001 ml

Discussion

The students will be surprised how little water is found in each of the remaining beakers. The vast majority of water is found in the oceans; approximately 97.2%. The following are the percentages for each water source:

Water Source	Water volume (cubic miles)	Percent of total water
Oceans	317,000,000	97.24%
Glaciers & icecaps	7,000,000	2.14%
Groundwater	2,000,000	0.61%
Fresh-water lakes	30,000	0.009%
Inland seas	25,000	0.008%
Soil moisture	16,000	0.005%
Atmosphere	3,100	0.001%
Rivers	300	0.0001%
Total water volume	326,000,000	100%

Despite the overabundance of rain we often receive, the atmosphere contains very little of the earth's total water supply.

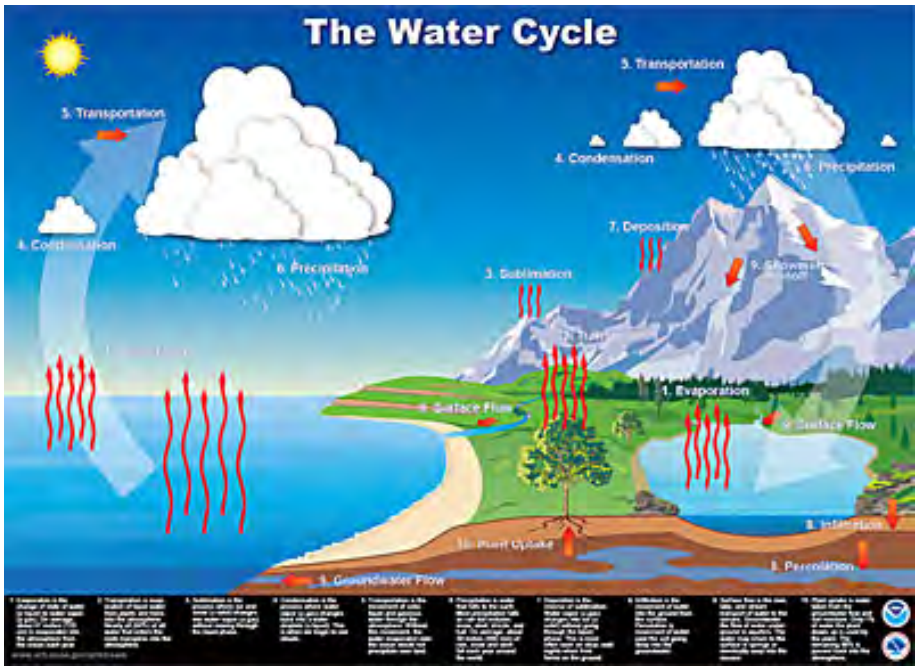
Fast Facts
A cubic mile of water equals more than one trillion gallons. If all the water in the atmosphere fell as precipitation at once, the Earth would be covered with only about 1 inch (2.5 cm) of water.

The 48 contiguous United States receives a total volume of about 4 cubic miles (6.4 cubic km) of precipitation each day. If all of the world's water was poured on the United States, it would cover

the land to a depth of 90 miles (145 km). Each day, 280 cubic miles (450 cubic km) of water evaporate or transpire into the atmosphere.

Back: The Hydrologic Cycle

What a Cycle!



Click image to enlarge.

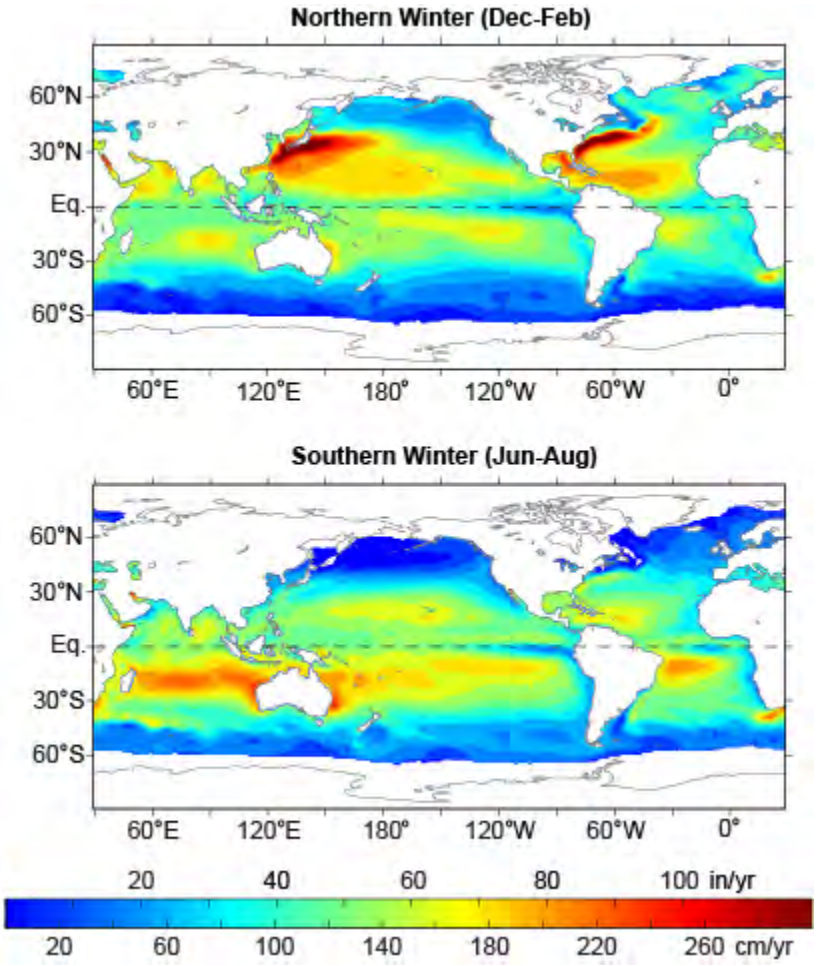
At its core, the hydrologic cycle is water, as a liquid or solid, changing into water vapor (a gas) and back into a liquid or solid. This change of state of water occurs in the atmosphere and between the earth's surface and atmosphere.

This basic cycle is seen almost daily around the world in the formation and dissipation of clouds. When a cloud develops it is water vapor becoming a liquid. Conversely, when a cloud dissipates, liquid water changes state back into a gas.

The Ocean's Role

The vast bulk of the water in the water cycle is found in the oceans. The oceans hold 96.5% of the earth's water and due to their size it may take thousands of years for a water molecule to move from the ocean to the atmosphere. This is in spite of an average 45 inches (114 cm) of water that evaporates from the ocean each year. (An additional 1% of salty water is also found in saltwater lakes and saline groundwater.)

The highest rate of evaporation from the oceans occurs in winter for both the Northern and Southern Hemispheres. The location of greatest evaporation is found on the east coasts of continents. (See maps lower right.) This is due primarily to winter storms that move off the east coasts of continents which tend to have strong winds. These winds help carry water vapor away from its source thereby allowing more evaporation to take place.



Maximum global evaporation rates

From "Global Variations in Oceanic Evaporation (1958–2005): The Role of the Changing Wind Speed" by Lisan Yu, WHOI OAFlux project.

The other factor is the warm ocean currents that move pole-ward along the east coasts of continents. The cold winter-time air masses that move over the water allow for large differences in air and sea temperatures so evaporation is also large. Then, when these differences in air and sea temperatures are combined with strong winds it makes evaporation in these regions very efficient.

Yet, of all evaporation that occurs over the oceans, a little over 90% of the moisture falls directly back into the sea as precipitation. And after spending upwards of a few thousand years in the ocean, a water molecule, on average, will only spend about nine days in the atmosphere before returning to earth. This is a very simple water cycle!

But over land, the water cycle can become quite complicated. The remaining 10% of moisture is transported over land and falls as precipitation from where it can travel a myriad of paths. If the precipitation falls as snow, it can remain frozen for a day or two then melt and flow into a river. Or the snow can become compacted and be locked up in a glacier for centuries.

Some water may infiltrate the soil or percolate into the groundwater. While most groundwater returns to the ocean, some groundwater can bubble up to the surface as a spring and evaporate back into the atmosphere, flow into a river, or even be captured and bottled for human consumption.

Learning Lesson: What-a-cycle

Learning Lesson: Water Cycle Paper Craft

But remember, of all the water on the earth only 2.5% is fresh water and nearly all of that fresh water is locked up in glaciers and groundwater. Perhaps surprisingly, the atmosphere only contains about one-thousandths percent of all water on the earth.

The distribution of fresh water as well as an estimation of the time a water molecule remains in various features, can be seen in the table (below). The Water Cycle chart (top right - click to enlarge) shows additional sub-cycles contained within the greater cycle. The USGS also has water cycle diagrams in over 60 languages.

Water Cycle Wheel

pdf 4.3 mb

Estimate of global FRESH water distribution	Total Water (%)	FRESH Water (%)	Duration
Ice caps, Glaciers, & Permanent Snow	1.74	68.7	> 1000 years
Groundwater	0.76	30.1	~300 years
Soil Moisture	0.001	0.05	~280 days
Ground Ice & Permafrost	0.022	0.86	
Lakes	0.007	0.26	1-100 years
Atmosphere	0.001	0.04	9-10 days
Wetlands	0.0008	0.03	
Rivers	0.0002	0.006	12-20 days
Humans / Animals / Plants	0.0001	0.003	

Back: Hydrologic Cycle